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MORE LINEAR THAN YOU WOULD THINK

Quadratic utilities, product differentiation and trade patterns

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*Thèse présentée en vue de l'obtention du grade de
docteur en sciences économiques et de gestion*

Composition du Jury:

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*“I call our world Flatland, not because we call it so, but
to make its nature clearer to you, my happy readers,
who are privileged to live in Space.”*

Flatland: A Romance of Many Dimensions, *Edwin Abbott Abbott (1884)*

Acknowledgments

In a thought-provoking op-ed motivated by the award of the 2013 Nobel Prize in Physics to François Englert and Peter W. Higgs for their work on the origin of mass of subatomic particles (related to the now-famous "Higgs boson"), the theoretical physicist Sean Carroll recalled the Nobel Prize winner Richard Feynman's griping about what he dubbed "Alfred Nobel's other mistake", which he identified as the "ridiculous idea that individuals should be awarded a prize for something as grand and open-ended as scientific research" (Carroll, 2013). As Carroll puts it, "no physicist is an island" and science has always been an intensely collaborative pursuit, with prizes and attributions to individuals rarely being able to capture the full nuance of the historical reality.

Is a Thesis in Economics less of a collective effort than an experiment in Physics? I hardly think so. The ideas, intuitions, theories, methods and data that come together in a PhD Thesis are the clear product of a shared effort to increase our common knowledge. Some of these contributions can be acknowledge explicitly, as in the 171 citations present in this Thesis, but others elude our awareness and lie hidden in our subconscious. This latter category includes all the conversations, presentations, lessons and exchanges of views enjoyed in several years of research and academic training. It would be easy to overlook the importance of this source of influence or to dedicate just a cursory, general mention to all the people that contributed to my education attainment, but I think instead that here and now would be the right place to sincerely acknowledge the importance of "everyone else" in what could otherwise be inaccurately perceived as a merely personal achievement.

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Introduction

The field of International trade is currently venturing into an era of ebullient transformation. Few other branches of economics experienced similar shock waves as a consequence of increased data availability and the development of novel analytical techniques. Increasingly detailed trade datasets are allowing researchers to unveil unprecedented information on firm, product and market characteristics, shaking the ground on which traditional and relatively new trade theories have been founded.

Until the second half of the twentieth century, traditional neoclassical trade theories relying on comparative advantages and product specialization received great credit but little rigorous empirical scrutiny, as their validation could only rely on intuition, internal consistency and rough macro-level evidence. These theories leveraged simplifying working assumptions such as competitive markets, constant returns to scale and perfect substitutability to provide analytically elegant models aimed at formalizing intuitions and sketching general patterns, but not meant to capture the actual behavior of individual market participants.

Yet, few researchers could have predicted how spectacularly unfit these models would have proven themselves in working with the highly disaggregated trade data available today at the product, firm-product, or even plant level. Indeed, during the last couple of decades micro-level datasets uncovered many puzzling surprises. To give some concrete examples, no neoclassically educated economist would have guessed the amount of intra-industry trade found in the data, which affects virtually every country, sector and product traded in the developed world (OECD, 2010). Similarly, few could have imagined that firms producing the same product, in the same place, at the same time, with the same technology could be characterized by a large amount of heterogeneity in size and productivity, among other dimensions (Bernard et al., 2003; Verhoogen, 2008). These findings motivated the shift of the field towards a new generation of models, such as Melitz (2003), blending cost heterogeneity à la Hopenhayn (1992) and love for variety à la (Dixit and Stiglitz, 1977) in a general equilibrium framework, with the aim of providing proper theoretical underpinnings to the emerging empirical patterns.

While innovating on many technical fronts, new trade theories have retained a typical feature of neoclassical models: the focus on supply-side heterogeneity as the main engine of differences trade patterns. These are explained in the two classes of models as stemming entirely from differences in productive efficiency or factor endowment, whereas heterogeneities on the demand side of the economy have not received the same

amount of attention, resulting in simplified demand structures with identical consumers and symmetric preferences across varieties. This abstract representation of the economy characterized an approach based on non-localized competition in which products are assumed to be generally differentiated but no real attention is paid to the actual sources of differentiation, consistently with the imperfect competition tradition à la Chamberlin (1933), Robinson (1933) and Spence (1976). This way of modeling has long been considered antithetical to the school of thought advocating for an explicit accounting of the sources of localized competition and product differentiation à la Hotelling (1929) where firms are allowed to choose their address on a horizontal space, as in d’Aspremont et al. (1979), or in terms of vertical attributes, as in Mussa and Rosen (1978), based on the intuition that products can be interpreted as bundles of attributes (Lancaster, 1966).

These two approaches need not be mutually exclusive and are not contradicting each other on substantive issues, but the development of an appropriate framework to accommodate the two in a similarly rigorous yet intuitive fashion represents a daunting challenge, which ranks still high the current economics research agenda. This is proven by the efforts recently undertaken in the literature to augment purely supply-side model with a more refined characterization of the demand side, be it in a more Chamberlinian (Foster et al., 2008; Khandelwal, 2010) or more Lancasterian (Carballo et al., 2013; Chen and Riordan, 2007) way.

The ambition of this PhD Thesis is to contribute to the achievement to this synthesis by developing a framework able to reconcile the two ways of conceiving the demand side of the economy, keeping the theoretical elegance and tractability of existing models while improving their fit of empirical data. To this end, the following steps are taken. First, a hermeneutic effort is undergone to realize a conceptual connection between Chamberlin (1933) and Hotelling (1929), borrowing from location theory the analytical tools needed to define and interpret the product differentiation components of monopolistic competition theories based on quadratic preferences. Second, it is shown how different variations of the standard quadratic utility framework à la Ottaviano et al. (2002) or Belleflamme et al. (2000) can be associated with underlying location problems and result in specific empirical properties that can be exploited in applied research. Third, the empirical relevance of this theoretical framework is tested by identifying one preferred variation of the resulting quadratic models and checking whether it can be fruitfully deployed to rationalize trade patterns (at the micro and macro level) and obtain aggregate indicators of market performance. Indeed, a by-product of this effort to develop and test a new model of trade is the possibility to produce indicators of competitiveness at different levels of disaggregation (from firms to countries) that can be used for policy purposes.

The framework presented in this Thesis is meant to push the frontier of trade research in the direction of characterizing a general set of consumer preferences that can enrich existing theories focusing on the supply side to better fit micro-level empirical observations, within the boundaries of a rigorous demand setting with elements of both localized and non-localized competition. The quadratic utilities preferences presented in this Thesis can provide the flexibility and identifiability needed to model consumer preferences in trade models, while allowing for both market-variety-specific variability

and the possibility of building aggregate market indices of competition. Eight variations are presented of the general framework, differing in the sources of demand heterogeneity. For each variation, theoretical properties and empirical applications are discussed, but one in particular is chosen as the best suited to accommodate existing evidence and deal with trade data when the entire economy is concerned. It is a combination of vertical and horizontal sources of variability, which is referred to in the Thesis as the "verti-zontal model".

Hopefully, this Thesis can also turn out to be a useful handbook for practitioners of trade research who want to exploit quadratic utilities in their studies but are not sure about which particular specification to adopt or have reasons to believe that the market they are studying is better approximated by models yielding specific empirical patterns, for example in terms of quantity or price variation. To this end, the Thesis is organized in such a way that can be promptly consulted as a methodological reference to find guidance on which particular specification of a quadratic utility is best suited to address specific modeling needs, in terms of market outcomes or underlying spatial problem.

In the field of international trade there is currently no uncontroversial definition for the concepts of horizontal and vertical differentiation, let alone a consensus about the details of this distinction. In models with love for variety with non-localized competition, for example, the concepts of substitutability and horizontal differentiation tend to overlap because they are both applied to all the varieties symmetrically. In addition, their impact on prices may coincide with the effect of vertical differentiation, which is normally approximated with quality as a demand shifter. For this reason, the framework presented in this Thesis turns to Hotelling (1929) and the Industrial Organization tradition to find a more rigorous setting for the study of product differentiation. In this literature, there has been a long tradition of clearly distinguishing vertical from horizontal differentiation and the models presented in this Thesis build on the same clear distinction. However, unlike Industrial Organization models, which emphasize strategic interactions between firms and assume indivisibility of consumption, here the focus is on varying quantities and the "weak interactions" typical of monopolistic competition, where firms' behavior is influenced by market aggregates which are unaffected by the choices made by any individual competitor. This has the advantage of substantially simplifying the analysis and the derivation of results while retaining competitive interactions.

The Thesis is divided in three parts: first the theoretical development of the framework, then its empirical test, and finally some ideas for future development.

The theoretical part, titled "Monopolistically competing Chamberlin-Hotelling tension away", comprises Chapters 1, 2 and 3. Chapter 1 illustrates the use of a standard quadratic utility without any source of productive or demand heterogeneity in the context of a New Economic Geography with two regions of different size as the only source of heterogeneity. In such a framework, the interplay between scale economies and transport costs alone determines differences in the location of firms and consumer utility. The system of preferences used in Chapter 1 is analyzed in depth in Chapter 2, which characterizes the link between location theory and trade theories based on quadratic preferences, spelling out the similarities and the differences between the two frameworks

and defining precisely the assumptions that need to be altered to move from one to the other. Then Chapter 3 describes the trade models based on quadratic preferences resulting from the generalization of a standard location-theory problem and describes the spatial interpretation and empirical properties associated with the resulting class of models. To help intuition, simulations of market outcomes are provided for each model, where the differences are explained in terms of corresponding sources of variability.

The empirical part follows, titled "Taking verti-zontal linearity to the data" and constituted by Chapters 4 and 5. In Chapter 4, the preferred variation of the models presented in Chapter 3 in the context of trade data covering the entire manufacturing sector, the verti-zontal model, is taken to the data at the micro level (firms-products) to adjudicate the robustness of its assumptions and the validity of its predictions, performing several robustness tests. Chapter 5 takes stock of the empirical methodology developed in the preceding Chapter to test whether the micro-level results still hold at more aggregate levels of analysis and to present a simple, yet powerful methodology to develop measures of country-product performance based on the verti-zontal model framework.

Finally, the last part of the Thesis, called "The ways forward", includes Chapter 6, which investigates avenues for future theoretical and empirical development of the models developed in the Thesis. In particular, it shows how the framework can be empirically employed to explore issues related to asymmetric transport costs, validation of quality measurements, the relation between income and preference for quality and the role of input quality in determining firm profitability. On the theoretical side, two challenging proposals for the future development of trade models based on quadratic preferences are advanced, the first aiming to reconcile the oligopolistic market structure often observed in reality with a framework mimicking the weak interactions typical of monopolistic competition, with the only difference that firms are allowed to internalize the impact of their product differentiation on the market aggregates. The second proposal for future research is to delve further into the subtleties of the integration of localized and non-localized competition features by developing a theory of endogenous location and pricing in a multidimensional characteristics space. To this end, a different variation among the ones presented in Chapter 3 is developed further, the verti-zontal with endogenous substitutability patterns depending on the location of each variety in the characteristics space. The resulting model can encapsulate more spatial information than the simple verti-zontal, but it is less tractable and harder to test or employ empirically, which is why it is left for future research.

Finally, the main results and achievements of the Thesis are wrapped up in a short conclusion.

Part I

Monopolistically competing Chamberlin-Hotelling tension away

Chapter 1

Quadratic utilities and New Economic Geography

In this first Chapter, a New Economic Geography (NEG) model without any source of demand or supply heterogeneity is presented. The only departure from perfect symmetry is the division of the economy into two regions inhabited by a different number of consumers. The model's spatial outcomes are therefore shaped uniquely by the tension between the agglomeration forces of market size and scale economies and the dispersion forces of trade costs and imperfect competition.

The Chapter thus shows how linear demands can be usefully deployed in the study of agglomeration patterns. Specifically, it proposes a tractable framework that can be used to investigate the long-run capital reallocation patterns triggered by transport liberalization once the determination of freight rates has been endogenized, measuring also its impact on welfare. Two policy scenarios are considered: one where the regulator fosters competition by increasing the number of carriers imposing a unique tariff per route, independently of the direction of shipment, and one of complete deregulation, which leaves carriers free to price discriminate by direction of shipment. Under the complete deregulation scenario, profit-maximizing carriers are indeed shown to charge different prices in the two directions of the same route, charging higher markups when delivering goods to the less competitive regions. This pricing behavior in the transport sector counterbalances the welfare-decreasing agglomeration forces associated with lowering trade costs and ensures that transport liberalization maps into welfare gains both in the short and in the long run.

This Chapter builds on a previous piece of research, resulting in the master Thesis "Transport liberalization and regional imbalance" (2007), extending and refining it in several directions.

1.1 Transport liberalization and regional imbalances

In the absence of product differentiation and economies of scale, trade costs can be seen as just a source of price distortion decreasing the welfare of all market participants

by driving prices up, profits down and leading to a mis-allocation of resources. This consideration led policy makers to develop an attitude towards transport costs which can be epitomized as: the cheaper, the better. Lower transport costs are expected to lead to better integrated markets which in turn should result in improvements in citizens' welfare through the reduction in prices associated with a more intense competition in the final products' market.

But are early welfare improvements meant to last in the long run? Do they depend on the market structure in the transport sector? And are the resulting gains evenly distributed among regions? This Chapter tries to answer these questions in the context of a New Economic Geography (NEG) framework in which products are differentiated and firms' interactions are described as in the monopolistic-competition tradition (Dixit and Stiglitz, 1977; Krugman, 1991) with the additional feature of an endogenous transport sector à la Behrens et al. (2009) where firms are also allowed to price discriminate by direction of shipment, similarly to Behrens and Picard (2011). NEG models are typically adopted to draw predictions on the spatial distribution of economic activities, which then map into location-specific market outcomes. The key underlying idea is that, once firms are allowed to relocate from one region to the other to equalize returns on capital investments, market outcomes are affected in both origin and destination markets because of an alteration in the competitive interactions between firms (Fujita, 1988; Gaigné and Behrens, 2006; Ottaviano and Thisse, 2004).

This Chapter investigates the spatial agglomeration patterns and welfare implications of a cost-reducing liberalization of the transport sector, with and without the possibility for carriers to price discriminate by the direction of shipment. Following the intuition of Behrens et al. (2009), transport costs are not treated as parameters after liberalization, but they are determined endogenously by profit maximizing carriers providing an undifferentiated transport service subject to capacity constraints. Two scenarios are analyzed: the first one is a regulated liberalization regime in which prices are fixed per route (or, say, distance), independently of the direction of the shipment, which follows the modeling strategy of Behrens et al. (2009). The second is a complete deregulation regime, allowing for price discrimination based on the direction of the shipment, similarly to Behrens and Picard (2011), who analyze the case of a transport industry characterized by carriers committing the same given level of capacity in the two direction of a route and defining a pricing strategy that allows them to avoid "empties" (the so-called back-haul problem). Differently from Behrens and Picard (2011), in this Chapter the carriers are allowed to set up a different level of capacity in the two directions so as to relax the constraint of an equal amount of quantities shipped in the two directions. This assumption is able to accommodate the observation that about 60% of the containers shipped from Asia to North America in 2005 came back empty, and those "that did come back full were often transported at a steep discount for lack of demand," (Behrens and Picard, 2011), which is consistent with a model in which carriers charge different prices in the two directions of shipment but can pre-commit to direction-specific capacity level not to undercut prices in one of the directions and reduce their profits.¹

¹To the extent that import and export procedures involve different activities, such as local sales

Whereas the transport service is assumed to be undifferentiated, leading to a standard oligopolistic outcome à la Cournot (1838) in the presence of a pre-commitment on capacity (Vives, 1999), the same is not true for the final goods transported by the carriers. These are supplied in horizontally differentiated varieties produced by firms operating in a monopolistic competition framework characterized by increasing returns to scale and a limited amount of market power granted from the assumption that consumers value variety. In particular, the use of a variable-elasticity-of-substitution utility functions (Belleflamme et al., 2000; Ottaviano et al., 2002), allows firms in the model to price discriminate across markets (as opposed to constant-elasticity-of-substitution preferences yielding constant markups on costs) and conveniently treat transport costs as linear rather than in iceberg terms. Linear transport costs have the notable advantage of enabling economists to explicitly model the transport sector and thus allowing researchers to study the impact of transport policies on the spatial distribution of economic activities and ultimately on welfare. This is what also Behrens et al. (2007, 2009) and Behrens and Picard (2011) do, by allowing transport prices to be determined endogenously as a result of the transport market structure and the distribution of economic activity, which is in turn affected by the transport costs. They show that the short-run static gains due to liberalization (lower prices for consumers) can be offset in the long run by the dynamic losses implied by inefficient agglomeration patterns and thus liberalization policies may be detrimental to consumers' welfare.

In the framework explored in this Chapter, however, there is no reversal of the short-run (static) welfare gains in the long run. Similarly to Behrens and Picard (2011), transport liberalization is shown to increase agglomeration, which affects welfare negatively, but the gains in terms of lower prices and higher profits more than compensate the negative impact of agglomeration. This is true in the case of symmetric freight rates in the two directions and even more so in the case of complete liberalization with asymmetric rates. Indeed, for a given level of competition in the transport sector (as approximated by the number of competing carriers), a complete liberalization regime is associated with less industrial agglomeration than a liberalization regime with symmetric pricing. The intuition behind this latter result is that, as compared to the unique-bilateral-tariff setting, the tougher (softer) degree of competition in the core (peripheral) regions forces carriers to charge a lower (higher) price to firms supplying those markets from the periphery (core), but this makes more convenient for firms to move to the periphery and enjoy softer competition than in the core region and lower transport costs to serve the core. One way to interpret this result is to look at the combined problem of the carriers and final good producers in terms of the well-known Industrial Organization concept of double marginalization (Tirole, 1988), where the profits that the two types of agents can extract from the final consumers depend on the toughness of competition in the downstream market, where the final goods are eventually sold to consumers.

personnel, facilities or marketing investments, carriers can achieve the desired level of direction-specific shipping capacity when they enter the market. This preliminary commitment plays also in their own interest, as it allows carriers to compete in quantities, à la Cournot, rather than in prices, à la Bertrand, as discussed by Vives (1999).

The model presented here has interesting policy implications in terms of the impact of transport liberalization on total welfare and geographical fairness. In terms of total welfare, a reduction in transport costs is always beneficial, but it comes at the cost of higher disparities in industrialization between regions. The latter effect can be mitigated by allowing carriers to price discriminate by direction of shipment, increasing the welfare improvements of liberalization further. Therefore, a clear policy message stems from the model: a full liberalization regime not imposing any restrictions on the market segmentation of carriers seems to be superior to a regulated market with symmetric low tariffs or a liberalization where carriers are required to charge the same price in the two directions of shipment of the same route (or to follow any other direction-invariant pricing strategy, such as a distance-based one). However, once the most efficient type of liberalization regime has been identified, policymakers have also to decide the extent of liberalization, i.e. how many carriers to allow in the market, keeping in mind that when the number of carriers is so high as to drive freight rates to marginal costs the differences between the two liberalization regimes disappear. In terms of global welfare measured in terms of real income, the answer would be as many as possible. Still, the level of industrial concentration increases monotonically in the level of competition in the transport sector. Therefore, if high levels regional disparities in industrialization are perceived as socially harmful, policymakers may still prefer to let a lower number of competitors in and enjoy a less concentrated economy.²

A final remark is that the analysis in this Chapter focuses on only transport costs (if exogenous) or freight rates (if endogenous), but the same arguments and modeling strategies could be adopted to capture different sources of trade costs, be them port or airport fees, revenue maximizing import tariffs, trade insurance contracts or any other endogenously determined variable source of trade costs which can be route- or direction-specific.

The Chapter is organized as follows. In Section 2, the model is developed in the short run and commented. In Section 3 the relocation of firms in the long run is described. In Section 4 the transport sector yielding endogenous freight rates is introduced in the model, under two different regulatory settings: complete deregulation and unique-bilateral-tariff liberalization. The two different regulatory regimes are compared in terms of welfare and geographic distribution of industrial activity in Section 5. Finally, Section 6 concludes.

1.2 The model

Consider an economy composed of two regions: a more populated core, H , and a less populated periphery, F (for notational purposes, the two regions are called i and j when considered in general terms). Consumers exhibit quadratic preferences and the economy is characterized by two sectors, one displaying constant returns to scale and using one unit of labor to produce the numéraire, the other exhibiting increasing returns

²A preference for lower spatial concentration can be explicitly included in the objective function of policymakers, keeping the rest of the model unaltered.

to scale and using inter-regionally mobile capital and local labor to produce varieties of a differentiated good. When the differentiated good is produced in i and sold in j , it incurs a linear transport cost $t_{i,j}$, whereas $t_{i,i} = 0$. The value of $t_{i,j}$ is initially taken as a parameter (under a regulated transport sector) and independent of the direction of the shipment ($t_{i,j} = t_{j,i} = t$); then, it is determined endogenously in the transport sector following two types of liberalization, one imposing $t_{i,j} = t_{j,i}$, which is called *unique-bilateral tariff* (or symmetric tariff), and the other allowing carriers to price discriminate by the direction of shipment, $t_{i,j} \neq t_{j,i}$, which is called *complete deregulation* (or full liberalization).

Here follows a description of the economy, first in the short run and then taking firm relocation into account (in the long run).

1.2.1 Consumers

The economy is inhabited by M identical consumers which are exogenously distributed in the two regions and are endowed with one unit of labor, L , which is geographically immobile, and one unit of capital, K , which can be invested in either region. The share of people living in region i is expressed by θ_i , i.e. $\theta_H \in [\frac{1}{2}; 1]$ and $\theta_F = 1 - \theta_H$, so that the absolute number of consumers living in that region is $M_i = \theta_i M$. To simplify the notation, in the rest of the paper whenever θ is left without subscript, it refers by convention to θ_H , which can be interpreted as a measure of demand concentration in the economy. The preferences of each consumer are captured by a standard quadratic utility function (Belleflamme et al., 2000; Ottaviano et al., 2002):

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_i^2(s) ds - \frac{\gamma}{2} \left[\int_{s \in S_i} q_{s,i} ds \right]^2 + q_0, \quad (1.1)$$

Where N_i is the mass of varieties present in region i , each variety being of negligible size for the market, $q_{s,i}$ is the amount of variety $s \in (0; N]$ consumed by each consumer i , the parameter α defines the intensity of preference accorded to the consumption of the differentiated good, as compared to the homogeneous one, q_0 , whose marginal utility is normalized to unity and used as the numéraire of the economy. The parameters $\beta \in (0; \infty)$ and $\gamma \in [0; \infty]$ determine consumer's love for variety by capturing perceived horizontal differentiation of varieties (β) and the degree of substitutability (γ) between varieties (Di Comite et al., 2014). Consumer are subject to the following budget constraint:

$$\int_{s \in N_{ii}} p_{s,ii} q_{s,ii} ds + \int_{s \in N_{ji}} p_{s,ji} q_{s,ji} ds + q_0 = y_i + \bar{q}_0, \quad (1.2)$$

where $p_{s,ii}$ and $q_{s,ii}$ are the price (in terms of the numéraire) and quantities sold of a variety s of differentiated good bought by a consumer living in the same region as the producing firm; $p_{s,ji}$ and $q_{s,ji}$ are the price and quantities sold of a variety of differentiated good bought by a consumer living in a region different from the one where the producing firm operates; the parameter $\bar{q}_0$ represents the consumer's i initial endowment of homogeneous good (assumed to be large enough to allow the consumer to enjoy any

level of consumption of the differentiated good); finally, y_i is consumers' nominal income earned through the provision of factors L in region i and K in either one of the two regions, in addition to the profits redistributed from the transport sector.³

Optimizing (1.1) subject to (1.2) with respect to $q_{s,ii}$ leads to the following linear demand function:

$$q_{s,ji} = \frac{\alpha - p_{s,ji} - \gamma Q_i}{\beta},$$

where $Q_i = \int_{s \in N_i} q_{s,i} ds$. This can be rewritten as

$$q_{s,ji} = \frac{\alpha\beta + \gamma N_i \bar{p}_i}{\beta(\beta + \gamma N_i)} - \frac{p_{s,ji}}{\beta}, \quad (1.3)$$

where

$$\bar{p}_i = \frac{\int_{s \in N_i} p_{s,i} ds}{N_i}$$

is a price index capturing the average price of all the varieties of the differentiated good sold in region i .

The linear demand function (1.3) encloses the idea that the demand of a certain variety s in market i falls when its price rises not only in absolute terms (*own price effect*, $p_{s,ji}$) but also with respect to the average price (*differential price effect*, $\bar{p}_i$). However, these effects exhibit a different magnitude, as the own price effect $[-\frac{1}{\beta}]$ is always stronger than each cross price effect (which is negligible by definition) and than the sum of all the cross price effects $[\frac{\gamma N}{\beta(\beta + \gamma N)}]$. In addition, notice that this demand structure allows for variable elasticity of substitution in own and market prices:

$$\epsilon_{s,ji} = \frac{\delta q_{s,ji} p_{s,ji}}{\delta p_{s,ji} q_{s,ji}} = \frac{p_{s,ji}}{\alpha\beta - p_{s,ji}(\beta + \gamma N_i) + \gamma N_i \bar{p}_i}.$$

For this reason, the quadratic utility is sometimes referred to as a Variable-Elasticity-of-Substitution (VES) utility function, to differentiate it from the Constant-Elasticity-of-Substitution (CES) types of preferences, associated with constant markups and no pro-competitive effects on prices.

1.2.2 Firms

Turning to the production side of the economy, only two factors are used in the production processes: a regionally mobile one, capital (K), and an immobile one, labor (L). The perfectly competitive constant-returns-to-scale sector produces the homogeneous good employing only labor. The monopolistically competitive differentiated manufacturing

³Notice that since wages are determined in the numéraire producing sector and profits are redistributed to consumers in the two regions, no differences arise between the two regions in terms of nominal income. The numéraire is assumed here to be freely traded, as common in NEG models, even if this assumption has been shown from Picard and Zeng (2005) to have stronger implications than generally thought. Indeed, the presence of transport costs in the homogeneous goods' market (which is assumed to be an agricultural good in their case) turn out to be a rather important dispersion force.

sector, with single-product firms operating under increasing returns to scale, employs both factors, capital in fixed amounts and labor proportionally to production. In the manufacturing sector, firms' profit can be expressed as follows:

$$\Pi_{s,i} = (p_{s,ii} - c)q_{s,ii}M_i + (p_{s,ij} - c - t)q_{s,ij}M_j - r_if, \quad (1.4)$$

where c is the amount of labor needed to produce one unit of the differentiated good, t is the linear transport cost, taken as exogenous, r is the return on capital invested, and f is the amount of capital needed to set up a firm, which can be interpreted as a fixed entry cost. Plugging (1.3) into (1.4) the profit function can be rewritten as:

$$\begin{aligned} \Pi_{s,i} = & (p_{s,ii} - c) \left[\frac{\alpha\beta - (\beta + \gamma N_i)p_{s,ii} + \gamma N_i \bar{p}_i}{\beta(\beta + \gamma N_i)} \right] M_i + \\ & + (p_{s,ij} - c - t) \left[\frac{\alpha\beta - (\beta + \gamma N_j)p_{s,ij} + \gamma N_j \bar{p}_j}{\beta(\beta + \gamma N_j)} \right] M_j - r_if. \end{aligned} \quad (1.5)$$

Notice that the total number of firms in the economy, $N = N_i + N_j$, is a function of the amount of capital in the economy and the fixed entry cost, $N = K/f$, but it is split between the two regions according to the fraction of capital, λ , allocated to each region, so that:

$$N_i = \frac{\lambda_i K}{f} \quad ; \quad N_j = N - N_i. \quad (1.6)$$

For notational convenience, when there is no subscript λ refers to the core region, i.e. $\lambda = \lambda_H$, and it can be considered a measure of producers' agglomeration.

1.2.3 Market outcomes in the short run

As manufacturing firms compete in a monopolistic competition framework, they are assumed to maximize their profits, as captured by (1.5), through the choice of optimal prices in their destination markets: the domestic and the foreign. Given that regions are not fully integrated (in the sense that $t_{ij} > 0$), two different prices will emerge for the same product in the two markets, whose level of competition is captured by price indices. Firms take price indices as exogenous because they are assumed to be of negligible size. Considering that there is no other source of heterogeneity except geographic location, four segments can be identified in the market, as in each of the two regions there will be one type of firm facing transport costs and the other not. The segments are then HH and HF for the firms located in the core and FF and FH for the firms located in the periphery.

The profit-maximizing prices chosen by the firms in region i are then:

$$p_{s,ii} = \frac{\alpha\beta + \gamma N_i \bar{p}_i}{2(\beta + \gamma N_i)} + \frac{c}{2} \quad ; \quad p_{s,ji} = p_{s,ii} + \frac{t}{2} = \frac{\alpha\beta + \gamma N_i \bar{p}_i}{2(\beta + \gamma N_i)} + \frac{c}{2} + \frac{t}{2}, \quad (1.7)$$

which is the standard outcome of a monopolist facing a linear demand function, the profit-maximizing price being just half of the highest possible price consistent with

positive consumption levels, plus half of any marginal cost associated with production, c and shipment, t , if applicable.

As expected, the differentiated varieties' prices rise as consumers' bias toward the consumption of differentiated goods (α), marginal costs (c) or price indices ($\bar{p}$) increase. Product differentiation as well, as captured by the parameter β (the higher, the more variety in consumption is appreciated) plays an important role, as can be better understood by developing equation (1.7). Indeed, taking into account that

$$\bar{p}_i = P_i/N_i = \int_{s \in N_i} \frac{p_{s,i}}{N_i} ds = \frac{N_{ii}}{N_i} p_{s,ii} + \frac{N_{ji}}{N_i} p_{s,ji} = p_{s,ii} + \frac{N_{ji}}{N_i} \frac{t}{2} = p_{s,ii} + \lambda_j \frac{t}{2} \quad (1.8)$$

and expressing p^* only in terms of structural parameters (taking λ as a parameter too, at least in the short run), it can be seen that:

$$p_{s,ii}^*(t) = \frac{\beta(\alpha + c) + \gamma N_i(c + \lambda_j \frac{t}{2})}{2\beta + \gamma N_i} \quad ; \quad p_{s,ji}^*(t) = p_{s,ii}^* + \frac{t}{2}. \quad (1.9)$$

From (1.9) it can be noticed that as $\beta \rightarrow 0$ (or similarly as $\gamma \rightarrow \infty$) consumers' love for variety disappears and $p_{s,ii}^* \rightarrow c + \frac{\lambda_j}{2}t$ and $p_{s,ji}^* \rightarrow c + \frac{\lambda_j}{2}t + \frac{t}{2}$. This is exactly equal to the marginal cost of production plus a markup component deriving from the acknowledgment that a share λ_j of firms in the market is characterized by higher marginal costs of production and delivery, $c + t$, thus affecting the price index and relaxing price competition. In fact, imported varieties pass-through to their consumers half of the transport costs incurred, $\frac{t}{2}$.

A visual representation is provided in Figure 1.1 to help intuition. In the graph, the operating profits associated with the sales of variety s are represented by the green-shaded area between the profit maximizing prices, $p_{s,ii}^*$ and $p_{s,ji}^*$, and the marginal costs, c and $c + t_{ji}$, up the equilibrium quantities sold, $q_{s,ii}^*$ and $q_{s,ji}^*$.

Similarly, average prices in market i can be expressed in terms of the structural parameters and transport costs:

$$\bar{p}_i = \frac{P_i}{N_i} = \frac{\alpha\beta + (c + \lambda_j t)(\beta + \gamma N_i)}{2\beta + \gamma N_i}, \quad (1.10)$$

which confirms that, as $\beta \rightarrow 0$ (or $\gamma \rightarrow \infty$), then $\bar{p}_i \rightarrow c + \lambda_j t$. This result is explained by the fact that a share λ_i of the varieties found in the region has marginal costs equal to c and a share λ_j of varieties has marginal costs equal to $c + t$. Remembering that that higher transport costs generate a less than proportional increase in final prices, it can safely be claimed that in the short run (i.e., when the spatial distribution of economic activities is considered fixed) *transport costs aggravate the market distortions generated by the existence of increasing returns to scale and love for variety. Consumers are hurt by both the reduction in manufacturing firms' profits and higher prices*, which is a common result in the NEG literature. In particular,

$$p_{s,ii}^*(t) = \bar{p}_i - \frac{t}{2}\lambda_j \quad ; \quad p_{s,ji}^*(t) = \bar{p}_i + (1 - \lambda_j)\frac{t}{2} = \bar{p}_i + \frac{t}{2}\lambda_i,$$

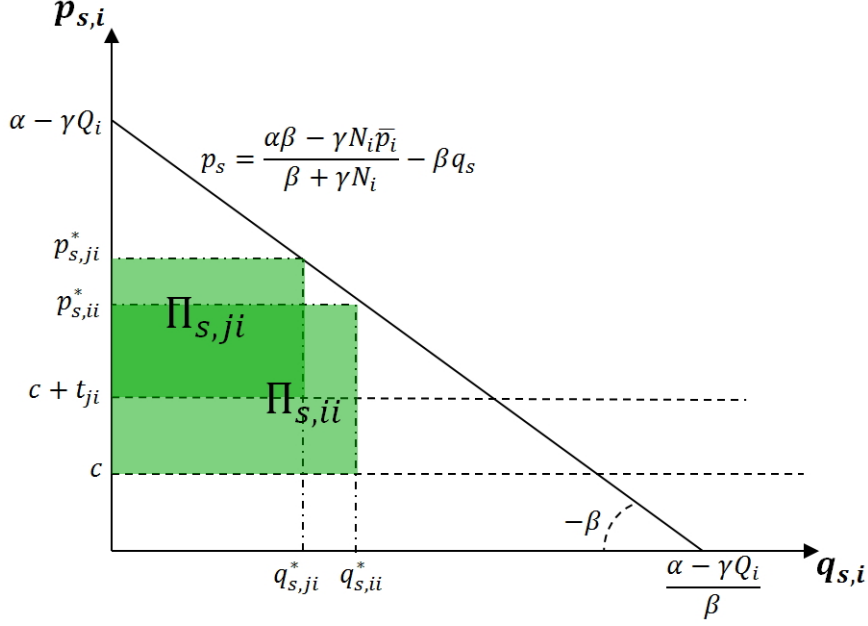


Figure 1.1: Operating profits for Core and Periphery varieties

from which two considerations derive. The first is that price differentials in price between the domestically produced and the imported varieties are directly related to the magnitude of transport costs. The second is that *transport costs affect asymmetrically the optimal pricing of the two varieties*. Since $\lambda_i > \lambda_j$, importers' deviation from the average price in region i (charging a higher price than the average) is higher than domestic firms' (charging a lower price than the average). In addition, from equation (1.7) it can be observed that prices of individual varieties and regional price indices can be seen as strategic complements, as shown in Figure 1.2.

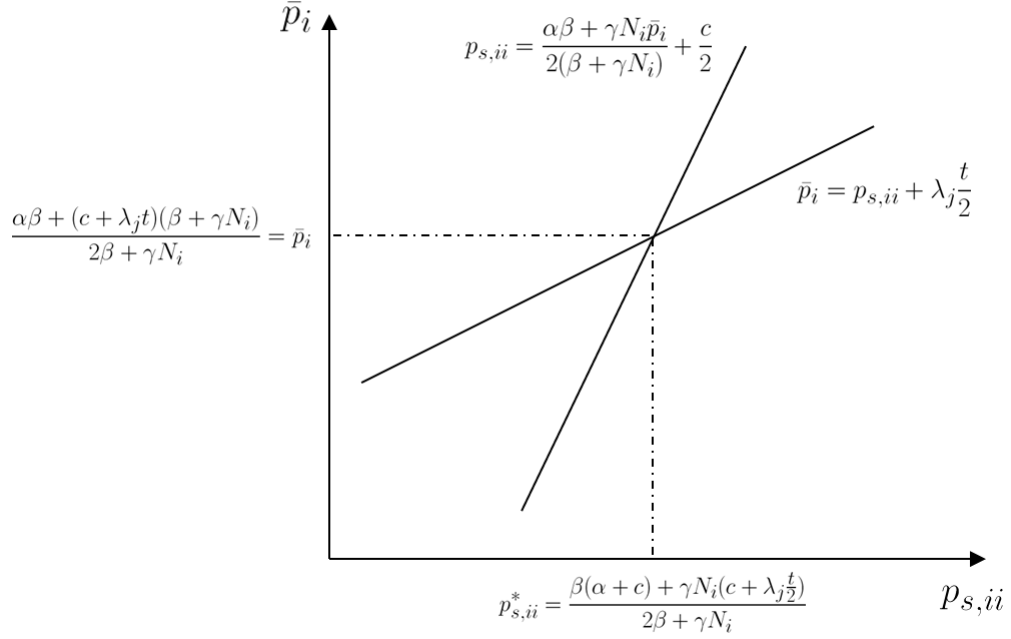
Equilibrium prices, as expressed in (1.9), could also be plugged into the demand function (1.3), so as to obtain the equilibrium quantities only as a function of structural parameters:

$$q_{s,ii}^*(t) = \frac{\beta(\alpha - c) + \gamma N_i \lambda_j \frac{t}{2}}{\beta(2\beta + \gamma N_i)} \quad ; \quad q_{s,ji}^*(t) = q_{s,ii}^*(t) - \frac{t}{2\beta}. \quad (1.11)$$

As expected, the transport cost, t , enters positively in q_{ii}^* and negatively in q_{ji}^* , but again asymmetrically. Indeed,

$$\frac{\partial q_{ii}^*}{\partial t} = \frac{\gamma N_i \lambda_j}{\beta(2\beta + \gamma N_i)} \quad ; \quad \frac{\partial q_{ji}^*}{\partial t} = -\frac{\beta + \gamma N_i \lambda_j}{\beta(2\beta + \gamma N_i)}. \quad (1.12)$$

This means that even if transport costs shift demand towards domestically produced goods at the expense of imported ones, they create less demand on the domestic segment

Figure 1.2: Strategic complementarity between $p_{s,ii}$ and $\bar{p}_i$.

than they destroy on the imported one. This implies that the total amount of consumption in the differentiated sector is reduced and this implies that prices in each region rise for both segments, as shown in equations (1.9) and (1.10).

As for the effects of industrial agglomeration, it can be noted that as long as $\lambda > \frac{1}{2}$, both prices and quantities are always lower in the bigger region than in the smaller one, when t is equal in the two directions. Therefore, tougher competition in the bigger region induced by lower transport costs benefits consumers in H by raising their real wage (because the nominal wage is normalized to unity, but goods' prices are declining). However, the same is not true for the firms located in H . Indeed, in the short run the profits of the firms located in the periphery increase in their export segment while the profits and market share of the domestic firms decrease in the local market.

1.2.4 Consumers' surplus

Based on the assumed preference structure shown in (1.3), the profit-maximizing pricing shown in (1.9) and the corresponding quantities sold in equation (1.11), it is possible to derive an expression to capture consumers' surplus, which is the conventional tool used to assess how the market structure is affecting consumers' welfare. The idea behind the analysis of the consumer surplus is that consumers in the economy would still buy some units of the differentiated good even if prices were higher, given that the marginal utility of consumption decreases in quantities. This means that at the actual equilibrium price, the infra-marginal units consumed are paid less than what the consumer would accept

to paid for them, thus providing more utility than is being paid for.

A visual representation is provided in Figure 1.3 to help intuition. In the graph, Consumer Surplus derived from the consumption of variety s can be thought of as the blue-shaded area standing below the inverse demand function, between the equilibrium prices, $p_{s,ii}^*$ and $p_{s,ji}^*$, and the maximum price associated with a positive consumption of the good.

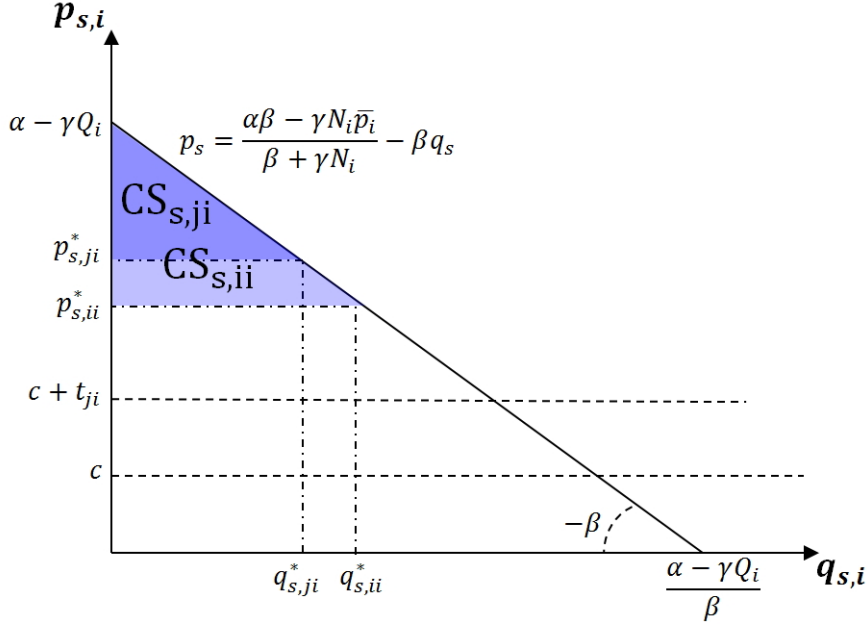


Figure 1.3: Consumers' surplus from Core and Periphery varieties

Analytically, the utility associated with these gains can be quantified through the analysis of the indirect utility function derived from (1.1). It can be expressed in function of prices and income:

$$W_i = \frac{\alpha^2 N_i}{2(\beta + \gamma N_i)} - \frac{\alpha}{\beta + \gamma N_i} \int_{s \in N_i} p_{s,i} ds + \frac{\int_{s \in N_i} p_{s,i}^2 ds}{2\beta} - \frac{\gamma}{2\beta(\beta + \gamma N_i)} \left[\int_{s \in N_i} p_{s,i} ds \right]^2 + y_i + \bar{q}_0, \quad (1.13)$$

where nominal income y_i is the sum of labor income, returns on capital invested and profits redistributed from carriers in the transport sector.

The exact amount of consumer surplus associated with a particular market structure can then be obtained by just plugging the equilibrium prices and income in the equation (1.13), but the main interest lies not on its value per se, but rather on its changes in response to policy or technology changes. It can be noticed in (1.13) that consumers' surplus is always negatively affected by price increases and the effect is stronger the higher are prices:

$$\frac{\partial W_i}{\partial p_{s,i}} = -\frac{\alpha\beta - (\beta + \gamma N_i)p_{s,i} + \gamma N_i \bar{p}_i}{\beta(\beta + \gamma N_i)} = -q_{s,ji} < 0. \quad (1.14)$$

This implies that surplus is expected to be higher in the core region and every change in transport costs (t) or industrial agglomeration (λ) affecting prices maps directly into changes in the surplus of the consumers in the two regions through the price channel, in addition to the impact on nominal income.

1.2.5 Factors' remuneration

As mention earlier in the text, of the two factors of the model labor can be used to produce the two types of good, the homogeneous under constant returns to scale and the differentiated under increasing returns to scale, its supply being perfectly elastic at the wage level corresponding to the value of the homogeneous good (the numéraire). Thus, the resulting wage in nominal terms will be equal in the two sectors of the two regions.

As for capital, it is taken as fixed in the short run but it becomes mobile in the long run. This means that, after a shock in transport costs, remuneration can temporarily differ, but will eventually equalize across the two regions. Its remuneration is directly related to the operating profits generated by firms in the two regions. Indeed, as capital is the scarce resource in this economy, all the operating profits (the difference between revenues and salaries) are absorbed by its remuneration. This can be interpreted as the result of a bidding process in which any new entrant firm, if incumbents are making profits, has room to offer a slightly higher remuneration and so attract all the capital of the economy, thus leading to a fierce competition between firms to the advantage of capital holders. As a consequence, as far as there is free entry of enterprises in the heterogeneous goods' manufacturing market and no heterogeneity across firms, consolidated profits are equal to zero and the remuneration of capital in the two regions equate the operating profits:

$$r_{s,i} = \frac{(p_{s,ii} - c)q_{s,ii}M_i + (p_{s,ij} - c - t)q_{s,ij}M_j}{f},$$

which can be rewritten as:

$$r_{s,i} = \frac{M}{f\beta} [(p_{s,ii} - c)^2\theta_i + (p_{s,ij} - c - t)^2\theta_j].$$

From this expression, it can be understood where the trade-offs concerning capital remuneration stem from. Each variety is in fact extracting profits from two segments, the domestic and the foreign, each having a different number of consumers ($\theta_i M$ and $\theta_j M$), different marginal costs of production and delivery (c and $c + t$) and different local price indices yielding different prices ($p_{s,ii}$ and $p_{s,ij}$). This explains how, even in the absence of any technological difference, subsidy or barrier to trade, the two regions can reach very different levels of industrialization, just on the basis of differences in the consumption levels.

1.3 The long run: industrial agglomeration and regional imbalances

In the long run, capital is free to move between the two regions. Thus, it will flow from one region to the other until capital holders are indifferent between investing in one region or in the other, i.e. when $r_i = r_j$, which can be rewritten as

$$[(p_{s,ii}^* - c)^2 \theta_i + (p_{s,ij}^* - c - t)^2 (1 - \theta_i)] = [(p_{s,jj}^* - c)^2 (1 - \theta_i) + (p_{s,ji}^* - c - t)^2 \theta_i].$$

As long as transport costs t are taken as exogenous, it must be noted that this relation holds only if transport costs are not excessive, i.e. if there is trade between the regions. The maximum value consistent with the existence of international trade in the two directions, which can be called t_{trade}^* , can be computed as the value which ensures q_{ji} in (1.11) or, equivalently, p_{ji} in (1.9) to be positive. In terms of the structural parameters, it is

$$t_{trade} = \frac{\beta(\alpha - c)}{\beta + \frac{\gamma N}{2}}. \quad (1.15)$$

Focusing then on cases in which $t \leq t_{trade}$ and solving the capital equalization equation, it can be seen that following relation holds between the agglomeration of consumption and production:

$$\lambda_i - \frac{1}{2} = \frac{2\beta(\alpha - c - \frac{t}{2})}{\gamma N \frac{t}{2}} \left(\theta_i - \frac{1}{2} \right), \quad (1.16)$$

which implies that $\lambda_i > \theta_i$ as long as there is trade between the two regions ($t < t_{trade}$) and $\theta_i > 1/2$. This means that *the region displaying a higher share of consumption, $\theta_i > 1/2$, will attract more than proportional quantity of capital and thus firms, $\lambda_i > \theta_i$* . This phenomenon is called the Home Market Effect (HME).

Furthermore, it can be noted that $\frac{\partial \lambda_i}{\partial t} < 0$ when $\theta_i > 1/2$, this meaning that lower transport costs, when t is equal in the two directions, always leads to a higher degree of industrial concentration in the regions with the highest level of consumption. A visual representation of this process is provided in Figure 1.4, where is shown, for every θ_i , how the range of possible values of λ_i changes in function of $t \in [\tau; t_{trade}]$, where τ is the cost of supplying the transport service (or alternatively, the lowest possible cost level, which can also be naught and yield corner solutions).

Therefore, the magnitude of the effect is inversely related to the level of transport costs in the two directions, so that *a symmetric bilateral decrease in transport costs is always bound to result in a higher degree of industrial concentration in the region with the highest share of consumption ($\theta_i > 1/2$), and intensify the HME*.

In order to give an idea of the outcome interaction between θ_i and t in the definition of the equilibrium agglomeration of economic activities in the economy, a simulation has been run, where τ has been normalized to unity (which is the prevailing remuneration for labor in the economy) and the other structural parameters have been chosen respecting the restrictions on the domain of certain variable.⁴ The results of the simulation are

⁴For example, β should be bigger than γ for the own substitution effect to be larger than the cross substitution effect.

shown in Figure 1.5, where each line represents a different level of concentration of consumption in the core (H) region, θ_H . It can be observed, for instance, that even a low level of concentration of consumption, $\theta_H = 0,53$, associated with very low transport costs, can lead to an almost total agglomeration of economic activities in the bigger region.

To have a further idea of the extent of the Home Market Effect, it suffices to consider that for $t = t_{trade}$, which is the highest value of t compatible with the existence of trade, the following relation holds:

$$\frac{\lambda_i - \frac{1}{2}}{\theta_i - \frac{1}{2}} = 2 + \frac{2\beta}{\gamma N}.$$

This means that, even if the highest possible transport cost is considered, defining an imbalance as the difference between the actual concentration of production and consumption, λ and θ , and a perfectly even distribution, $\frac{1}{2}$, it can be seen that imbalance in production are more than twice as big as imbalances in consumption. This can be seen as a lower bound for the Home Market Effect when transport costs are exogenous. Higher levels of imbalance depend on structural parameters such as the bias towards the consumption of different varieties, captured by β and γ , and the number of firms in the economy, N , which is a function of the relative importance of the fixed cost of entry.

In order to give an idea of the size of the imbalance magnification effect associated with the changes in transport costs, Table 1.1 shows the level of production concentration associated with the lowest and the highest levels of transport costs used for plotting Figure 1.5. It can be remarked that the ratio between imbalance in production and consumption is constant in the level of consumption concentration θ but varies with the transport costs.

Table 1.1: Quantification of the HME in the simulation: lower and upper bounds

θ	$\lambda(t_{trade})$	$\lambda(\tau)$	$\theta - \frac{1}{2}$	$\lambda(t_{trade}) - \frac{1}{2}$	$\lambda(\tau) - \frac{1}{2}$
0,5	0,5	0,5	0	0	0
0,51	0,521	0,583	0,01	0,021	0,083
0,55	0,604	0,916	0,05	0,104	0,416
0,6	0,709	1,33	0,1	0,209	0,83
0,65	0,813	1,75	0,15	0,313	1,25
0,7	0,917	2,16	0,2	0,417	1,66
0,75	1,02	2,58	0,25	0,52	2,08
			$\frac{\theta-1/2}{\lambda-1/2} :$	2,09	8,31

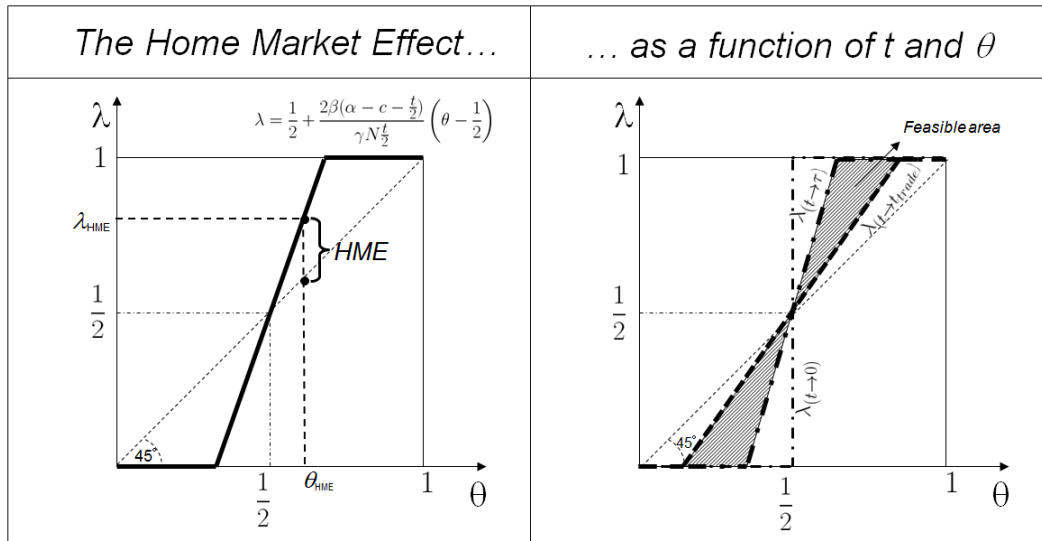


Figure 1.4: The Home Market Effect. On the left pane is represented the intuition behind the agglomeration measure. On the right pane is shown the range of possible values of λ , depending on the values of t and θ .

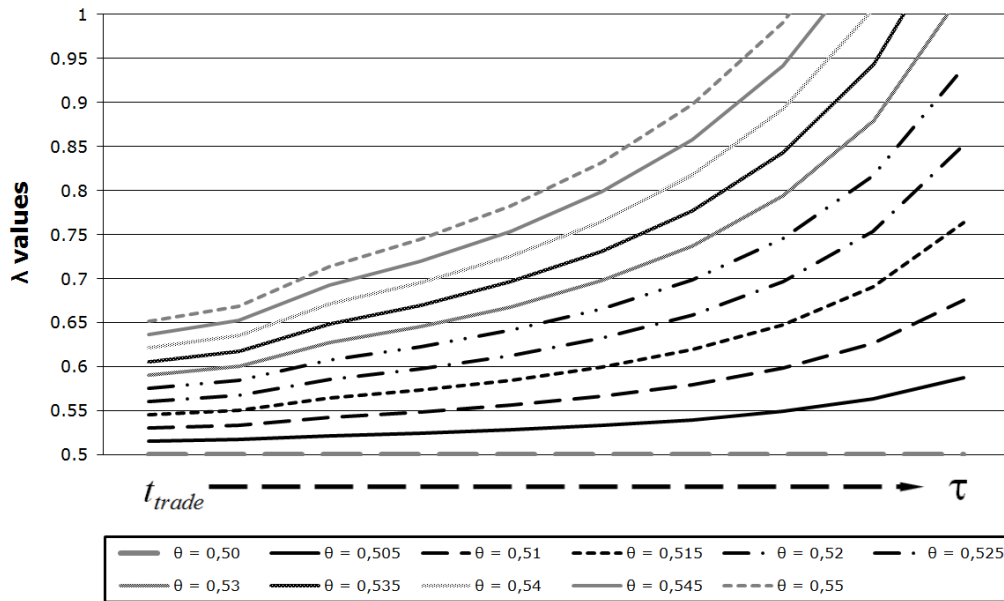


Figure 1.5: Simulation of changes in the agglomeration of industrial activities, λ_H , as a function of transport costs (ranging from t_{trade} to τ) and agglomeration of consumption, θ_H . The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

1.3.1 Industrial concentration and market outcomes

Looking at the price, quantity and profit equations (1.9), (1.11) and (1.5) it can be noted that all the relevant market outcomes are affected by the level of industrial concentration, λ , in the core and in the periphery regions. Before turning to the impact of changes in freight rates on the consumers, it can be useful to analyze the relationship between industrial concentration, λ , and equilibrium prices and quantities, holding the freight rate fixed, as could result for example from an exogenous shock in the relative concentration of consumption, θ . Notice that, In order to simplify notation, the industrial concentration parameter λ refers to the largest region when written without subscripts and can be interpreted as an index of concentration for the entire economy given that only two regions are considered in this analysis.

First of all, from (1.9) it can be seen that prices in the four segments would react as follows:

$$\frac{\partial p_{HH}}{\partial \lambda} = \frac{\partial p_{FH}}{\partial \lambda} < 0 < \frac{\partial p_{FF}}{\partial \lambda} = \frac{\partial p_{HF}}{\partial \lambda} \quad ; \quad \left| \frac{\partial p_{HH}}{\partial \lambda} \right| = \left| \frac{\partial p_{FH}}{\partial \lambda} \right| = \left| \frac{\partial p_{FF}}{\partial \lambda} \right| = \left| \frac{\partial p_{HF}}{\partial \lambda} \right|.$$

The price indices would change accordingly, as can be seen from (1.8):

$$\frac{\partial P_H}{\partial \lambda} < 0 < \frac{\partial P_F}{\partial \lambda} \quad ; \quad \left| \frac{\partial P_H}{\partial \lambda} \right| = \left| \frac{\partial P_F}{\partial \lambda} \right|.$$

A rising level of concentration of firms in the bigger region is then expected to have opposite and symmetric effects on the consumers' surplus of the two regions. Indeed, in the region hosting more firms tougher competition pushes prices down for both local and imported varieties. The opposite happens in the less industrialized region. Since the total number of firms in the two regions is determined exogenously by the fixed costs of entry, the channel through which competition toughens in the bigger region is the reduction in the number of imported varieties. A lower number of varieties is indeed internalizing the transport costs in their final price, and thus domestic firms need to charge a lower price to remain attractive for their consumers. In the smaller region, exactly the opposite happens: as more goods are imported, the price index rises and firms accurately charge higher prices to maximize their profits.

Similarly the effects of a change in the distribution of economic activities (λ) on quantities sold of each variety can be analyzed from (1.11):

$$\frac{\partial q_{HH}}{\partial \lambda} = \frac{\partial q_{FH}}{\partial \lambda} < 0 < \frac{\partial q_{FF}}{\partial \lambda} = \frac{\partial q_{HF}}{\partial \lambda} \quad ; \quad \left| \frac{\partial q_{HH}}{\partial \lambda} \right| = \left| \frac{\partial q_{FH}}{\partial \lambda} \right| = \left| \frac{\partial q_{FF}}{\partial \lambda} \right| = \left| \frac{\partial q_{HF}}{\partial \lambda} \right|.$$

Therefore, while changes in the freight rate, t , have been shown in (1.12) to be distortionary and globally welfare reducing (since as they rise, the rises in quantities of domestic varieties are more the counterbalanced by falls in quantities of imported varieties), any change in the distribution of economic activities is just transferring exactly the same amounts of quantities and price margins from one segment to another, as can be easily seen through this new formulation of (1.9), (1.8) and (1.11). This means that,

while reducing transport costs can have positive effects from a global welfare point of view, the extent of spatial distribution is affecting only the relative prosperity of the regions, but not their overall welfare. Thus, as economic imbalance grows between regions, no beneficial effect for the whole economy can compensate for the potentially negative effects of rising inequality in the distribution of economic activities.

It can also be noticed that quantities move in the same direction as prices, which may be surprising at first sight, but it is not once it is realized that the parameter λ affects directly the regional price index.

A visual representation of the results for the four segments is provided in Figure 1.6, where the top arrows indicate the number of varieties produced in each segment, the second ones indicate the quantities sold in each segment and the bottom ones refer to the prices.

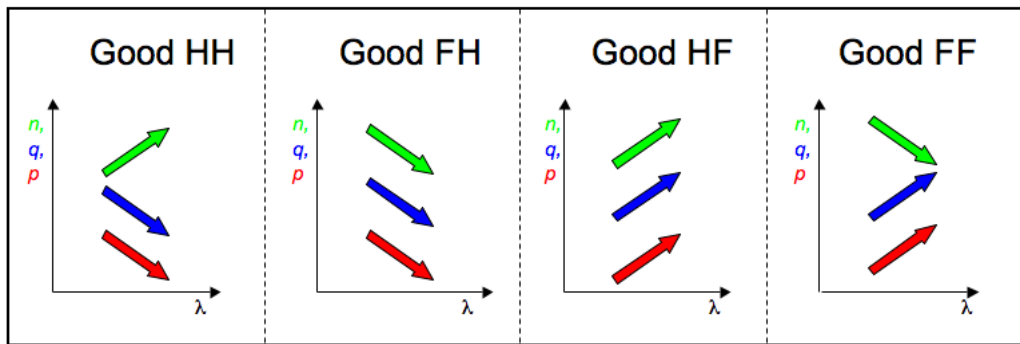


Figure 1.6: Core and Periphery effects of marginal changes in λ on market outcomes.

After the introduction on the market of less expensive varieties, whose demand is the same as it was when they were imported but whose price is now free from the burden of transport costs, even the reduction in selling price is not able to help domestic firms keep their production levels as before in the bigger region. Firms exporting in the bigger region then just follow, as their selling volumes are shown in (1.11) to be systematically lower.

Summing up, from a firm's perspective, after an exogenous increase in the concentration of economic activities, λ , prices and quantities of the increased number of varieties produced in the core region fall in the domestic market and rise in the periphery. The same happens to the fewer firms left in the peripheral region: prices and quantities fall in the core and rise in the domestic market.

It could be interesting to note, at this point, that while the number of varieties and the quantity per variety produced in F and sold in H decrease, the number of varieties and the quantity per variety produced in H and sold in F rise. But what will then be the overall effect on international trade? The answer is not *a priori* clear, as it depends on transport costs and structural parameters in a complex way. The two components of total trade flows (the flow from H to F and the flow from F to H) can be shown to behave asymmetrically and move in opposite directions, i.e. Q_{FH} monotonically decreases in

λ whereas Q_{HF} increases. Indeed, the total volume of inter-regional trade in the two directions is determined by three elements: the number of people living in the importing region, M_i , the individual consumption of each imported variety $q_{s,ji}$ and the number of exported varieties (which coincides with the number of firms in the exporting region), N_j . Formally, it is $Q_{ij} = \lambda_i N_{ij} \theta_j M_j q_{ij}$ which, plugging (1.11), can be written in terms of specific regional flows as

$$Q_{HF} = \lambda N(1 - \theta) M q_{HF} = \frac{\lambda N(1 - \theta) M}{\beta(2\beta + \gamma N)} \left[(\alpha - c)\beta - \frac{t}{2}(2\beta + \gamma(1 - \lambda)N) \right]$$

and

$$Q_{FH}(t_{FH}) = (1 - \lambda) N \theta M q_{FH} = \frac{(1 - \lambda) N \theta M}{\beta(2\beta + \gamma N)} \left[(\alpha - c)\beta - \frac{t}{2}(2\beta + \gamma \lambda N) \right].$$

Therefore,

$$\frac{\partial Q_{HF}}{\partial \lambda} \geq 0 \quad \text{and} \quad \frac{\partial Q_{FH}}{\partial \lambda} < 0 \quad \forall \text{ feasible } t \text{ (i.e. } t < t_{trade} \text{ as defined in equation (1.15))}.$$

This means that an increase in industrial agglomeration increases the shipments from the core to the peripheral region and decreases them from the periphery towards the core. The overall effect can be seen by combining the trade flows in the two directions, $Q(t) = Q_{HF}(t) + Q_{FH}(t)$, which can be written explicitly as

$$Q(t) = NM \frac{(\alpha - c)\beta(\theta_H \lambda_F + \theta_F \lambda_H) - t \left[\lambda_H \lambda_F \gamma \frac{N}{2}(\theta_H + \theta_F) + \beta(\theta_H \lambda_F + \theta_F \lambda_H) \right]}{\beta(2\beta + \gamma N)}. \quad (1.17)$$

It is worth noting that the effect is always positive, for every feasible level of inter-regional transport costs. Formally

$$\frac{\partial Q(t)}{\partial \lambda} > 0 \quad \forall t < t_{trade}.$$

1.4 Introducing the transport sector in the economy

Up to now, the transport cost t in the model has been treated as an exogenous parameter, shaping market outcomes in the differentiated good sector and the location choice of firms. From now on, a transport sector is introduced in the economy, turning the exogenously given transport costs into endogenously determined freight rates, similarly to Behrens et al. (2009) and Behrens and Picard (2011). This analysis then feeds into the next Section, whose focus is on how freight rates affect market outcomes and shape the economic geography of the regions. Two different regulatory regimes for the transport sector are considered, each one corresponding to a different type of liberalization:

- First, the case is considered of a transport sector in which carriers are allowed only to charge the same price per route or, equivalently, to set the tariff based only on distance and not on the direction of the shipment. This is referred to as the **unique-bilateral-tariff liberalization**, or just symmetric freight rates;

- Second, the case is considered of a transport in which carriers are left free to set their prices freely and possibly segment their market based on the direction of the shipment (which is the only source of heterogeneity among their clients). This is referred to as **complete deregulation**, or full liberalization.

The central difference between the two regimes is, thus, the possibility of segmenting the transport market into HF and FH sub-markets, shipping different amounts of goods for different rates.

Regulators are also allowed to determine the intensity of competition in the transport sector by choosing the number of carriers in the market. It is important to notice that differences between the two regulatory regimes hold as long as the number of carriers is small. When the number of competitors increases in the transport sector and competition intensifies, prices converge to the marginal costs of production in the two regimes.

1.4.1 Market structure in the transport sector

Before showing how the transport sector is actually modeled, it will be useful to spend a few words on the nature of the transport service to justify the modeling strategy. First of all, it should be decided whether the transport service is to be considered within the perfect or the imperfect competition framework. As a matter of fact, it can be claimed that there are several dimensions over which firms operating in the transport sector (from now on, carriers) can differentiate their service, both vertically (speed, punctuality, traceability and so on) or horizontally (specializing in particular sector of the economy or geographical areas). Yet, none of this would be conceivable in an economy characterized by identical consumers and identical firms producing a continuum of horizontally differentiated varieties of the same good in four segments, whose only distinctive features are the regions of production and sale.

Following this consideration, the transport sector is modeled in a more classical way, treating the transport service as homogeneous. This said, if also free entry and no fixed costs were assumed, prices would be pushed to marginal costs and the contribution of the transport sector to the dynamics of the model would be null. The most straightforward way to model the transport sector is then to turn to a standard oligopoly, in which a fixed number of firms, K , compete in quantities or, equivalently, compete in prices after having committed to a certain capacity (Vives, 1999). This would be a reasonable assumption, as transport capacity and service infrastructures have to be prepared before the delivery can effectively take place. This market structure is also convenient in terms of analytical tractability, as the only decision available to regulators to shape the market outcomes is to decide the numbers of competitors to allow in the transport sector.⁵

It should be noted that also Behrens and Picard (2011) model the transport service as homogeneous and produced under constant returns to scale, but they model the market

⁵For simplicity, without loss of generality, the number of firms in the transport sector is chosen by the regulator. In alternative, the amount of fixed entry costs could be decided by the regulator and indirectly determine the number of carriers associated with a sufficient level of profits to cover the fixed costs.

interactions as perfectly competitive with freight rates equal to the costs of a round-trip. In contrast, the oligopolistic structure suggested here allows firms to retain some market power and charge a markup which can be used to repay the fixed costs of entry into the transport sector if the regulator sets the number of competitors by issuing licenses (or simply redistributed to consumers if no fixed cost is involved and the number of carriers is chosen exogenously). The advantage of the approach followed here is that, while it can also generate a perfectly competitive framework by setting the number of competitors arbitrarily high, it still leaves one degree of freedom to regulators (the number of competitors to allow in the market or equivalently the fixed entry costs) to compare different policy options. In other words, in addition to comparing symmetric and asymmetric pricing, it can also be shown how the level of competition in the transport sector interacts with the transport liberalization regime adopted.

The other difference with respect to Behrens and Picard (2011) concerns the constraint on carriers' capacity, which is not assumed here to be the same in the two directions of shipment, thus relaxing the back-haul problem. Even though the cargo space may be the same in the two directions, indeed, additional fixed costs have to be incurred to ship the goods from and to a specific destination (as for example the personnel devoted to deal with import procedures, or the stocking facilities, or any kind of regulatory asymmetries in the exporting and importing region). As for the marginal costs associated with the shipment, it may be argued that the route-specific part (such as fuel consumption), when considered per unit of good transported, may be much less relevant than direction-specific marginal costs such as insurance, so that the cost of returning half-empty or not completely full in the return trip can be assumed negligible.⁶ These assumptions imply that capacity in this Chapter is treated as direction-specific, and the finite number of carriers allowed in the market are allowed to use it as a commitment device to compete in a standard oligopolistic outcome à la Cournot (1838) on each direction of shipment as discussed by Vives (1999). This set of assumptions on direction-specific capacity and a finite number of carriers allows the model to be consistent with the observation reported by Behrens and Picard (2011) "that about 60% of the containers shipped from Asia to North America in 2005 came back empty, and those that did come back full were often transported at a steep discount for lack of demand," because it can indeed yield different volumes of trade in the two directions of shipment and different prices.

1.4.2 Endogenization of the transport costs under a unique tariff

Assuming that all the carriers have the same marginal costs of shipment, after having committed to a given direction-specific capacity, the operating profit function determining the k^{th} carrier's behavior resulting from the market structure adopted for the

⁶Of course, the importance in terms of price of route-specific costs such as unused cargo capacity or fuel depends on the goods shipped. As noted by Hummels (2007), shipping the same volumes of coal or computer microchips would result in a different relative importance of insurance over other types of costs. Hence, depending on the types of goods that are shipped over a given route, different sets of assumptions may be more appropriate. The set of assumptions used in this paper would be more consistent with the shipment of goods with high value added per unit of weight.

transport sector can be written as

$$\Pi_k = (t - \tau)q_k, \quad (1.18)$$

where t is the freight rate, τ is the marginal cost of transport and q_k represents the quantity of goods delivered by each carrier, $q_{k,ij} = Q_{ij}/k$. Notice that the expression capturing the total amount of international trade, as computed in equation (1.17), can now be seen as the demand function associated with the transport sector. It is well behaved in the sense that it linearly decreases in the parameter of interest, the freight rate t , so that the carriers' problem is well defined and yields an interior solution: as the price of the transport service rises, the imported goods become more expensive and the inter-regional trade flows decline. More formally, it can be shown that the elasticity of international trade to transport costs is negative and decreasing in t :⁷

$$\begin{aligned} \epsilon_{Qt} &= -\frac{\partial Q}{Q} \cdot \frac{t}{\partial t} \equiv -\frac{\partial Q}{\partial t} \cdot \frac{t}{Q} \\ \Rightarrow \epsilon_{Qt} &= \frac{t[\theta_i \lambda_j (2\beta + \gamma N \lambda_i) + \theta_j \lambda_i (2\beta + \gamma N \lambda_j)]}{2(\alpha - c)\beta(\theta_i \lambda_j + \theta_j \lambda_i) - t[\theta_i \lambda_j (2\beta + \gamma N \lambda_i) + \theta_j \lambda_i (2\beta + \gamma N \lambda_j)]}, \end{aligned}$$

where $\epsilon_{Qt} \in [0; +\infty] \forall t \in [0; t_{trade}]$. A visual representation of the carrier's problem is provided in Figure 1.7, where it can be observed that the problem of the carriers closely resembles the problem of suppliers of an intermediate input in the context of a double marginalization setting (Tirole, 1988).

In order to solve analytically the carrier's problem, it is convenient to express the freight rate, t , in terms of the inter-regional flow of goods, given by (1.17), and then maximize profit function (1.18) with respect to total quantities shipped. The inverse demand for inter-regional transport is then

$$t(Q) = \frac{(\alpha - c)\beta(\theta_i \lambda_j + \theta_j \lambda_i) - Q^{\frac{\beta(2\beta + \gamma N)}{NM}}}{\lambda_i \lambda_j \gamma^{\frac{N}{2}}(\theta_i + \theta_j) + \beta(\theta_i \lambda_j + \theta_j \lambda_i)}$$

and the resulting optimization problem of each carrier results in the pricing function

$$t^* = \frac{k}{k+1}\tau + \frac{2(\alpha - c)\beta}{(k+1)} \left[\frac{\theta_i \lambda_j}{(\theta_i \lambda_j + \theta_j \lambda_i)}(2\beta + \gamma N \lambda_i) + \frac{\theta_j \lambda_i}{(\theta_i \lambda_j + \theta_j \lambda_i)}(2\beta + \gamma N \lambda_j) \right]^{-1}. \quad (1.19)$$

This expression has the advantage of being fairly flexible in terms of market outcomes. In fact, ranging from $k = 1$ to $k \rightarrow \infty$, all the possible market structures involving homogeneous goods are met. This latter case, indeed, corresponds to a perfect competition

⁷The analysis of the elasticity is rather convenient too in the study of monopolies and oligopolies. Indeed, the multiplicative inverse of the price elasticity equals exactly the relative mark-up which a pure monopolist will charge in the market. This result is easily generalizable to oligopolists by simply dividing this value by the number of competitors. For example, in the case here analyzed, it would hold the following relationship:

$$\frac{t^* - \tau}{t} = \frac{1}{k} \cdot \frac{1}{\epsilon_{Qt}}$$

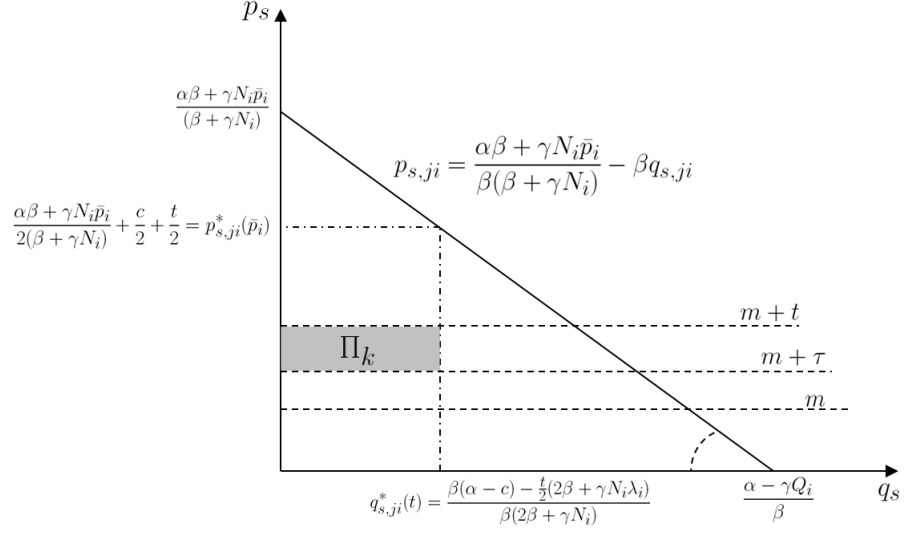


Figure 1.7: Visual illustration of how final good's demand structure affects the carriers' problem.

framework where $t^* \rightarrow \tau$, the marginal cost of production and profits are null. The opposite is true for the former case, where $k = 1$ and the monopolist can take advantage of its market power and extract the maximum possible level of profits, charging the typical price a monopolist charges when facing a linear demand function: half of the maximum price compatible with positive amount of service sold, plus half of any marginal cost of production on which it incurs.

As the system gets further away from a monopoly, prices fall: in other words, t^* declines as the number of competitors, k , increases. Regulators can thus indirectly determine the resulting price in the transport sector by just setting the number of competitors.

Notice, however, that also λ is endogenous in the model and an explicit long-run characterization of t^* in terms of structural parameters alone would require also λ to be written explicitly, as in (1.16). Given the analytical complexity of the resulting equations, whose behavior cannot be studied through the computation of simple derivatives, the long-run outcomes are analyzed using simulation throughout the Chapter. In Figure 1.8 are shown the equilibrium freight rates on the two directions in the long run.

1.4.3 Endogenization of the transport costs under segmentation

In a completely deregulated regime, profit maximizing carriers are expected to segment their markets because all the conditions for segmenting are satisfied: their revenues will be higher, consumer screening is costless and arbitrage between consumers (firms involved in inter-regional trade, in this case) is not profitable.

The first condition can be inferred by the analysis of the elasticities of trade flow to the freight rate in the two segments. Since the elasticity in the segment from F to H

can be shown to be higher than the one from H to F , applying the same price to both segments would imply too high prices in the former segment and too low price in the latter, which would not be profit-maximizing in the short run.⁸

The second condition holds because the key characteristic for segmentation is impossible to hide, since the very purchase of the transport service in one region rather than the other gives information about the segment which is being served.⁹

Finally arbitrage can be excluded, as the third condition states, because it is never profitable to carry it out as can be argued from the following relationship, based on equations (1.9) defining equilibrium prices:

$$p_{FF}^* - p_{HH}^* = \frac{t}{2} \cdot \frac{\gamma N(\lambda_H - \lambda_F)}{(2\beta + \gamma N)} < t.$$

This means that no third agent could make profits out of buying a good in one region and reselling it in the other one, as long as some transport service has to be purchased.

Redefining economic variables under market segmentation

Once segmentation in the transport market is allowed, the relationships between economic variables have to be rewritten to take into account of the potentially different transport costs in the two directions of shipment. Here follows the description of the economy under a segmented transport sector.

Consumer demand

The formal representation of consumers' utility function is essentially unaffected and so is the resulting demand function. The only difference with respect to the demand function (1.3) is that the prices entering the demand function are now different, as they depend on the segmented freight rates t_{ji} and no more on a unique t , as previously assumed:

$$q_{s,ji}(t_{ji}) = \frac{\alpha - \gamma Q_i(t_{ji})}{\beta} - \frac{p_{s,ji}(t_{ji})}{\beta} = \frac{\alpha\beta + \gamma N \bar{p}_i(t_{ji})}{\beta(\beta + \gamma N)} - \frac{p_{s,ji}(t_{ji})}{\beta}.$$

Firms

In order to reflect the fact that exporters of the two regions are now facing different transport costs, profit functions have to be slightly adjusted to account for the fact that

⁸An interesting result is that in the long run, after firms relocate due to the carriers pricing strategy, the profits of the carriers turn out to be lower when they segment the transport markets as compared to imposing a symmetric tariff, but it would probably not be reasonable to expect that each carrier takes into account the aggregate relocation patterns of manufacturing firms when setting its freight rate on an individual shipment.

⁹It can also be noted that the assumption of identical firms (or, at least, technologies of production) rules out the possibility of alternative, cheaper ways of getting from one region to the other: if even one firm were able to deliver its products to the other region in a cheaper way, indeed, all the other firms would be also able to, leaving no room for the existence of a specific transport sector.

t has now an origin and a destination, so it is t_{ij} :

$$\Pi_{s,i} = (p_{s,ii} - c)q_{s,ii}M_i + (p_{s,ij} - c - t_{ij})q_{s,ij}M_j - r_i f \quad (1.20)$$

Also profit-maximizing prices have to be adapted:

$$p_{s,ii}(t_{ji}) = \frac{\alpha\beta + c(\beta + \gamma N) + \gamma N \lambda_j \frac{t_{ji}}{2}}{2\beta + \gamma N} \quad ; \quad p_{s,ji}(t_{ji}) = p_{s,ii} + \frac{t_{ji}}{2} \quad (1.21)$$

Thus, the price index can be recomputed as follows:

$$\bar{p}_i(t_{ji}) = \frac{P_i(t_{ji})}{N} = \frac{\alpha\beta + (c + \lambda_j t_{ji})(\beta + \gamma N)}{2\beta + \gamma N} \quad (1.22)$$

An important aspect illustrated by this formulation of the price indices is that, as long as t is fixed in the two directions, the price index in H is always lower than in F because $\lambda_H > \lambda_F$, but this may not necessarily be the case when carriers segment the transport market due to the additional impact of t_{ji} . Finally, given these prices and price indices, the equilibrium quantities sold in the two markets become:

$$q_{s,ii}(t_{ji}) = \frac{(\alpha - c)\beta + \gamma N \lambda_j \frac{t_{ji}}{2}}{\beta(2\beta + \gamma N)} \quad ; \quad q_{s,ji}(t_{ji}) = q_{s,ii}(t_{ji}) - \frac{t_{ji}}{2\beta} \quad (1.23)$$

The segmented transport sector

The study of the transport sector's dynamics will proceed as before. Carriers' profits maximizing behavior is reflected in the same way as in (1.18), with the only difference that now the inter-regional flows in the two directions are considered and used as the demand function for the segmented transport services, i.e. $Q_{ij}(t_{ij})$ in each direction. The sum of these two regional components determines the aggregate inter-regional trade flow:

$$Q = Q_{HF}(t_{HF}) + Q_{FH}(t_{FH}),$$

where, for each region, exports to the other can be expressed as

$$Q_{ij}(t_{ij}) = \lambda_i N \theta_j M q_{ij} = \frac{\lambda_i N \theta_j M}{\beta(2\beta + \gamma N)} \left[(\alpha - c)\beta - \frac{t_{ij}}{2}(2\beta + \gamma \lambda_j N) \right] \quad (1.24)$$

This means that the transport services offered in the two segments are now traded in different markets, each one characterized by a specific elasticity of inter-regional trade flows to transport cost:

$$\epsilon_{Q_{ij}t_{ij}} = t_{ij} \frac{(2\beta + \gamma \lambda_j N)}{2(\alpha - c)\beta - t_{ij}(2\beta + \gamma \lambda_j N)} \quad (1.25)$$

which are both increasing in the freight rate and in λ , but since $\lambda_i = 1 - \lambda_j$ the trade elasticity in the two regions move in opposite directions as industrial concentration increases. Indeed it can be verified that

$$\frac{\partial \epsilon_{Q_{ij}t_{ij}}}{\partial \lambda_i} > 0 \quad ; \quad \frac{\partial \epsilon_{Q_{ij}t_{ij}}}{\partial \lambda_j} < 0.$$

From (1.24) it is then possible to derive the two inverse demand function in the regions:

$$t_{ij} = \frac{1}{2\beta + \gamma\lambda_j N} \left[2(\alpha - c)\beta - \frac{\beta(2\beta + \gamma N)}{\lambda_i N \theta_j M} Q_{ij} \right]$$

Then, plugging them into equation (1.18) and optimizing with respect to quantities, the prevailing freight rates on the two segments become

$$t_{ij} = \frac{k}{k+1} \tau + \frac{2(\alpha - c)\beta}{(k+1)(2\beta + \gamma\lambda_j N)} \quad (1.26)$$

These two freight rates in the segmented markets can be compared with the equation in (1.19), which describes the freight rate carriers would choose for the transport service if not allowed to price discriminate. It can be noticed that their second term displays the same numerator, but the denominator, which is the part in square brackets in (1.19), is the weighted average sum of the value of the denominator in (1.26) in the two directions of shipment. Given the higher elasticity of demand in the core region because of the price pressure imposed by the presence of a higher number of varieties in the market not being subject to transport costs, transport from the smaller to the bigger region will be cheaper than under the unique tariff, but transport from the bigger to the smaller would be more expensive in the short run:

$$t_{FH} < t < t_{HF}. \quad (1.27)$$

Indeed, since the unique-bilateral-tariff pricing equation shown in (1.19) turns out to be a weighted average of the two segmented tariffs (1.26), moving from a regulated tariff system, implying a unique freight rate in both directions, to a deregulated one, leading to segmentation, is likely to affect in a complex way all the agents of the economy: *inter-regional delivery would be cheaper from F to H, but more expensive from H to F and this affects local consumers and firms in opposite ways, limiting the agglomeration in the core region.* The simulation of equilibrium freight rates in the two directions in the long run is shown in Figure 1.9.

As noticed earlier, indeed, t_{ij}^* also depends on λ , so the fact that agglomeration is limited by segmentation in the transport sector (due to different elasticities of export demand) implies also that in terms of structural parameters, in the long run, the relation in (1.26) may not hold. In fact, if it is true also in the long run that $t_{FH} < t_{HF}$, the different levels of λ associated with different liberalization regimes, for a given level of competition in the transport sector (as approximated by the number of carriers), imply that it is possible that $t_{FH} < t_{HF} < t$ if the agglomeration patterns induced by the symmetric tariffs are much stronger than those induced by asymmetric tariffs. This is shown in Figure 1.10, where equilibrium freight rates in the long run are simulated for a monopolist carrier ($k = 1$) and for an oligopoly of ten carriers ($k = 10$).

Further simulations are shown in the next Section to study the impact on welfare and spatial agglomeration patterns of transport regime's changes.

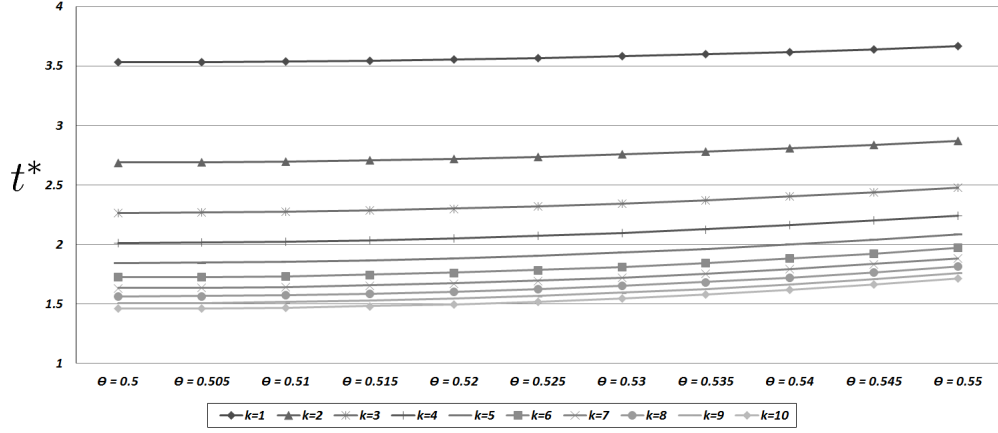


Figure 1.8: Simulation of equilibrium freight rates in the long run as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are symmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

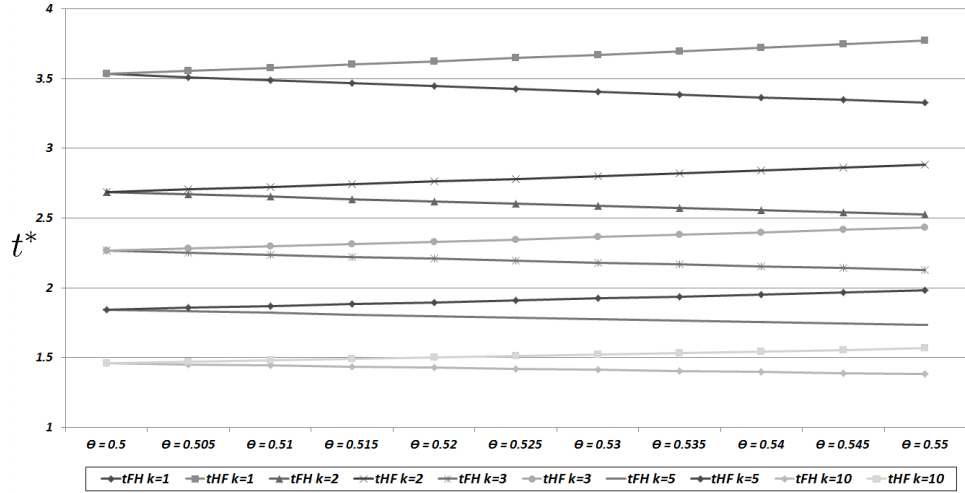


Figure 1.9: Simulation of equilibrium freight rates in the long run as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are asymmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

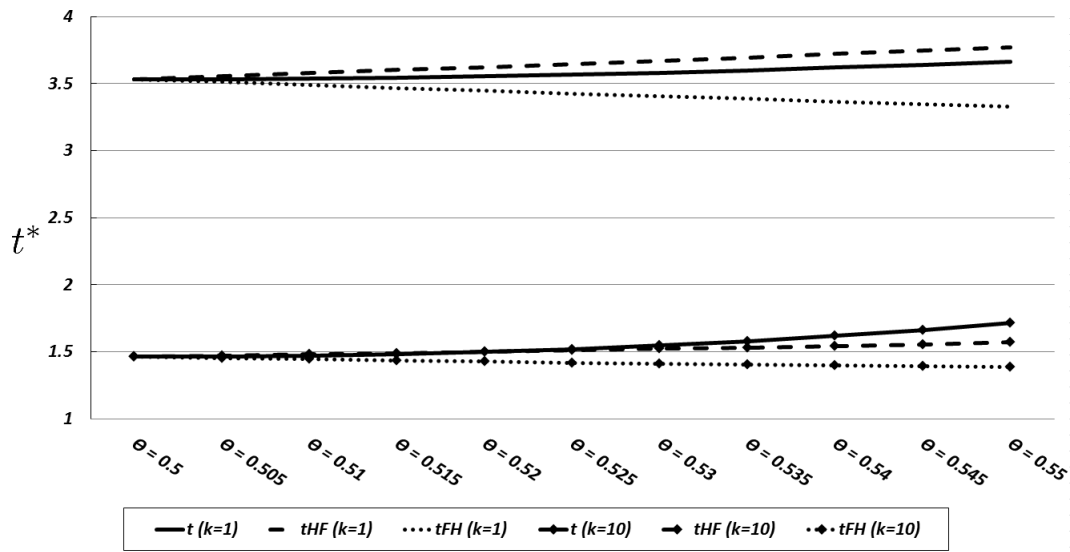


Figure 1.10: Equilibrium freight rates in the long run, as a function of agglomeration of consumption, θ and the number of carriers ($k = 1$ and $k = 10$). The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

1.5 Comparing regulatory regimes

In this section, the two kinds of liberalization are considered. The starting point is an economy with high, symmetric transport costs before regulatory intervention. Two policy options are then available to public authorities willing to reduce freight rates by liberalizing the transport sector:

- A regulated **unique-bilateral-tariff liberalization**, imposing carriers to charge the same price per route or, equivalently, to set the tariff based only on distance and not on the direction of the shipment;
- A **complete deregulation**, allowing carriers to set their prices freely and possibly segment their market based on the direction of the shipment (which is the only source of heterogeneity among their clients).

Trade liberalization regimes are compared in a sequential way. First, the transition from an expensive and heavily regulated framework to a unique-bilateral-tariff liberalization is considered, as captured by an increase in the number of carriers. Then, the additional effect of allowing carriers to price discriminate by the direction of shipment is explored. The two regimes yield different results as long as the number of carriers is finite, but converge to the same outcomes (pricing to marginal costs) as the number of carriers increase.

1.5.1 Transport liberalization under symmetric tariffs

The focus of the welfare analysis is on the effects of transport liberalization on prices, quantities and industrial agglomeration in the heterogeneous good sector. A visual overview of the relation between transport costs and the most relevant market outcomes in the four segments is provided in Figure 1.11, for ease of comparison with Figure 1.6.

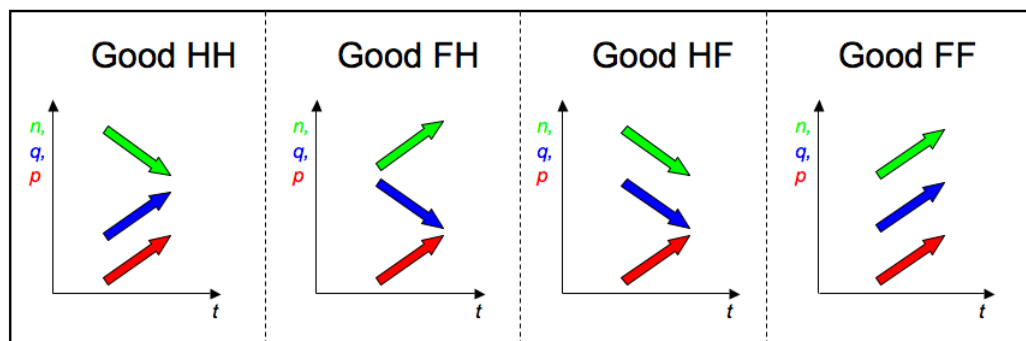


Figure 1.11: Core and Periphery effects of marginal changes in t

Prices and quantities

As for prices, equation (1.9) implies that that prices of the heterogeneous goods decrease together with transport costs in the short run, but with different intensities in the different segments. Looking at the first derivatives of (1.9) (or, equivalently, (1.21)) with respect to t , it suffices to remind that $\lambda_H > \lambda_F$ to see that

$$\frac{\partial p_{HF}}{\partial t} > \frac{\partial p_{FH}}{\partial t} > \frac{\partial p_{FF}}{\partial t} > \frac{\partial p_{HH}}{\partial t} > 0.$$

A reduction in transport costs thus affects all manufacturing firms in the economy, but while in the domestic segment firms located in the peripheral region (F) are more affected than those in the core region (H), the opposite is true in the export segments. From a consumers' standpoint this means also that prices in F will decrease more than prices in H : this is a consequence of the higher share of imported varieties in the smaller market. Indeed, it can also be checked from (1.22) that

$$\frac{\partial \bar{p}_F}{\partial t} > \frac{\partial \bar{p}_H}{\partial t},$$

which implies higher consumer surplus gains in the periphery than in the core in the short run, with the overall impact in the long run depending on the extent of agglomeration after the liberalization.

As for the quantities, (1.12) ensures that in the short run

$$\frac{\partial q_{HH}}{\partial t} > 0 \quad ; \quad \frac{\partial q_{FH}}{\partial t} < 0$$

and

$$\frac{\partial q_{FF}}{\partial t} > 0 \quad ; \quad \frac{\partial q_{HF}}{\partial t} < 0.$$

Note that, interestingly, movements in opposite directions have been found also as a consequence of changes λ . However there is an important difference between the effects of variations in the parameters t and λ : the latter, in fact, implies a zero-sum transfer of quantities sold, i.e. a perfectly balanced and symmetric variation. However, this is not the case for transport costs, whose variation yields

$$\left| \frac{\partial q_{ii}}{\partial t} \right| < \left| \frac{\partial q_{ji}}{\partial t} \right|. \quad (1.28)$$

This relationship shows why transport costs can be considered intrinsically distortionary and why their reduction is unambiguously found to be welfare improving in the short run.

Agglomeration and Manufacturing firms' Operating Profits

As for the agglomeration of economic activities, it can be seen from equation (1.16) that a reduction in transport costs implies a magnification of the disparities in the long run,

$$\frac{\partial \lambda_H}{\partial t} < 0,$$

This reallocation of resources is triggered by a disproportionate impact of changes in t on the firms based in the smaller region. It may appear counterintuitive, as firms in the peripheral region have to incur lower transport costs to serve customers in the other region. However, this effect has to be traded off against tougher competition coming from the firms located in the core region, which now have easier access to the peripheral markets. Equation (1.16) is derived from the equalization of capital remuneration across the two regions and it signals that profits of firms located in the smaller region are affected more severely than those in the bigger region from the intensification of competition due to lower transport costs, so as to lead a higher share of region F 's capital to flow toward H and a higher relative number of varieties produced there.

In the short run (i.e. before capital remuneration re-equalize between regions), firms' profits in the different segments are affected in a complex way. Indeed, two interacting effects are at play: profits in the export segments rise as a consequence of higher mark-ups (remember that firms pass through half of their linear transport costs) and quantities sold. Yet, operating profits on the domestic market fall because tougher competition lowers prices and quantities sold of each variety, i.e.:

$$\frac{\partial \Pi_{HH}}{\partial t} > 0 \quad ; \quad \frac{\partial \Pi_{FF}}{\partial t} > 0$$

and

$$\frac{\partial \Pi_{FH}}{\partial t} < 0 \quad ; \quad \frac{\partial \Pi_{HF}}{\partial t} < 0.$$

The overall effect in the short run can be deducted from the HME relationship in (1.16), implying momentarily higher returns in region H as t decreases, ensures that firms in the bigger region systematically outperform firms in the smaller one in the short run, before capital returns are equalized again across the regions:

$$\frac{\partial \Pi_H}{\partial t} > \frac{\partial \Pi_F}{\partial t} > 0.$$

Thus they earn higher profits than smaller region's ones as a consequence of a reduction in freight rates.

As shown in the previous Sections, the level of industrial agglomeration, λ resulting from transport liberalization depends on the concentration of consumption, θ and the extent of competition in the transport sector after the liberalization, k . Figure 1.12 shows a simulation plotting the long-run equilibrium λ for different levels of θ and k .

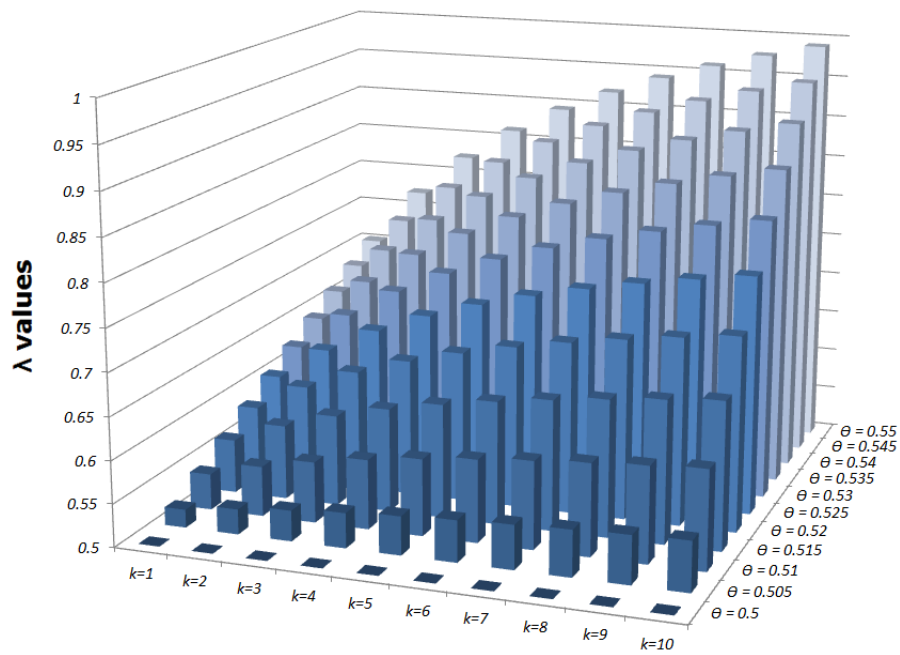


Figure 1.12: Simulation of agglomeration of industrial activities, λ_H , as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are symmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

Carriers' profits

Considering the previously regulated transport sector as behaving like a monopoly or, at least, assuming it to be a less competitive (because of fewer players) oligopoly than after the liberalization takes place, the global level of profits generated by the transport sector decreases because of a higher intensity of competition between carriers. In addition, this already lower global amount of total profits has to be distributed across a higher number of carriers.

The effect on the carriers' sector profits for each variety shipped from i to j , $\Pi_{K,ji}$, is illustrated in figure (1.13). Before liberalization, carriers' profits $\Pi_{K,ji}^0$ are described by the area between the marginal costs of providing the transport service (in addition to the marginal costs of production), $c + \tau$ and the price charged to the goods' producers (in addition to the marginal costs of production) $c + t_{ji}^0$. After liberalization, carriers' profits $\Pi'_{K,ji}$ are instead captured by the area between the marginal costs of providing the transport service (in addition to the marginal costs of production), $c + \tau$ and the new price charged to the goods' producers because of tougher competition (in addition to the marginal costs of production) $c + t'_{ji}$. Of course, the lower markup is only partially compensated by the higher volumes shipped per variety, which increase from q_{ji}^{0*} to q'_{ji*} because of the lower costs passed through from goods' producers to consumers.¹⁰ Both in the short run and in the long run, total profits of the transport sector decrease with the liberalization while profits in the manufacturing sector increase, the relative size of the two effects depending on the model's parameters.

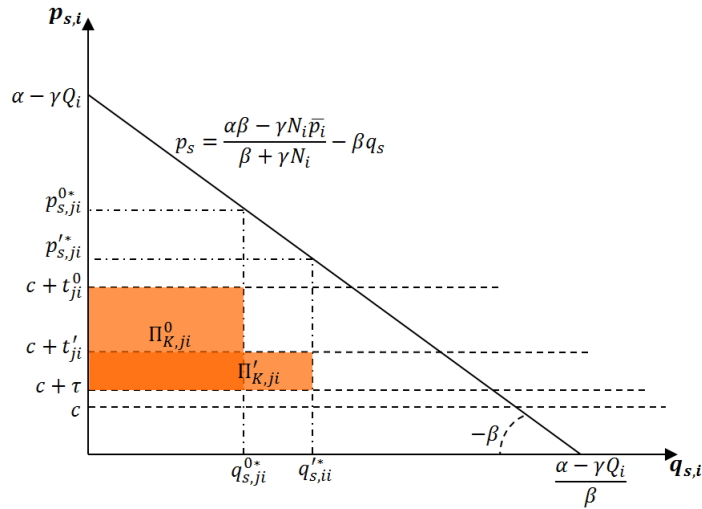


Figure 1.13: Graphical illustration of effects on carriers' profits of changes in transport costs between Core and Periphery

However, the existence of some residual market power (as long as $k \rightarrow \infty$ or $t \rightarrow \tau$)

¹⁰Remember that half of the marginal costs of production and delivery is always transferred to profit-maximizing prices under quadratic preferences.

still causes some welfare dead-weight losses in the economy because every inter-regionally traded product will still be incorporating both the mark-up applied by carriers for their transport service and the mark-up applied by manufacturing firms. The former is caused by the oligopolistic structure of the transport sector and the latter is due to the market power conferred by the horizontal differentiation. As observed earlier, this phenomenon mirrors what is usually called *double marginalization* in industrial organization and is known to lead to an under-provision of good from both a consumers' and a manufacturing firms' standpoints (Tirole, 1988).

Global welfare

The analysis above shows how, at least in the short run, transport liberalization (as any other shock or policy whose result is to reduce the transport costs) is welfare improving for the entire economy. The result is mainly driven by the evolution of prices, which fall in all the four segments of the heterogeneous goods' sector, as the transport costs fall. An overview of the effects on prices, quantities, profits and consumer surplus is presented in Figure (1.14) for the four segments.

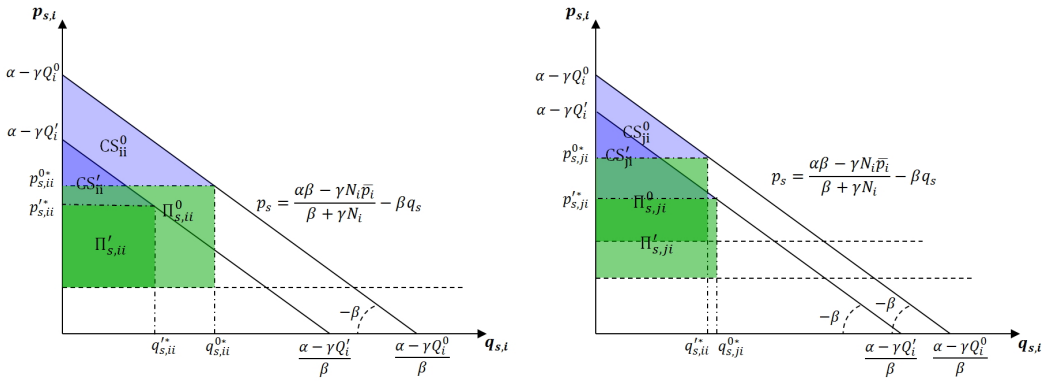


Figure 1.14: Effects in domestic (left-hand pane) and foreign (right-hand pane) segments of changes in transport costs

As noted in (1.13), indeed, the indirect utility function stemming from (1.1) can be expressed as a function of prices and income,

$$W_i = \frac{\alpha^2 N_i}{2(\beta + \gamma N_i)} - \frac{\alpha}{\beta + \gamma N_i} \int_{s \in N_i} p_{s,i} ds + \frac{\int_{s \in N_i} p_{s,i}^2 ds}{2\beta} - \frac{\gamma}{2\beta(\beta + \gamma N_i)} \left[\int_{s \in N_i} p_{s,i} ds \right]^2 + Y_i + \bar{q}_0,$$

which shows that the higher the quantities consumed of a given variety, the higher the welfare gain from its price reduction:

$$\frac{\partial W_i}{\partial p_{s,i}} = -\frac{\alpha\beta - (\beta + \gamma N_i)p_{s,i} + \gamma N_i \bar{p}_i}{\beta(\beta + \gamma N_i)} = -q_{s,ji} < 0.$$

An important remark is that *the distribution of economic activities gets more unbalanced while global welfare rises*, which creates a clear trade-off for policy makers.

Nonetheless, *welfare improvements in the de-industrializing region, F , are stronger than in the bigger region*, because price reductions are more intense. However, from (1.8) (or, equivalently, from (1.22) when $t_{HF} = t_{FH}$) it can be seen that, when t is identical in the two directions of trade, F dwellers could never catch up entirely with the welfare level of consumers living in H , in the absence of proper redistribution mechanisms.

Simulations show that in the long run the welfare gains realized in the short run are not reversed under a wide range of parameter combinations.¹¹ The increase in agglomeration does affect welfare negatively in itself, but it is a second-order effect as compared to the first-order effect of lower prices (price indices decrease in both regions) and higher profits in the manufacturing sector (because of higher markups in the inter-regional shipments) caused by the decrease in transport costs.

1.5.2 Complete deregulation

The analysis of full deregulation leads to qualitatively similar but quantitatively different conclusions. The departure from the symmetric transport cost towards a direction-specific pricing implies that unique-bilateral-tariff liberalization and full deregulation have different impacts on regional prices. In particular, as it has been noted, the symmetric outcome shown in equation (1.19) is the weighted averages for the two regions of equation (1.26), where weights are represented by the relative number of firms and consumers. Therefore, moving from a unique-bilateral-tariff liberalization to full deregulation, transport prices in the two directions move in opposite directions, counteracting the agglomeration effect due to lower freight rates.

Prices and quantities

The regional differentials on prices in the short run can be easily deduced by the analysis of (1.21), keeping in mind the relationship stated in (1.27):

$$p_{HH}^S < p_{HH} \quad ; \quad p_{FH}^S < p_{FH}$$

and

$$p_{FF}^S > p_{FF} \quad ; \quad p_{HF}^S > p_{HF},$$

where the superscript S stands for market outcomes after carriers are allowed to segment the transport market. What is worth noting is that prices increase for consumers in the smaller region for both domestic and imported goods. The opposite holds for consumers in the bigger region. This results in price indices diverging further, as can be checked using equation (1.22):

$$\bar{p}_H^S(t_{FH}) < \bar{p}_H(t) \quad ; \quad \bar{p}_F^S(t_{HF}) > \bar{p}_F(t).$$

¹¹Welfare losses can be observed in the long run only when the number of firms approaches the number of consumers, i.e. when the fixed costs of setting up a firm are very low. However, the effect is entirely driven by the redistribution of profits to consumers and not by the consumer surplus as captured by prices, but the quadratic utility framework is not the best suited to capture income effects because of the assumption of a large enough endowment of numéraire to satisfy any level of consumption, so it would be fair to say that the most robust results in this framework are the ones related to consumer surplus.

This effect reinforces the relation noted in (1.8) and yields

$$\bar{p}_H^S(t_{FH}) < \bar{p}_H(t) < \bar{p}_F(t) < \bar{p}_F^S(t_{HF}) .$$

Therefore, *in the short run segmentation is expected to increase the gap in prices between the two regions as compared to a unique tariff in the two directions*. Interestingly, this result is reverted in the long run, due to the restraint in agglomeration due to asymmetric tariff, which keeps more firms in the peripheral region (for the same level of competition in the transport sector) and thus reduces the share of varieties in the periphery that have to incur transport costs to be consumed.

As for quantities, the impact of segmentation in the short run can be seen from equation (1.23), taking into account the effect on prices shown in (1.27):

$$q_{HH}^S < q_{HH} \quad ; \quad q_{FH}^S > q_{FH}$$

and

$$q_{FF}^S > q_{FF} \quad ; \quad q_{HF}^S < q_{HF}.$$

Hence, once carriers are allowed to segment the transport market, each variety produced by the firms located in region F would sell more than under symmetric tariffs in the short run, both in the local (because freight rates from the core are higher) and the export segments (because shipping goods from the periphery to the core is cheaper). The opposite is true of the firms located in H . Hence, compared to a unique-bilateral tariff, *in the short run complete deregulation implies higher levels of production in F and higher employment in the manufacturing sector. In addition, given the higher level of domestic prices, complete deregulation engender higher profits in the short run to the firms located in F , as compared to a unique-bilateral tariff*. This latter effect plays against agglomeration and yields the following result. This result holds only partly in the long run. After also relocation of firms is taken into account, indeed, simulations show that quantities on the inter-regional export segment are higher under asymmetric tariffs than under symmetric tariffs, but the opposite is true for the domestic segment in the periphery, whose sales are lower.

Agglomeration and Manufacturing Firms' Operating Profits

In terms of agglomeration, due to the analytical intractability resulting from the feedback loop of transport costs and agglomeration, the most suitable way to compare a unique-bilateral-tariff liberalization regime with complete deregulation is through simulations. It should be noted that once carriers are allowed to price discriminate by the direction of shipment, equation (1.16) must be generalized to allow for the possibility of segmentation. The agglomeration patterns as a function of transport costs and structural parameters can thus be computed as

$$\lambda_i - \frac{1}{2} = \frac{2\beta(\alpha - c)}{\gamma N} \left(\frac{\theta_i t_{ji} - \theta_j t_{ij}}{\theta_i t_{ji}^2 + \theta_j t_{ij}^2} \right) + \frac{\beta}{\gamma N} \left(\frac{\theta_j t_{ij}^2 - \theta_i t_{ji}^2}{\theta_i t_{ji}^2 + \theta_j t_{ij}^2} \right), \quad (1.29)$$

where capital remuneration in the two regions is now expressed in terms of two different freight rates and the changes in profitability of firms in the two regions depend on structural parameters and levels of concentration of consumption, θ , in a highly non-linear way. It should be noted that replacing t_{ij} and t_{ji} with t , equation (1.29) turns into (1.16). Thus, intuitively, it can be argued that, since the only difference between (1.29) and (1.16) is transport segmentation and transport costs in the two directions follow the ranking shown in equation (1.27) for a given level of λ , then agglomeration should be restrained by the possibility of transport market segmentation. Simulations show that this intuition is correct, as shown in Figure 1.15, which should be compared to 1.12, where exactly the same structural parameters, levels of consumption concentration and number of carriers are used as inputs of the simulation, the only difference being the transport liberalization regime.

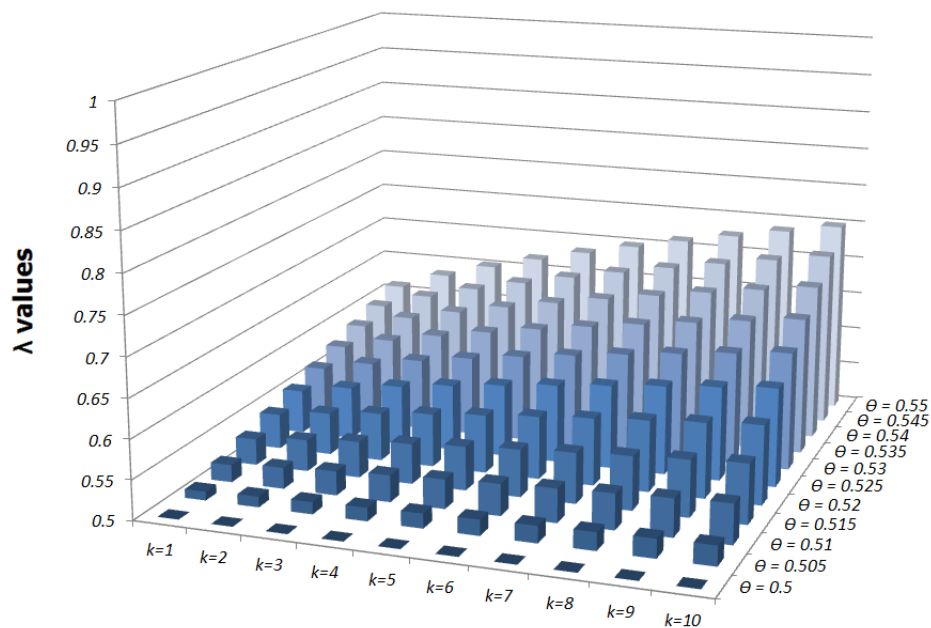


Figure 1.15: Simulation of agglomeration of industrial activities, λ_H , as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are asymmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

The simulation confirms the intuition that transport market segmentation, as opposed to a symmetric tariff, makes the core region less attractive for firms because it increases the costs of shipping their products to the periphery and, at the same time, makes it cheaper to produce goods in the periphery and ship them to the core. An analytical short-run analysis of how profits are affected by segmentation in the transport sector is complicated by the fact that, even if quantities rise for every segment supplied by firms

located in F and falls for varieties produced in H , selling prices of each manufacturing firm move in different directions in the domestic and the export segments, which are populated a different share of the total population. Therefore, even if it surely holds that

$$\Pi_{FF}^S > \Pi_{FF} \quad ; \quad \Pi_{HH}^S < \Pi_{HH},$$

there is no clear trend for Π_{HF} and Π_{FH} , because in the FH segment sales are higher but prices lower and in the HF case the opposite holds in the short run. However, since the agglomeration patterns are driven by the equalization of returns on capital, the observation of lower levels of spatial relocation in the long run ensure that profit differentials between the two regions in the short run are smaller under asymmetric tariffs than under a unique-bilateral-tariff regime. This result is robust to different structural parameters and number of competitors in the transport sector.

Global welfare comparisons

As in the case of symmetric tariffs, transport liberalization increases welfare under a full liberalization regime because of the impact on prices in both regions. In order to compare the two liberalization regimes in terms of welfare, a simulation has been performed, whose results are shown in Figure 1.16 for a given level of consumption concentration. Welfare levels under a complete deregulation are plotted in black for the two regions and for the overall economy (weighing the welfare level of each region by its share of consumers); for the unique-bilateral-tariff regime they are plotted in gray.

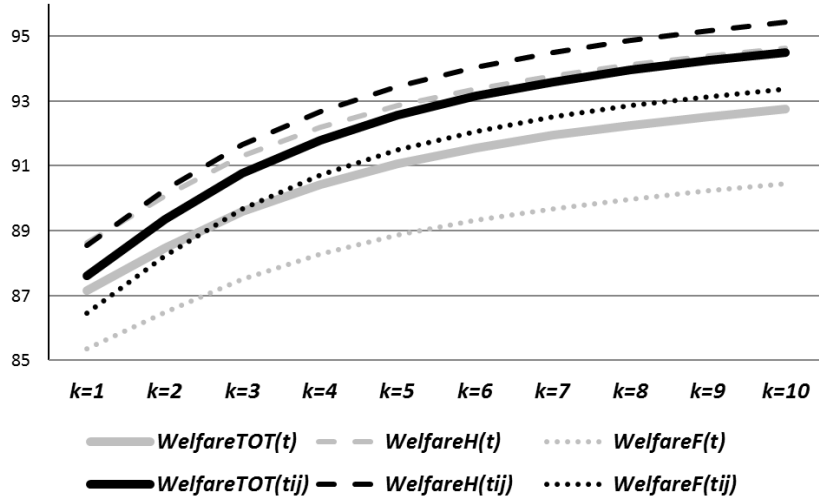


Figure 1.16: Simulation level of welfare in the two regions, and in the entire economy, as a function of the level of competition in the transport sector (ranging from $k = 1$ to $k = 10$) and liberalization regime. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$; $\theta = 0.55$.

As noted earlier, consumers in the core region always enjoy higher levels of welfare than consumers in the periphery. In addition, complete liberalization yields always higher levels of welfare in the two regions as compared to a liberalization regime imposing a unique tariff per route. The ranking of liberalization regimes is robust to changes in the structural parameters, but a caveat is due on the welfare impact of the extent of competition in the transport sector. In fact, when the number of manufacturing firms increase as compared to the number of consumers (for example, by altering the fixed amount of capital needed to set up a firm, f) unreported simulations show that intermediate levels of competition in the transport sector may be welfare superior to high levels of competition. This result is driven by the nominal income effect of higher levels of competition in the final goods sector (causing reduction in returns on capital in the economy) that generate welfare losses in the peripheral region only partly compensated by the gains from lower prices. At the limit, when there are as many firms as consumers ($f = 1$), any reduction in transport costs decreases welfare instead of increasing it. However, when the analysis of welfare is restricted to consumer surplus, which may be the best way to account for welfare in a quadratic utility setting without income effects, welfare results are again robust to different structural parameter values and confirm that gains from transport liberalization increase as more carriers are allowed into the transport sector.

There is an important implication stemming from the welfare comparison of transport liberalization regimes. Since asymmetric tariffs are shown to be welfare superior to symmetric tariffs, any policy aimed at reducing transport costs should keep in mind that a decentralized market-driven reduction in transport costs (which can be obtained by regulating only the number of entrants in the market) is to be preferred to an exogenous reduction in transport costs, as can be obtained for example by keeping the transport sector highly regulated and decreasing the tariffs. In order to be optimal, a reduction in transport costs which does not result from a complete liberalization should indeed apply different prices in the two directions of the same route depending on the elasticities of inter-regional export demand to transport costs, but that means that the regulated sector should mimic the decentralized market behavior. So it may be arguably more efficient to allow carriers to set the prices maximizing their profits per segment of shipment, subject to an entry fee. This solution ensures that, while in equilibrium the carriers' profits are redistributed to the public, their pricing strategies result in direction-specific freight rates that increase welfare and restrain agglomeration in the core region.

One final remark on the impact of agglomeration on total welfare of the economy is due. As often discussed in NEG models, agglomeration may be inefficient in terms of welfare and turn static welfare gains into dynamic welfare losses. In the particular framework studied in this Chapter this has shown not to be the case, unless an unreasonably high number of firms is assumed, however then negative impact of agglomeration on welfare is confirmed. In Figure 1.17 is shown how the exogenous distribution of consumption affects the level of welfare that can be attained in the two regions. On the left pane is shown the case of a monopolist carrier and on the right pane a more competitive transport sector. On the one hand, it can be noticed that when carriers can segment the

transport sector (black lines in the Figure) the overall negative impact of consumption concentration on welfare is the result of an improvement in the core region more than compensated by a loss in the periphery, even if the weight of the welfare level in the core increases with θ . On the other hand, when a symmetric tariff is imposed (gray lines in the Figure), high levels of concentration in consumption cause losses in both the core and the periphery, which signals a very inefficient level of agglomeration.

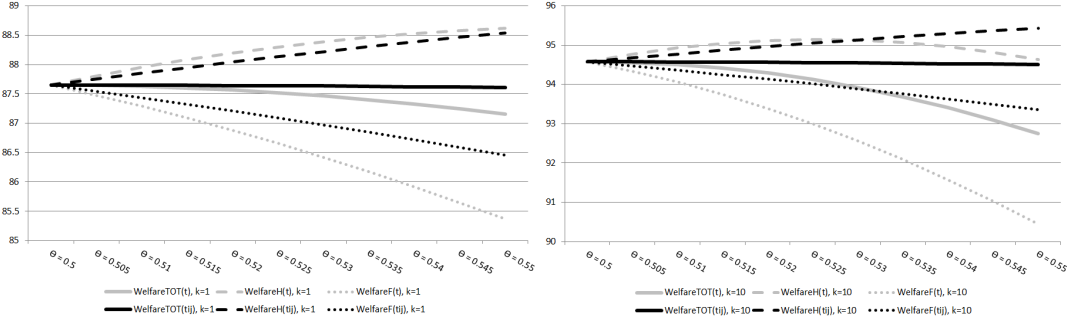


Figure 1.17: Simulation level of welfare in the two regions, and in the entire economy, as a function of concentration of consumption and liberalization regime. On the left pane with a monopolist carrier, $k = 1$, and on the right pane with $k = 10$. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

Another striking feature of the model highlighted by Figure 1.17 is that, while overall welfare and welfare in the periphery always benefit from a complete deregulation, welfare in core region (where most of the consumers live) is higher under a transport liberalization regime where symmetric tariffs are imposed, except for high levels of concentration of consumption (i.e. if the core region is much bigger than the periphery). This may give rise to complex political economy dilemmas (as the preferred policy of the median voter would not coincide with the first best) which add up to the usual NEG trade-off between efficiency in terms of welfare and regional imbalances in terms of distribution of the economic activities.

1.6 Concluding remarks

In this Chapter, a New Economic Geography (NEG) model has been presented where the only source of heterogeneity across varieties is the location of producers and consumers. Goods produced in one region and shipped to another have to incur transport costs, which are first assumed exogenous and treated as a parameter and then endogenized and obtained as the market outcome of a decentralized transport sector. Through the endogenization of freight rates in the model it is then possible to study the welfare impacts of different transport liberalization regimes and the corresponding location patterns of the economic activity. Two liberalization policies are analyzed, the first one imposing symmetric tariffs the two directions of a route, the second one leaving carriers free to price

discriminate. Notably, the former type of liberalization is equivalent to an exogenous reduction in transport costs, whereas the latter describes a competitive behavior, under given market conditions.

The model shows that transport liberalization (or a reduction in exogenous transport costs) is expected to yield static and dynamic welfare gains for consumers of the entire economy. The result is not trivial, because in the short run cheaper inter-regional connections induce tougher competition in the manufacturing sector and reduce prices for consumers, but a typical result of NEG models is that the ensuing relocation of economic activities may be inefficient in terms of welfare, making the overall impact on welfare not *a priori* clear.

It is shown in this Chapter that transport liberalization turns out to be beneficial for consumers under rather general conditions, but the choice of liberalization regime matters. A full liberalization is shown to yield the highest level of overall welfare by counteracting the inefficient agglomeration patterns resulting from a symmetric reduction in transport costs. This is because the profit-maximizing pricing strategy of carriers responding to differences in the elasticity of interregional demands implies charging higher prices for shipments from the periphery to the core than vice versa. This makes it more convenient to stay in the peripheral region for firms that would have otherwise (under a symmetric tariff) relocated towards the core. An interesting analysis of the evolution of transport costs, underlying the interaction between the transport sector and the rest of the economy, has been conducted by Hummels (2007), who finds that *ad-valorem* prices of ocean shipping and air shipping displayed sensibly different trends in the last fifty years. Whereas the latter declined utterly because of technological progress, the former kept constant as a consequence of increasing prices in upstream markets, underlying the importance of the interaction between the transport sector and the other sectors of the economy.

Under any liberalization regime, however, the model shows that the increases in welfare are associated with higher regional imbalances in terms of economic activity. As compared to a symmetric reduction of transport costs, the possibility for carriers to segment the transport market is found to counteract the agglomeration forces associated with lower transport cost, but does not manage to nullify them. This means that, if policy-makers attribute an inherent value to an even distribution of economic activities over the territory, they would not find it optimal to aim at the first best in terms welfare. In addition, it has been show that there are some suboptimal policy options that would make consumers in the bigger region better off than the socially optimal policy, which may also be an issue for policymakers if they aim at pleasing the median voters.

Finally, two remarks in terms of policy relevance are in order. First of all, in the present model only interactions between manufacturing and transport sectors have been analyzed, thus nothing can be easily inferred about transport liberalization processes affecting commuters or travelers. Second, the implicit simplifying assumption on which this work has relied is that the most direct effect of liberalizations is to reduce prices. This is not always true, but this doesn't invalidate the underlying analysis, which can be extended to different types of shocks affecting trade costs. The framework presented here

can indeed be applied to other sources of change in trade costs, such as the efficiency gains in transport derived from technological improvement or, conversely, the inefficiencies generated by higher marginal costs of delivery (for example, trade tariffs, port fees, fuel price and so on). Of course, when extending this framework to other contexts it should be verified that the main modeling assumptions be relevant, such as the oligopolistic market structure or the possibility of committing capacity (or setting prices) in specific directions of shipment. When these assumptions do not hold, the results presented here on welfare in the long run may not hold anymore, as shown for example by Behrens and Picard (2011), who stress the back-haul problem faced by carriers by modeling an equal level of capacity in the two directions of a given trade route and analyze the market and agglomeration outcomes in such a perfectly competitive setting.

Summing up, in this Chapter a purely theoretical model has been presented. A natural next step, as explored in Chapter 6, is to test empirically some of the implications of the model, especially the ones concerning the determination of the freight rate in the transport sector. In addition, the model has been developed only for two countries, but it could be possible to extend it to a multi-country framework, even if it is very likely that the complexity of the interaction between attraction (market size) and accessibility (domestic competition and access to foreign market) effects, as noted by Behrens et al. (2004).

The next Chapters are based on the same class of utility functions as the one adopted in this Chapter, with a richer characterization of the demand side. However, this development comes at a cost: the supply side of the economy is simplified to avoid adding complexity when not strictly needed. Specifically, the number of regions in the economy, the endogenization of transport costs and the long-run equilibrium outcomes are left in the background in the rest of the Thesis.

Chapter 2

Re-thinking product differentiation in trade

In Chapter 1 it has been shown how, even in the context of homogeneous consumers, firms and products, complex dynamics may emerge purely from market size, transport costs and increasing returns to scale. These effects, in combination with firm heterogeneity are considered by many theoretical trade modelers as being enough to capture most of the relevant trade patterns, but is it really the case?

In this Chapter, a collection of recently published empirical evidence and some first-hand observation are presented on the need to introduce at least two sources of heterogeneity on the demand side of the economy: one called "quality" and the other called "taste". The latter is bound to affect only quantities sold, whereas the former is associated also with changes in prices.

First, the role quality and taste can play in reconciling theory and empirics is explained. Then, a clear link is drawn between spatial theories and new trade models of monopolistic competition, discussing relevant implications and paving the way to Chapter 3, in which quadratic utilities with different combinations of vertical and horizontal differentiation are discussed.

2.1 Motivation: some stylized facts in the literature

As a result of the increased availability of micro-level data, implications and results of new trade models can now be directly tested. Thus, early attempts to model heterogeneity through cost differences (following the lead of Melitz, 2003; Melitz and Ottaviano, 2008) have recently undergone intense scrutiny. One directly testable implication of models of cost heterogeneity is that, assuming a homogeneous demand structure for all the varieties, higher prices should be associated with lower quantities sold. Authors testing explicitly for this implication (Crozet et al., 2012; Hummels and Klenow, 2005; Manova and Zhang, 2012; Verhoogen, 2012) tend to reject it and suggest that additional dimensions of heterogeneity are needed.

The usual suspect as a relevant source of additional variability is generally referred to as quality¹. As Hallak and Sivadasan (2009) point out, the interaction between product quality and productive efficiency may help explain the "*empirical fact that firm size is not monotonically related with export status*" and that "*there are small firms that export while there are large firms that only operate in the domestic market*". Also Brooks (2006) proposes a similar explanation to account for the "*tendency for Colombian plants to under-export manufactured goods to the United States*". In general, it seems reasonable to expect that quality and efficiency have a different relative weight depending on the industry, as Kneller and Yu (2008) suggest by looking at Chinese exporters and Khandelwal (2010) confirms by studying US imports.

As a matter of fact, at a macro level, recent empirical works consistently report that differences in product quality, as generally measured by differences in unit prices, are an important determinant of the pattern of international trade flows across countries². However, it is important to notice that "*international specialization is taking place within products across varieties, rather than across products or industries*" (Fontagné et al., 2008). Therefore, ignoring idiosyncratic shifts in demand for single varieties within a sector may bias results (Foster et al., 2008; Katayama et al., 2009) and hide rich underlying processes (Kneller and Yu, 2008).

The importance of quality in shifting demand seems to be confirmed also at a micro level by trade data on a wide range of countries, such as China (Manova and Zhang, 2012; Schott, 2008), Colombia (Brooks, 2006; Eaton et al., 2007; Verhoogen, 2012) and Mexico (Iacovone and Javorcik, 2008). Furthermore, exploiting product-level Hungarian custom data, Gorg et al. (2010) show that even the same product may be sold at a very different unit price in different markets, justifying the claim that local competitive pressure may be as important as idiosyncratic quality as a demand shifter. This view is confirmed also within integrated markets, such as the EU in the case of the car industry (Goldberg and Verboven, 2001), at virtually any geographical scale, even cities within the same country (Engel and Rogers, 2001; Handbury and Weinstein, 2011).

Likely demand shifters such as quality-improving investments (Iacovone and Javorcik, 2008) and high-quality inputs (Verhoogen, 2012) are indeed consistently and significantly associated with prices and turnover, but do not seem to perform well in predicting output levels. Using plant-level manufacturing data on revenues and physical output and focusing on firms serving local markets, Foster et al. (2008) show that "*a large dispersion in output across producers of the same product*" is observed, even "*after taking into account productivity variations and the movements along the demand curve associated with these*". The presence of this large unexplained variability may also be contributing to the puzzlingly weak relation between productivity and size (Brooks, 2006; Hallak and Sivadasan, 2009) and to the empirical evidence of a bias towards domestic varieties (Brooks, 2003; Chung and Song, 2008; Ferreira and Waldfogel, 2013; Goldberg and Ver-

¹See, for example, Edwards and Lawrence (2010); Foster et al. (2008); Helble and Okubo (2008); Hummels and Klenow (2005); Iacovone and Javorcik (2008) and Gervais (2010)

²Relevant works directly addressing this issue are Baldwin and Harrigan (2011); Hallak (2004); Hummels and Klenow (2005); Hummels and Skiba (2004) and Schott (2004)

boven, 2005). There seems to be no theoretical models of monopolistic competition that take advantage of the information provided by "unexplained" output variability to adjust price indices and other relevant measures of competition (Gaulier et al., 2008). This is one key contribution of this thesis.

Besides technical efficiency, product quality and taste-driven idiosyncratic output variations, another commonly envisaged variable affecting firms' performance appear to be product substitutability within and across sectors. Khandelwal (2010), for example, claims that there is "*substantial heterogeneity in product markets' scope for quality differentiation*", relating within-sector competition between varieties to the "length" of the quality ladder. According to the author, this could explain the heterogeneity across industries in the impact of low-wage competition on U.S. output and employment growth reported by Bernard et al. (2006). Similarly, using data on geographically isolated monopolies, duopolies, and oligopolies in retail and professional industries, Bresnahan and Reiss (1991) find important inter-industry differences in entry threshold ratios, suggesting that the patterns of substitutability vary across markets. Finally, running a principal component analysis on the responses provided by owners of London-based businesses to a set of questions about their priorities, Gordon (2010) notes that, together with quality and efficiency, differentiation stands out as an important strategic dimension of competition, suggesting that firms do take indirect competition into account when setting their pricing strategies and try to relax it by horizontally differentiating their offer within a sector as well.

Finally, it is worth stressing that market-specific competitive pressure has consistently been found to act as a demand shifter and affect the pricing behavior of firms (Ohno, 1989). In the case of multi-product firms, for example, Mayer et al. (2014) find that tougher competition in an export market induces firms to alter their product mix by skewing its export sales towards their best performing products.

2.1.1 An illustrative example: the car market

Before turning to the theoretical contribution and to the modeling and interpretation of the empirical observations reported above, it may be useful to have a preliminary look at how micro-level evidence on prices and quantities typically looks like. Looking at the data can help visualize concretely what drives the empirical stylized facts mentioned above. For this purpose it is possible to turn to a free and publicly available dataset on the European car market used by Goldberg and Verboven (2001). Even if the car sector is a very particular one, the patterns arising from the car data are perfectly in line with what will be later observed on the Belgian export dataset shown in Chapter 4 and in the micro-level literature in general. The reason for using the car evidence to motivate the choice of assumptions is that these data can be easily verified by any reader, which is useful given that access to firm-level data is not always granted.³ In addition, in this dataset it is possible to observe product characteristics which are not visible on trade data, so they will be used again later in the thesis, in Chapter 4, to provide some intuition

³The dataset can be found on <http://www.econ.kuleuven.be/public/ndbad83/frank/cars.htm>.

on the connection between actual product characteristics and the model parameters in an exploratory factor analysis.

In order to give an idea of typical trade patterns, prices and quantities are analyzed in the five countries reported in the dataset (France, Italy, Germany, UK and Belgium) in the year in which more car types were sold simultaneously in the five markets. From Figure 2.1 it can be noted that the best year is 1999, when 72 varieties of cars were sold in the 5 markets included in the sample. Notice that the entire number of varieties covered in the 30 years considered is 410. Out of these, 117 were present in 1999, resulting in 463 market-variety observations.

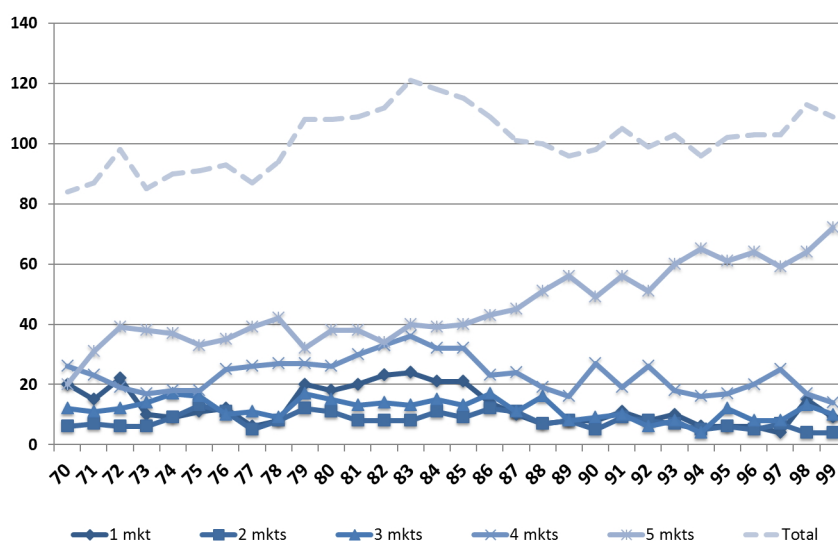


Figure 2.1: Total number of car varieties in the sample and markets served by each.

The list of varieties considered is included in Table 2.1. In addition, some summary statistics on the sample, and notably on prices and quantities, are shown in Table 4.1 in Chapter 4, together with many other variables used to perform a factor analysis.

A price and a quantity rank is assigned to each car type in each market and, in Figure 2.2, plot one against the other in all markets. Each dot in the figure represents a combination of a price and quantity rank in a particular geographical market for a particular variety of car.

If one assumes, as most trade models implicitly do, that all car types face the same demand in every market, and that the only difference between car types is the cost at which they are produced, one would expect all observations to lie around the diagonal from top-left to bottom-right. Put differently, one would expect high-cost cars to rank high in the price ranking (close to the origin on the price axis) with few people buying them (top-left area of the figure). Low-cost cars, on the other hand, would sell a lot at a low price (bottom-right area of the figure). If instead one assumes that quality is the only source of heterogeneity and acts as a demand shifter, one would expect observations of different car types to cluster around the diagonal running from bottom-left to top-right,

Table 2.1: Car types present in 1999 in Belgium, France, Germany, Italy and UK.

Car types included in the sample			
BMW 3	nissan primera	audi a6	ford ka
BMW5	opel corsa	audi a8	mercedes A
citroen xantia	opel vectra	audi a4	saab 9.5
fiat punto	opel omega	mitsubishi carisma	seat arosa
ford fiesta	opel astra	renault laguna	skoda octavia
ford escort	peugeot 106	seat cordoba	volvo S70/V70
ford mondeo	peugeot 306	fiat bravo/brava	alfa 166
honda civic	renault clio	peugeot 406	daewoo matiz/M
honda accord	rover 200	skoda felicia	ford focus
hyundai pony	rover 400	suzuki baleno	hyundai atos
hyundai lantra	rover 416	nissan almera	mazda demio
mazda 323	rover 400	audi a3	peugeot 206
mazda 626	seat ibiza	citroen saxo	saab 9.3
mercedes C klasse	seat toledo	volvo S40/V40	toyota avensis
mercedes E klasse	suzuki swift	alfa 156	volvo S80
mitsubishi colt	toyota corolla	citroen xsara	rover 75
nissan micra	volkswagen polo	daewoo lanos	toyota yaris
volkswagen golf	daewoo nubira	volkswagen lupo	
volkswagen passat	fiat marea	volkswagen bora	

with high-quality cars being highly priced and selling a lot and low-quality cars being associated with low prices and poor sales in all markets.

Interestingly, Figure 2.2 shows that there is no clear correlation pattern between price and quantity rankings. On average, the correlation between price and quantity rankings of car types within markets is around -11%, with rank correlations ranging from 10% in Germany to -30% in Italy, through -0.2% in Belgium, as shown in Table 2.2. This suggests that a particular variety of car, displaying the same price ranking across markets, can sell relatively well in one market but badly in another. Such a pattern is inconsistent with a model where the only source of heterogeneity between models is productive efficiency or quality. Consequently, an important first observation arising from the car data is that more than one source of demand heterogeneity appears to be needed to fit micro-level data.⁴

A second important observation arises from plotting price rankings between countries,

⁴Similar conclusions are reached through more formal analyses by authors such as Crozet et al. (2012); Hummels and Klenow (2005); Manova and Zhang (2012).

which is done in the left pane of Figure 2.3. Each dot in the figure now represents the ranking of a car type in a particular geographical market compared to the ranking of that car type in Belgium (horizontal axis), in such a way that a perfect correlation between price ranks across markets would result in dots following the 45° line. Looking at the left pane of Figure 2.3, it can be noted that bilateral price rank correlations are in fact surprisingly high, ranging from 95.7% to 98.3%. A strong and positive price correlation between markets corresponds to the prediction arising both from a pure cost and a pure intrinsic quality model, but appears inconsistent with a model of differently perceived quality. A model that assumes quality to be perceived differently in every market would in fact result in a low price correlation between markets. When quality is introduced in the model, it is thus assumed it to be variety-specific but not market-variety-specific. This choice is also shown to be consistent with a rigorous interpretation of what is horizontal and what is vertical in product differentiation.

A third observation arising from the car data stems from the right pane of Figure 2.3. There quantity rankings of car types between countries are plotted in a similar way as price rankings in the previous figure. The pattern arising from quantity rankings is very different. Bilateral rank correlations of car types averages 66% and can be as low as 49.5%, which is much less than the corresponding price rank correlations. Hence, while price rankings of car types are quite stable across markets, quantity rankings are not. In Section 4 evidence is discussed based on a detailed micro-level dataset on Belgian exporters and show that these empirical regularities turn out to be extremely robust and hold in virtually all markets and products considered.⁵

All the bilateral rank correlations of prices and quantities associated with Figure 2.2 and the left and right panes of Figure 2.3 are shown in Table 2.2

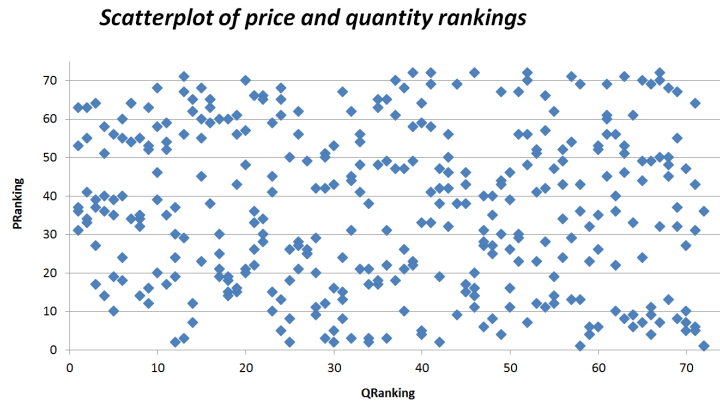
Based on existing trade models incorporating either cost or quality heterogeneity or both, one would expect quantity rankings to be just as regular as price rankings. What this observation is saying, though, is that there appears to be a source of heterogeneity affecting quantities that is not just variety-specific but also market-specific. The introduction of an additional source of heterogeneity affecting quantities but not prices seems necessary to account for prices and quantities behaving so differently. Or in other words, *heterogeneity on the supply side needs to be supplemented by heterogeneity on the demand side*, and notably by idiosyncratic consumer taste.

These empirical challenges can be tackled by proposing variations of a quasi-linear model of monopolistic competition with a quadratic sub-utility for the differentiated good where each variety may be viewed as a different bundle of horizontal and vertical attributes. Vertical attributes, like quality, are assumed to be intrinsic to varieties, affecting prices similarly in all markets. Horizontal attributes are allowed to be valued differently across markets. The vertical attributes are captured by a demand-shifting parameter; the horizontal attributes will be interpreted as measuring taste mismatch between varieties' characteristics and consumers' ideals as it has been developed in in-

⁵This finding is consistent with the observation of a puzzlingly weak relationship between firms' productivity and size found by Brooks (2006) and Hallak and Sivadasan (2009) and with the evidence of a bias towards the consumption of domestic varieties (Ferreira and Waldfogel, 2013).

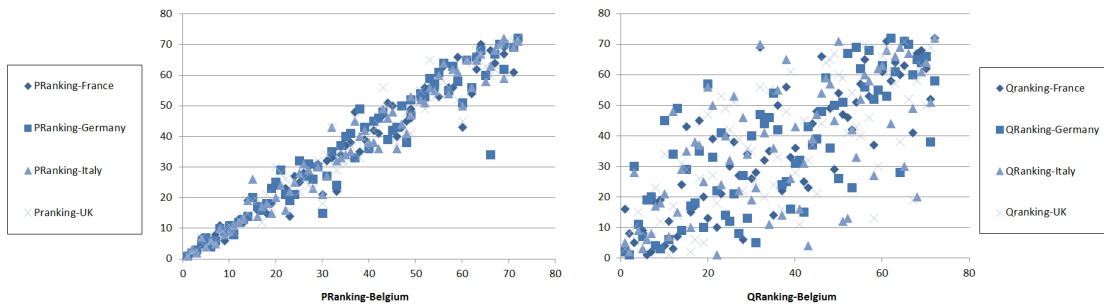
dustrial organization (Anderson et al., 1992). In line with the overwhelming majority of trade models and empirical evidence, cost heterogeneity is also introduced.

Figure 2.2: Price-quantity rankings within markets, EU car markets



Note: Scatterplot of price against quantity rankings for car types sold in Belgium, France, Germany, Italy and UK within each market.

Figure 2.3: Price rankings across markets, EU car markets



Note: To the left, price rankings in France, Germany, Italy and UK are plotted against price rankings in Belgium for car types sold in all these markets simultaneously. To the right, the same scatterplot is drawn for quantity rankings.

By choosing the quadratic utility model, it is acknowledged that competition effects are important and that they can differ in geographical markets. Empirical evidence has shown indeed that absolute price levels can be very different between countries. Exploiting product-level Hungarian custom data, Gorg et al. (2010) show that even the same firm-product may be sold at very different prices in different markets. This suggests the existence of important local market effects, which operate like a market-specific demand shifter (but which does not affect price rankings). In other words, markets appear to be segmented, with the intensity of local competition playing a role as important as individual product characteristics in affecting prices and quantities.

Table 2.2: Across- and within-market correlations in the European car market for prices and quantities.

corr	QrankBE	QrankFR	QrankDE	QrankIT	QrankUK	THINKING PRODUCT DIFFERENCE				
QrankBelgium										
QrankFrance	0.8361									
QrankGermany	0.7363	0.6308								
QrankItaly	0.6111	0.7232	0.495							
QrankUK	0.7032	0.7436	0.5639	0.6019						
corr	QrankBE	QrankFR	QrankDE	QrankIT	QrankUK	PrankBE	PrankFR	PrankDE	PrankIT	PrankUK
PrankBelgium	-0.0024									
PrankFrance			-0.1872			0.9758				
PrankGermany			0.1025			0.96	0.9572			
PrankItaly					-0.2985	0.9783	0.9825	0.9674		
PrankUK					-0.1453	0.9697	0.9777	0.9582	0.9781	

2.2 Theoretical Background

The previous example and review of findings in the literature illustrate a robust empirical fact trade economists usually have to struggle with: one source of heterogeneity alone cannot explain trade patterns within markets and the higher volatility of quantities with respect to prices variations across markets. Indeed, almost all empirical facts reported above are usually presented by their authors together with theoretical explanations and models delivering the desired results. Most of the works reviewed do so by proposing slight ad hoc departures from Melitz (2003), even as its generality has been increasingly disputed (Behrens and Murata, 2007; Zhelobodko et al., 2012). In this Chapter, a general framework is proposed building on a combination of product differentiation, monopolistic competition and location theories. This Section provides a brief review of these strands of theory, underlying their common origin and stressing how their paths have often overlapped in the past and may be currently converging again.

2.2.1 Product differentiation and imperfect competition drifting apart

The idea of product differentiation emerged as a result of the debate on imperfect competition and the need to develop a unified theory allowing for intermediate cases between perfect competition and pure monopoly (Schumpeter and Nichol, 1934). The abstract intuitions on the role of differentiation developed by Edgeworth (1925) as a response to the criticism of Bertrand (1883) on the solution of the duopoly problem proposed by Cournot (1838), were further developed by Sraffa (1926) and Hotelling (1929) by proposing a conceptual framework in which the horizontal and vertical characteristics (in what was then defined as the "symbolic space") of a certain product determine the amount of competitive pressure a good faces and, hence, the price it is able to charge and the portion of the market that it serves. In particular, Sraffa (1926) recognizes that "*the causes of the preference shown by any group of buyers for a particular firm are of the most diverse nature*", including that "*special features of modeling or design have for their principal purpose that of distinguishing it from the products of other firms*" and claims that "*when each of the firms producing a commodity is in such a position the general market for the commodity is subdivided into a series of distinct markets*". Hotelling (1929) notes that within each of these sub-markets firms are in a quasi-monopolistic position, so that "*the seller sets the price and the buyers the quantities they will buy*".

Two strands of literature emerged from these intuitions: one concerned with firms' location, pricing and differentiation choices, the other focusing on competition, theory of value and trade. The first, started by Lerner and Singer (1937) and developed by Shaked and Sutton (1982, 1983), d'Aspremont et al. (1979) and Gabszewicz and Thisse (1979), analyzes firms' optimal positioning strategies and checks their stability and properties, in terms of vertical and horizontal differentiation. The second, inaugurated almost contemporaneously by Chamberlin (1933) and Robinson (1933), abstracts from actual positioning of firms along vertical and horizontal dimensions, but incorporates the notion of imperfect substitutability across goods and varieties to justify differences in pricing behaviors of firms and in competitive toughness of markets. This strand of literature re-

ceived great impulse thanks to the technical innovations on demand modeling proposed by Dixit and Stiglitz (1977) and their application in the context of trade by Krugman (1980, 1979) to account for the emerging evidence of intra-industry trade collected by Grubel and Lloyd (1975).

2.2.2 Product differentiation and imperfect competition converging again

It is actually by integrating the latter class of models with the mechanism proposed by Hopenhayn (1992) to capture firm and industry productivity dynamics that Melitz (2003) ideated what is still regarded as one of the reference frameworks for studying firm heterogeneity and endogenous firm selection processes. An additional technical development has been achieved recently, as the quadratic utility function proposed by Ottaviano et al. (2002) has been embedded in the Melitz (2003) to deliver an analytically solvable model of firm heterogeneity and selection with non-constant markups and feedback effects from aggregate market characteristics Melitz and Ottaviano (2008). An alternative way of achieving non-constant markups and feedback effects followed by many authors is to introduce quality-adjusted CES demand functions, where quality is generally referred to as a means of vertical differentiation and acts basically as a demand shifter⁶. As noted by Manova and Zhang (2012), in these models product quality enters the utility function through a quantity-augmenting term and all implications for quality-adjusted prices are as in Melitz (2003).

However, the reintroduction of idiosyncratic vertical differentiation into the picture has never been paired with an equal attention towards idiosyncrasies in horizontal differentiation, which is always assumed to be constant across varieties in the same sector and captured by the elasticity of substitution parameter. The same holds for works based on quadratic utility functions: Foster et al. (2008) just consider vertical differentiation, Kneller and Yu (2008) and Antoniadou (2008) impose vertical and horizontal differentiation to be captured by the same parameter, thus concealing their individual effects, Altomonte et al. (2010) allow for variation in differentiation across subsets of varieties, but keep it constant within each subset. In terms of the present framework, a constant degree of horizontal differentiation means that all the varieties are equidistant from representative consumer's tastes, thus muddling up the effects of substitutability and differentiation. Whereas in the context of CES models this constraint may still appear technically insurmountable, this is not the case for the Ottaviano et al. (2002) quadratic utility function, which can be straightforwardly generalized to account for both vertical and horizontal idiosyncratic differentiation.

A brief review of past attempts to embed vertical and horizontal differentiation into trade theory may help better illustrate how the framework proposed in this Chapter relates to previous works. Indeed, in the same years in which Dixit and Stiglitz (1977) and Krugman (1980) proposed their monopolistic competition models where an explicit

⁶See, for example, Baldwin and Harrigan (2011); Hallak (2004); Johnson (2012); Verhoogen (2012) and Verhoogen (2008)

accounting of differentiation was sacrificed in favor of tractability and variable prices and quantities, a parallel strand of literature focused on horizontal and vertical differentiation in frameworks where a consumer is called to a fixed quantity of a certain good, choosing among mutually exclusive varieties (Gabszewicz et al., 1981; Salop, 1979). While initially more focused on abstract equilibrium properties and characteristics (Gabszewicz and Thisse, 1980), concerns over empirical relevance grew increasingly important in the field and finally exploited the intuition of Lancaster (1966) to decompose a good into a particular set of elemental characteristics to provide some elements of measurability of differentiation, as for example in Goldberg and Verboven (2001). This allowed recent empirical papers to follow Berry (1994) in describing demand through a discrete-choice model combining "*horizontal differentiation, in the sense that if the prices of all goods are equal each will be purchased with positive probability, with vertical differentiation, in sense that if the prices of all goods are equal higher-quality goods will be purchased with higher probability*" (Verhoogen, 2008). As Khandelwal (2010) notes, this methodology implies that products with large variation in prices could nonetheless possess little differences in quality.

Indeed, as long as quantities are held constant, both horizontal and vertical differentiations do necessarily affect prices. In the traditional framework in which it has been studied, then, the main differences between the two kinds of differentiation lies in whether consumers in the market are unanimous on the desirability of a certain attribute. In other words, paraphrasing Gabszewicz and Wauthy (2012) if the improvement on a certain product characteristic raises the willingness to pay of all the consumers, this attribute will be considered vertical. If, instead, a certain characteristic is welcomed by some consumers, but disliked by others, this will affect their willingness to pay in opposite ways and will be considered horizontal. This is in stark contrast with the model presented in this Chapter, where horizontal characteristics of a variety do not affect the profit maximizing price set by the firm. All the adjustments to differences in the horizontal dimension are shown to run through differences in quantities sold, which in this framework are allowed to vary. On the other hand, vertical characteristics in this framework coincide with the standard interpretation of a parallel demand shifter.

Summing up, by generalizing the utility function proposed by Ottaviano et al. (2002) a model of monopolistic competition can be obtained where idiosyncratic vertical and horizontal differentiation can be studied without holding quantities fixed. Thus insights developed by the literature on differentiation are merged with the empirical relevance of literature on intra-firm trade and heterogeneous firms. To do so, in this Thesis is based on a theoretical framework known for its tractability, yielding predictions consistent with recent empirical evidence and in line with current modeling efforts.

2.3 Chamberlin and Hotelling unified

There are several definitions of vertical and horizontal differentiation, which are (more or less) equivalent. Ever since Hotelling (1929) and Lancaster (1979), two varieties of the same good are said to be horizontally differentiated when there is no common ranking

of these varieties across consumers. In other words, horizontal differentiation reflects consumers' idiosyncratic tastes. By contrast, two varieties are vertically differentiated when all consumers agree on their rankings. Vertical differentiation thus refers to the idea of quality intrinsic to these varieties (Gabszewicz and Thisse, 1979; Shaked and Sutton, 1983). Such definitions of horizontal and vertical differentiation have been proposed for indivisible varieties with consumers making mutually exclusive choices. In what follows, first a standard model of differentiation is presented. Then, it is generalized to allow for consumers to buy more than one variety and the differentiated good to be divisible.⁷

2.3.1 The one-variety case

Consider an economy involving one differentiated good and one homogeneous good, which is used as the numéraire. There is one consumer who is endowed with income y . Consider one variety s of the differentiated good. The utility from consuming the quantity $q_s > 0$ of this variety and the quantity $q_0 > 0$ of the numéraire is given by

$$u_s = \alpha_s q_s - \frac{\beta_s}{2} q_s^2 + q_0,$$

where α_s and β_s are positive constants. The budget constraint is

$$p_s q_s + q_0 = y,$$

where p_s is the price of variety s . Plugging the budget constraint in u_s and differentiating with respect to q_s yields the inverse demand for variety s :

$$p_s = \max \{ \alpha_s - \beta_s q_s, 0 \}. \quad (2.1)$$

In this expression, p_s is the highest price the consumer is willing to pay to acquire the quantity q_s of variety s , i.e. her willingness-to-pay (WTP). When the good is indivisible, the WTP depends only on α and β . Here, instead, it declines with consumption, following the decrease in its marginal utility. As long as the WTP for one additional unit of variety s is positive, a consumer chooses to acquire more of this variety. In contrast, she chooses to consume more of the numéraire when the WTP is negative. The equilibrium consumption is obtained when the WTP is equal to zero. The utility u_s being quasi-linear, the above expressions do not involve any income effect. However, it is shown in the next Chapter that quadratic utility models can indirectly capture also the impact of income differences across markets.

2.3.2 The two-variety case: a spatial interpretation

Consider now the case two varieties, whose degree of substitutability is captured by a parameter $\gamma > 0$. The utility of variety $s = 1, 2$ is now given by

⁷Note that this approach, like most models of monopolistic competition, abstracts from the way product characteristics are chosen by firms. This issue has been tackled in a handful of theoretical papers (Hallak and Sivadasan, 2009) and analyzed empirically by Verhoogen (2012) and Eckel et al. (2011).

$$u_s = \alpha_s q_s - \frac{\beta_s}{2} q_s^2 - \frac{\gamma}{2} q_s q_r + q_0 \quad (2.2)$$

where q_r is the amount consumed of the other variety.

In this case, $\alpha_s - \gamma q_r/2$ is the marginal utility derived from consuming the first unit of variety s . It varies inversely with the total consumption of the other variety because the consumer values less variety s when the consumption of its substitute r is larger. Note that the intercept is positive provided that the desirability of variety s (α_s) dominates the negative impact of the consumption of the other variety, q_r , weighted by the degree of substitutability between the two varieties (γ). As q_s increases, the WTP of this variety decreases and variety s is consumed as long as its WTP is positive.

Repeating the above argument, the WTP of variety s becomes

$$p_s = \alpha_s - \beta_s q_s - \frac{\gamma}{2} q_r. \quad (2.3)$$

Compared to (2.1), the WTP for variety s is shifted downward to account for the fact that the two varieties are substitutes; the value of the shifter increases with the total consumption of the other variety and the degree of substitutability.

Following the literature, two varieties are said to be vertically differentiated when consumers view the vertical characteristics of variety 1 as dominating those of variety 2. Therefore, it is said that varieties 1 and 2 are vertically differentiated when all consumers' WTP for the first marginal unit of variety 1 exceeds that of variety 2, i.e. $\alpha_1 > \alpha_2$. The increase of WTP in α_s thus implies that this parameter captures the vertical characteristics embodied in the differentiated product. Consequently, it seems natural to interpret α_s as a measure of the *quality* of variety s . Since the WTP for a variety decreases with its level of consumption, an alternative definition would be to say that varieties 1 and 2 are vertically differentiated when $\alpha_1 - \beta_1 q > \alpha_2 - \beta_2 q$ for all $q > 0$. However, this definition overlaps with the definition of the WTP that captures more features than vertical attributes only. In this respect, it can be expected that the WTP of a variety also depend on its horizontal attributes.

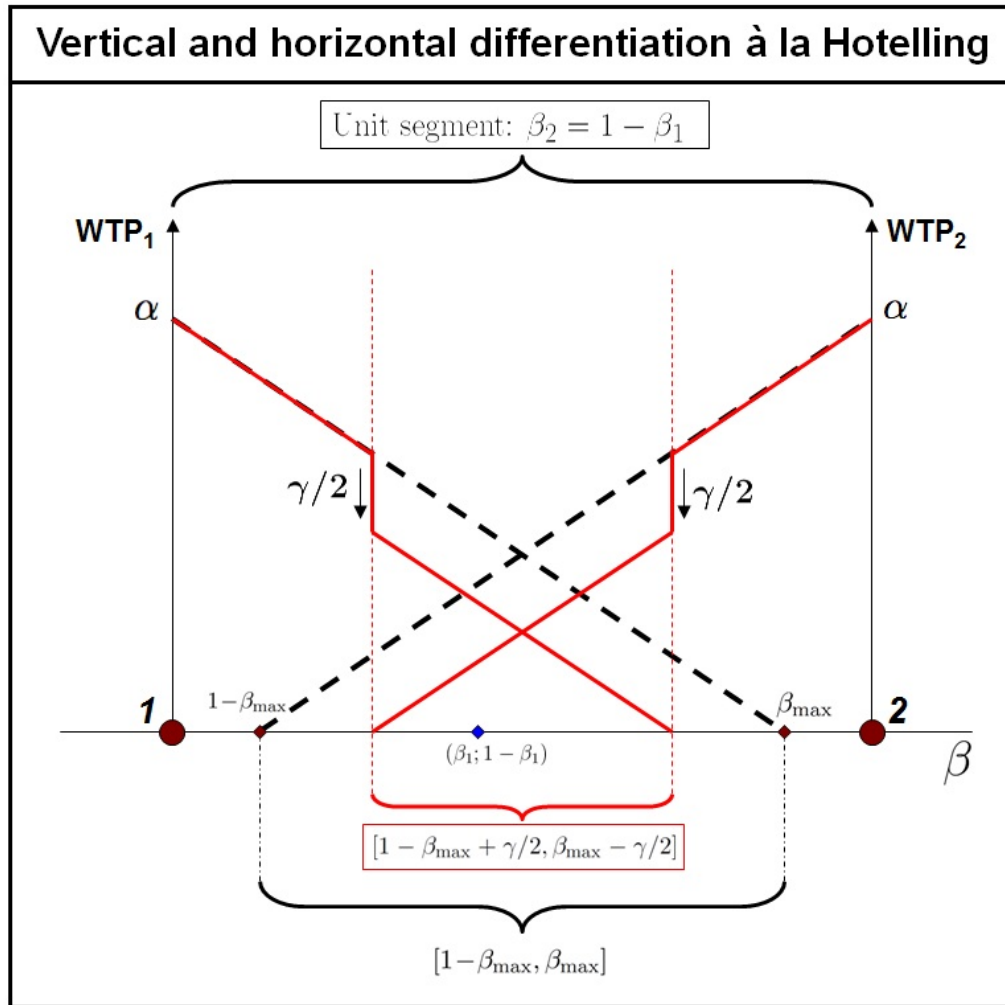
Turning to the interpretation of parameter β_s . It is generally recognized that the best approach to the theory of differentiated markets is the one developed by Hotelling (1929) and Lancaster (1979) in which products are defined as bundles of characteristics in a multi-dimensional space. In this respect, one of the major drawbacks encountered in using aggregate preferences such as the CES and quadratic utility models is that a priori their main parameters cannot be interpreted within a characteristics space.⁸ This is why it is critical to provide an unambiguous interpretation of β_s within the Lancasterian framework, each parameter of the model developed here is given a precise and specific definition. In addition, the differentiated good being divisible, the interpretation of these parameters must be independent of the unit in which the good is measured.

⁸Anderson et al. (1992) have pinned down the Lancasterian foundations of the CES utility. To be precise, they show that there exists a one-to-one relationship between the elasticity of substitution across varieties and the distance between these varieties in the characteristics space: the larger the distance between varieties, the smaller the elasticity of substitution.

The spatial metaphor involves a continuum of heterogeneous consumers. Whereas in Hotelling's model consumers are assumed to make mutually exclusive purchases, in the verti-zontal model they are allowed to visit several shops. In the spirit of spatial models of product differentiation, first consumers are assumed to buy one unit of the good in each shop they visit, an assumption that will be later relaxed.

In Figure 2.4, a spatial setting is depicted in which varieties/shops $s = 1$ and $r = 2$ are located at the endpoints of a unit segment, where $\alpha_1 = \alpha_2 = \alpha$ and $\beta_2 = 1 - \beta_1 > 0$. Using (2.3), the WTP for, say, variety 1 has an intercept equal to $\alpha - \gamma/2$, while β_1 is the distance between shop 1 and consumers, the transport rate being normalized to 1. The consumer's WTP for variety 1 equals zero at $\beta_{\max} = \alpha - \gamma/2$.

Figure 2.4: Graphical intuition of the spatial problem



Treading in Hotelling's footsteps, it can be said that a consumer located at $\beta_1 \in [0, \beta_{\max}]$ is willing to buy variety 1 when her WTP for one unit of the good from shop 1 is positive, that is, when the distance to this shop is smaller than $\beta_{\max}$. Therefore, a high (low) value of β_1 amounts to saying that the consumer is far from (close to) shop 1. As a result, β_s in (2.2) may be viewed as a parameter expressing the *idiosyncratic mismatch* between the horizontal characteristics of variety s and the consumer's ideal. This interpretation of β_s is nicely related to the concavity of u_s . As the mismatch between variety s and the consumer's ideal horizontal characteristics β_s increases, it is natural to expect the consumer to reach faster the level of satiation. In other words, if the consumer prefers vanilla to chocolate as an ice-cream flavor, the utility of an additional chocolate scoop will decrease faster than that of a vanilla scoop.

Turning to the links between the above spatial setting and a model of monopolistic competition, when $\beta_1 < \beta_{\max}$, the consumer visits at least shop 1. However, as long as $\alpha - \gamma/2 - \beta$ is positive at $1/2$, then there is another segment $[1 - \beta_{\max}, \beta_{\max}]$ in which both $\alpha - \gamma/2 - \beta_1$ and $\alpha - \gamma/2 - (1 - \beta_1)$ are positive. Indeed, since consumers have a love for variety, a consumer located in the vicinity of $1/2$ may want to visit both shops. For this to happen, it should be accounted that the consumer has already acquired one unit of the good so that the two WTP-lines shift downward by $\gamma/2$. Therefore, the segment over which both shops are actually visited is narrower than $[1 - \beta_{\max}, \beta_{\max}]$ and given by $[1 - \beta_{\max} + \gamma/2, \beta_{\max} - \gamma/2]$. Consequently, when the consumer is located at $\beta_1 < 1 - \beta_{\max} - \gamma/2$ she visits shop 1 only, whereas she visits both shops when her location belongs to $[1 - \beta_{\max} + \gamma/2, \beta_{\max} - \gamma/2]$.

The foregoing argument shows how the spatial model can cope with consumers buying one or two varieties of the differentiated good. In particular, regardless of her location β_1 , any consumer acquires the two varieties when the interval $[1 - \beta_{\max} + \gamma/2, \beta_{\max} - \gamma/2]$ is wide enough. This will be so if and only if

$$\alpha - \gamma > 1.$$

This condition holds when the desirability of the differentiated good is high, the substitutability between the two varieties is low, or both.

Conversely, it is readily verified that, regardless of her location, the consumer acquires a single variety if and only if

$$1 > 2(\alpha - \gamma) \Leftrightarrow \gamma > \alpha - \frac{1}{2}.$$

In other words, when varieties are very good substitutes, consumers choose to behave like in the Hotelling model: despite their love for variety, they patronize a single shop because the utility derived from buying from the second shop is overcome by the cost of patronizing this shop. In particular, consumers located near the ends of the segment buy only one variety and consumers located in the central area buy both if and only if

$$\alpha - \gamma < 1 < 2(\alpha - \gamma).$$

Note that, when α is sufficiently small, a consumer located in the central area does not shop at all because both her desirability of the differentiated good is low and her

taste mismatch is high. In the standard Hotelling framework, this corresponds to the case in which the price of the good plus the transport cost borne by the consumer exceeds her reservation price.

Summing up, it would be fair to say that the preferences (2.2) encapsulate both vertical (α_s) and horizontal (β_s) differentiation features. This specification is also flexible enough to retain the tractability of the standard quadratic utility model.

2.3.3 A multi-dimensional generalization of the spatial interpretation

In order to adhere as closely as possible to the original description of the Hotelling (1929) spatial problem, a two-dimensional representation has been initially adopted, with a continuous segment of consumers and two goods at its extremity. While simple and intuitive, there are obvious limitations in adopting such a form of representation alone. For example, it would be impossible to introduce a third good with horizontal differentiation equally distant from the other two and one consumer or, more in general, there may be goods' location properties and relations which strictly depend on the definition of the horizontal differentiation space as a simple segment.

Therefore, it is now proposed a slightly more general way of visualizing the spatial problem that can be described by a quadratic utility function. Horizontal differentiation is still captured by the parameters β , but this is now defined over two independent dimensions of differentiation on two axes. In practice, consumers are now located (in terms of their ideal horizontal variety characteristics) on a continuous plane defined over the dimensions β' and β'' . For example, Figure 2.5 describes in three dimensions the same spatial distribution of consumers and the two goods as in the two-dimensional Figure 2.4 without substitution effects. For the correspondence between Figures 2.4 and 2.5 to be exact, imagine initially that in Figure 2.5 all consumers are defined by the same ideal location on β'' and the only difference is over their β' position between the two varieties. In this case, Figures 2.4 would be the equivalent of Figure 2.5 also in terms of representation. Figure 2.4 can then be seen as a special case of the three-dimensional representation shown in this subsection, where instead consumers are characterized by the coordinates $(\beta'_1; \beta''_1)$.

Taking also the substitution effect into account, the three-dimensional representation of Figure 2.4 is illustrated in Figure 2.6. In fact, also the intuition is exactly the same as in Figure 2.4. Every consumer that consumes either one of the products see her willingness to pay for the other decrease by the degree of substitution γ times the quantities consumed, which is for the moment fixed to unity per variety consumed.⁹

⁹Remember that in the spatial metaphor adopted here quantities represent the slope of the WTP function, therefore a visual representation not exploiting the indivisibility assumption would result in complex and would require additional assumptions on the market structure to determine the quantities sold of each variety.

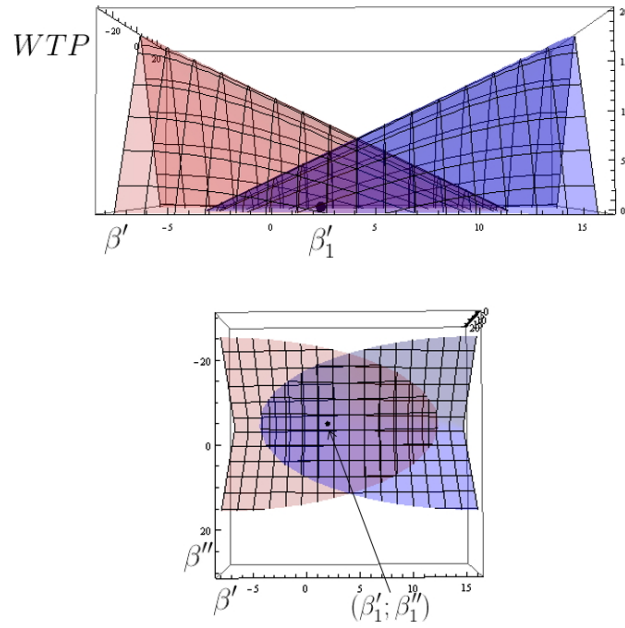


Figure 2.5: Three-dimensional representation of the Hotelling (1929) problem, corresponding to Figure 2.4, without substitution effects

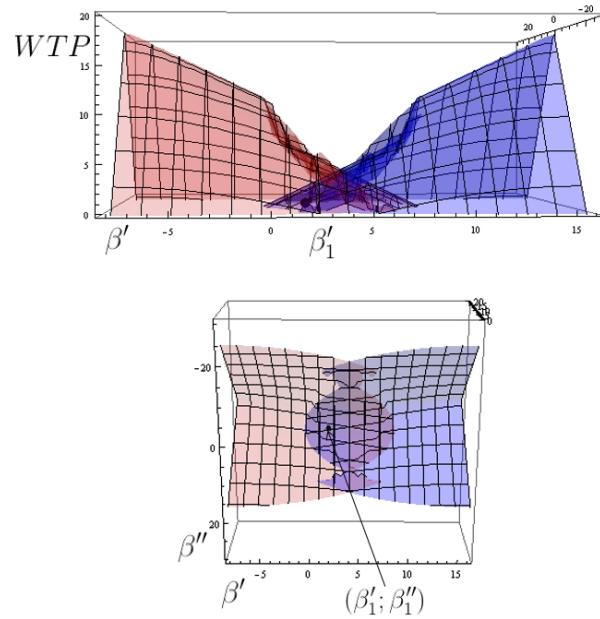


Figure 2.6: Three-dimensional representation of the Hotelling (1929) problem, corresponding to Figure 2.4, with substitution effects

The most visible difference induced by the introduction of an additional horizontal dimension of differentiation is that the willingness-to-pay functions are not represented by a two-dimensional line, but by three-dimensional cones whose base lies on the two-dimensional horizontal differentiation space and whose height coincides with the value of the vertical differentiation parameter α (or $\alpha - \gamma$ if a positive amount of the other variety is consumed). As in the two-dimensional example, the apex of the cone lies in correspondence of the coordinates $(\beta'_1; \beta''_1)$ describing consumers whose ideal variety characteristics are identical to the actual characteristics of the variety. This particular shape is due to the fact consumers whose ideal characteristics coincide with the characteristics of a variety will have the highest willingness to pay for that particular variety and, as the characteristics of the variety move further away from the consumers' ideal, the value attributed by the consumer to one unit of that particular variety decreases until it becomes null.¹⁰ For example, if the ideal horizontal characteristics' coordinates of consumer 1 are $(\beta'_1; \beta''_1)$, then her willingness to pay for variety s , $p_{s,1}$ can be computed as

$$p_{s,1} = \alpha_s - [(\beta'_1; \beta''_1) - (\beta'_s; \beta''_s)] \Rightarrow p_{s,1} = \alpha_s - \left[(\beta'_1 - \beta'_s)^2 + (\beta''_1 - \beta''_s)^2 \right]^{\frac{1}{2}}.$$

Focusing on one variety, for example, Figure 2.7 shows the willingness to pay for that particular variety for each consumer in the continuum (represented, for the sake of illustration, by the gray dots). Therefore, when $(\beta'; \beta'')$ describe both consumer 1's ideal and a particular variety location (which can also be seen as $\Delta\beta' = \Delta\beta'' = 0$), then the willingness to pay for that variety is equal to the quality parameter α_s associated with that variety. As shown in Figure 2.7, a threshold distance in taste mismatch can be identified beyond which consumers are not interested in purchasing one unit of the variety s . In other words, some consumers may not be willing to give away any positive amount of their numéraire to purchase it, even if they recognize the presence of a positive vertical differentiation.¹¹ Of course, the spatial distribution of those consumers who are indifferent between buying the variety and holding the numéraire in the two-dimensional horizontal characteristics space has the shape of a circle in the stylized framework proposed here.

As in the two-dimensional case, the overlap between the willingness-to-pay cones of two different varieties, when positive, imply a parallel shift downwards for both, proportional to the quantities consumed and the level of substitutability between the different varieties. In the absence of substitution (i.e., for $\gamma = 0$) the two cones would be unaffected, as shown in Figure 2.8.

¹⁰For the sake of tractability, in this example it is assumed that all the consumers give exactly the same weight to the two dimensions of horizontal differentiation in such a way that their taste mismatch can be measured simply as the distance between each consumer (represented by the gray dot) and the variety's characteristics (whose exact position on the $\beta'; \beta''$ coordinates is just under the tip of the cone).

¹¹As a side note, in an earlier version of this research this behavior of consumers, resulting from the interaction of vertical and horizontal characteristics, had been described using the only apparently self-contradictory expression "it's very good, but I don't like it", or rather "It's very good but I don't buy it".

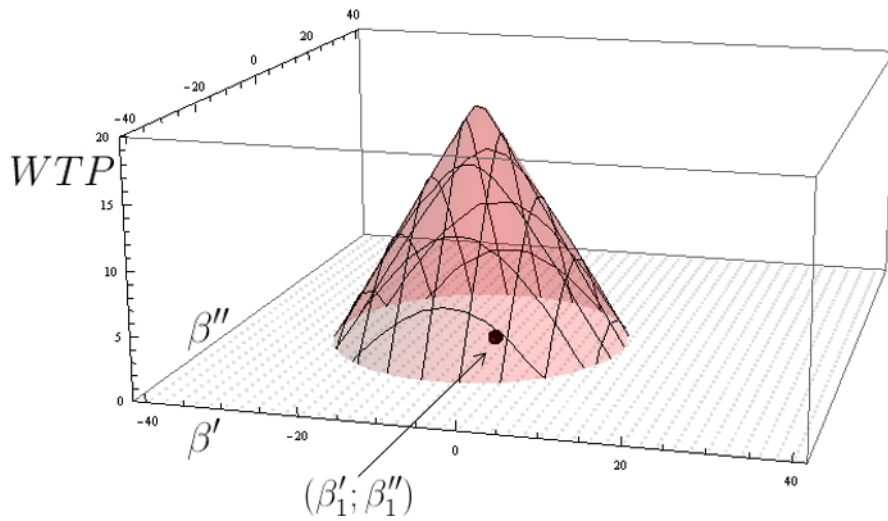


Figure 2.7: Three-dimensional representation of one variety and a continuum of consumers

In the more likely circumstance of a positive degree of substitutability ($\gamma > 0$), instead, the WTP cones would be affected as shown in Figure 2.9. Comparing Figures 2.8 and 2.9 the three cases can be illustrated: the first is of a consumer (Consumer 1) consuming only one variety, with or without substitution effects; the second is the case of a consumer (Consumer 2) that would consume the two varieties without in the absence of substitution (Figure 2.8) but consumes only one of the two once substitution is taken into account (Figure 2.9); the third of a consumer (Consumer 3) purchasing the two varieties in any case, even in the presence of substitution effects, with the only difference being that when substitution is included she is willing to pay less for each of the two varieties, hence the downward shift in the cones' representation. Notice that, in standard Industrial Organization location theories, varieties are mutually exclusive, so that consumers may not end up buying more varieties at the same time, which is a possibility granted in the framework proposed here. This property turns out to be rather useful when the indivisibility assumption is relaxed, in order to fully bridge the gap between location and trade theories.

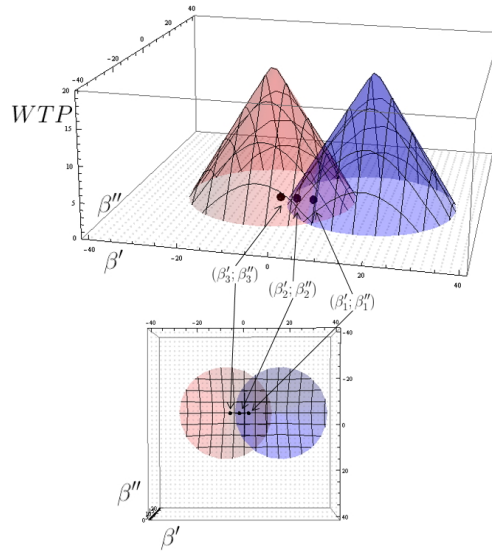


Figure 2.8: Three-dimensional representation of two varieties and three consumers without substitution effects

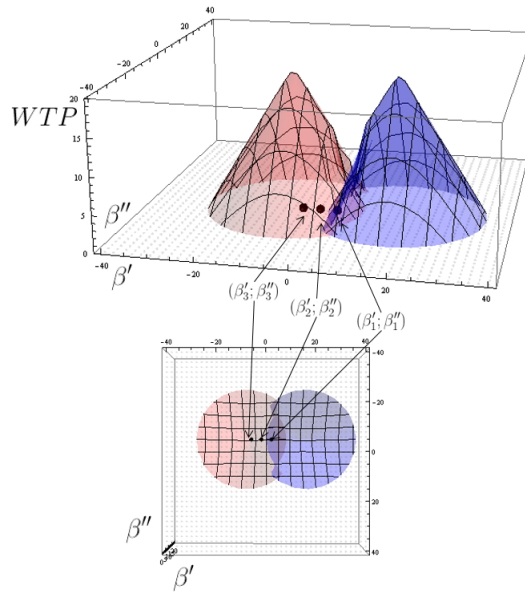


Figure 2.9: Three-dimensional representation of two varieties and three consumers with substitution effects.

One of the advantages of this three-dimensional representation is that it clearly highlights the interaction between different varieties for each consumer (which can be interpreted also as a representative consumer and thus a market). Up to this moment only examples with two varieties have been proposed, but it is now straightforward to introduce more varieties into the picture and visualize the impact on the willingness to pay for each variety. To this end, in Figure 2.10 it is shown, with and without substitutability effect, the case of a consumer (Consumer 4) that consumes three of the five vertically and horizontally differentiated varieties produced present in the product space. For the sake of illustration, it can be noted that the two varieties not consumed are the one with the highest quality α but, given their distance on the horizontal characteristics space from the ideal of Consumer 4, her willingness to pay for one unit of those particular varieties is lower than the value of the numéraire which the consumer should use to purchase them.

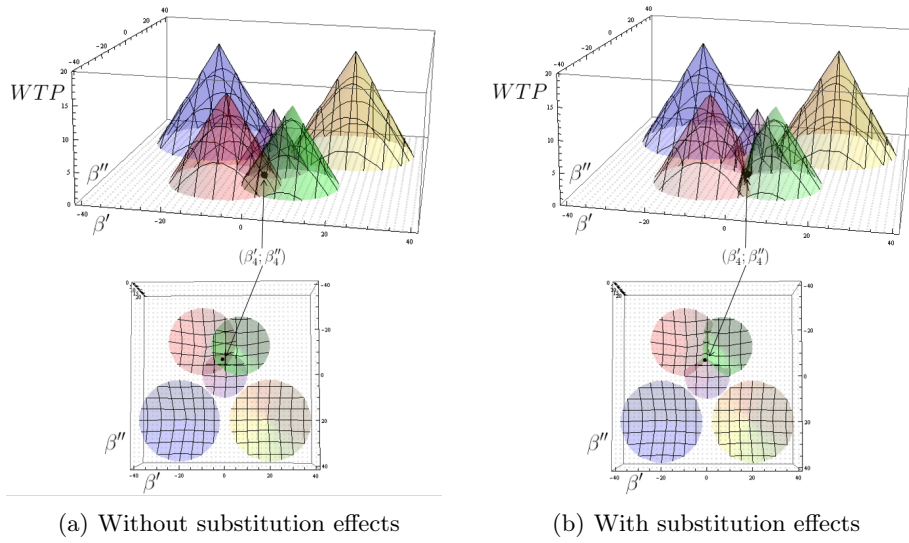


Figure 2.10: Three-dimensional representation of five horizontally and vertically differentiated varieties

Finally, it is possible now to provide some early intuition on some concepts that will be introduced in the next Chapter of the thesis, where different variations of the quadratic utility are analyzed. Remembering that at this stage the framework in place still holds the quantities sold of each variety as indivisible, it is possible to show how a purely horizontal and purely vertical differentiation problem would be represented à la Hotelling (1929) in three dimensions. Figure 2.11 shows the three-dimensional representation of pure horizontal differentiation ($\alpha_s = \alpha$ for all consumers) and Figure 2.12 shows the three-dimensional representation of pure vertical differentiation in the characteristics space ($\beta_{s,i} = \beta$ for all consumers). However, before being ready to apply this framework to trade, a further step is needed: the relaxation of the indivisibility assumption, whose consequences are now discussed.

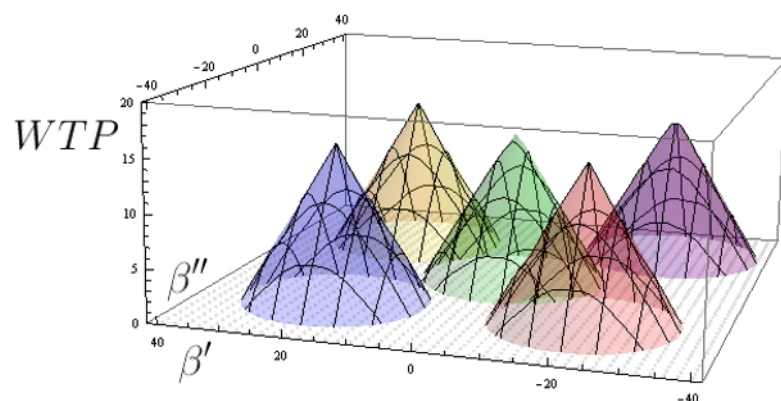
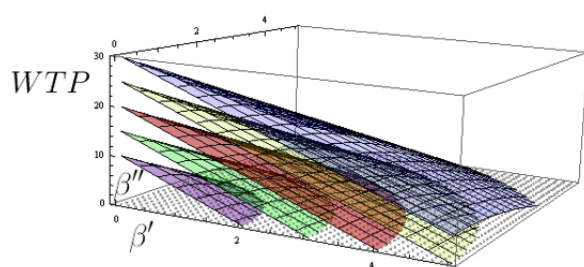
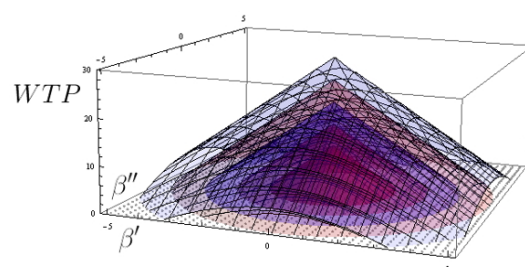


Figure 2.11: Three-dimensional representation of pure horizontal differentiation



(a) Section of the cone



(b) entire cones

Figure 2.12: Three-dimensional representation of pure vertical differentiation

2.3.4 Relaxing the indivisibility assumption

As stressed in the foregoing, in the product differentiation framework presented up to this point consumers can only decide whether to buy a fixed quantity of units of the varieties at hand. The only difference between the varieties bought lied on the consumers' willingness to pay for one unit of those varieties. The assumption of indivisibility, used for the sake of illustration, is from now on relaxed and so consumers are allowed to choose also how much to buy of each variety. In this way, the framework becomes directly comparable to existing monopolistic competition trade models and can be directly applied to the data.¹²

However, before turning to the divisible case, it is important to understand the implications of holding quantities fixed, as it is an assumption usually exploited in models such as the discrete choice models whose implications are often overlooked. Indeed, in the example involving a fixed $\bar{q}$, the impact of taste (β) and quality (α) on the willingness to pay, and thus observed prices, may appear similar. A visual intuition is proposed in Figure 2.13.

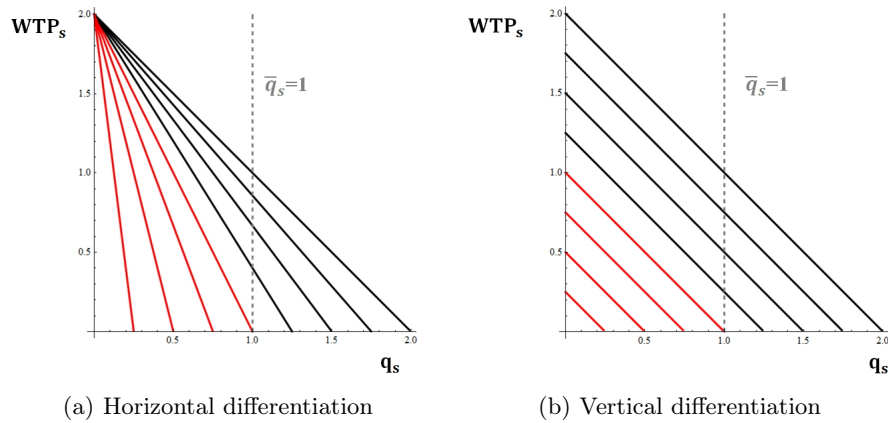


Figure 2.13: Indivisibility assumption and product differentiation

Notice that in Figure 2.13 on the vertical axis there is still the willingness to pay, as in the previous graphs, but on the horizontal axis now are shown the quantities purchased resulting from the utility system expressed in equation (2.2) yielding a linear demand as in (2.3). In red are varieties which will not be consumed because one of their units is not considered worth enough by the consumer i ; in black are varieties to which consumer i attributes a positive value in terms of the numéraire. Horizontal differentiation is then displayed on the left pane. Changes in β_s do not shift the vertical intercept (where $q = 0$) but affect the slope of the willingness-to-pay function as q_s increases. Vertical

¹²The assumption of fixed quantities consumed will be exploited in the rest of the Thesis only for graphical illustration purposes, to represent consumers' willingness to pay for a particular variety as a function of its location in a way that follows the representation used in this Chapter.

differentiation is shown instead on the right pane. Here notice that changes in α_s are mapped into parallel shifts in demand. In the next Chapter it will be shown that whereas the latter affect profit-maximizing prices, the former doesn't, but then why this is not the case under the indivisibility assumption? The answer becomes clear by looking at Figure 2.13. When quantities are fixed, indeed, both vertical and horizontal differentiations have an impact on the willingness to pay of consumers because of the artificial rationing imposed by a discrete binary choice between buying or not. Therefore, in models of discrete choice where individual binary choices are aggregated into market statistics it becomes extremely difficult to distinguish between vertical and horizontal differentiation by looking at prices and quantities (which is an appealing feature of quadratic utilities on which the rest of the Thesis relies heavily). To illustrate this point in Figure 2.14 the WTP functions of varieties with different combinations of vertical and horizontal attributes have been plotted together. It can be noticed that some of these combinations may be associated with the same prices (and, by construction, the same quantities). This is for example the case of variety $(\alpha = 1; \beta = .5)$ and variety $(\alpha = 1.5; \beta = 1)$, represented by dashed blue linear demand segments, for both of which consumer i is willing to pay $p = .5$ to buy $\bar{q} = 1$ units, abstracting for simplicity from substitutability effects (which would in any case just shift the two demands in an identical, parallel way).

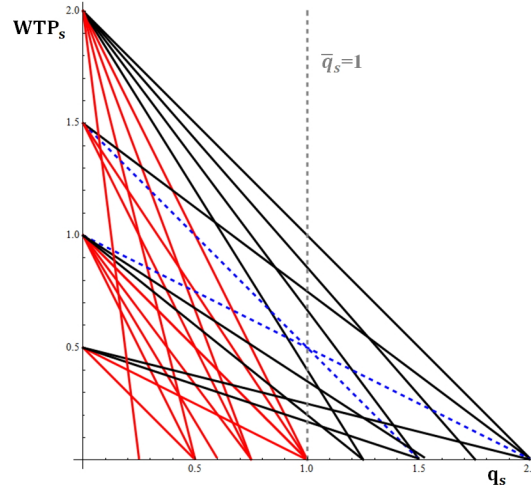


Figure 2.14: Vertical and horizontal differentiation and prices under the indivisibility assumption

However, it is not a priori clear whether a quadratic utility framework is always superior to a discrete choice framework. There are admittedly certain categories of purchases for which the indivisibility assumption is extremely reasonable: buying a house, a car, or any other item whose unit price may represent a significant share of a consumer's income are typical examples. A quadratic utility with a clear distinction between horizontal and vertical features of a product may instead be more reasonable in the context of recurrent small purchases such as clothes, domestic mechanical appliances, food and so on. In the

field on Industrial Organization it is commonly accepted that different products and market structures require different analytical frameworks; in the field of international trade it is more common to look for one particular preference and market structure fitting the data as well as possible. In this Thesis the latter approach is followed and the empirical Chapters are dedicated to show how well some variations of quadratic utilities perform in describing trade patterns.

Multiple varieties are now introduced in the picture. Then, in the next Chapter the different possible variations of the general framework presented in this Chapter are analyzed in detail.

2.3.5 The multi-variety case

Finally, after having shown the single-variety case and the extension to two varieties and different dimensions of horizontal differentiation, it is worth turning the attention towards the multi-variety case, in which consumers are allowed to buy any quantity of each variety. Notice that it doesn't matter what are the actual product features are associated with vertical and horizontal characteristics, as long as all the consumers agree on desirability of some features and their presence is a variety, determining α_s . As for the horizontal characteristics, they are by definition either not desired by all the consumers to the same extent or not perceived by all the consumers as being present to the same extent in a variety, so they are captured by the variety-consumer-specific $\beta_{s,i}$. The parameters α_s and $\beta_{s,i}$ can thus be interpreted as aggregate indices of characteristics for each variety (in the case of vertical differentiation) and variety-consumer (the multi-dimensional distance in the characteristics space between the consumer and the variety). For notational simplicity, the case can be made for one market whose demand side is represented by a representative consumer indexed by i and consider the standard setting of monopolistic competition in which the differentiated good is available as a continuum $S_i \equiv [0, N_i]$ of varieties, where N_i is the mass of varieties. The utility derived from the consumption of variety s is now given by

$$u_{s,i} = \alpha_s q_{s,i} - \frac{\beta_{s,i}}{2} q_{s,i}^2 - \frac{\gamma}{2} q_{s,i} \left[\int_{S_i} q_{r,i} dr \right] + q_0, \quad (2.4)$$

where the parameter α_s coincides with the vertical axis intercept of the willingness-to-pay function for variety s and $\beta_{s,i}$ represents its distance on the horizontal characteristics space from the consumer, concentrating into one distance index all the possible dimensions of horizontal differentiation. The parameter $\gamma > 0$ captures the degree of substitutability between variety s and the total consumption of the differentiated good, Q_i (it is reasonable also to assume that $\gamma < \beta_{s,i}$ in every market, because γ captures the discount in utility derived from the consumption of different varieties of the same good and $\beta_{s,i}$ the discount derived from the consumption of exactly the same variety of the same good). In this expression, γ measures the substitutability between variety s and any other variety $r \in S_i$. Consequently, the two-variety willingness-to-pay function in

equation (2.3) generalizes into

$$p_{s,i} = \alpha_s - \beta_{s,i} q_{s,i} - \frac{\gamma}{2} \left[\int_{S_i} q_{r,i} dr \right]. \quad (2.5)$$

Compared to (2.1), the WTP for variety s is shifted downward to account for the fact that all varieties are substitutes; the value of the shifter increases with the total consumption of the differentiated good and the substitutability across varieties.

Integrating (2.4) over the set S of varieties consumed, and including an outside good q_0 to act as a numéraire, yields the utility function

$$U_i = \int_{S_i} \alpha_s q_{s,i} ds - \int_{S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{\gamma}{2} \left[\int_{s \in S_i} \int_{r \in S_i} q_s q_r ds dr \right] + q_0 \quad (2.6)$$

where α_s and $\beta_{s,i}$ are two positive and continuous functions defined on S_i , the former measuring the intrinsic quality of variety s and the latter capturing the distance between the consumer's ideal and variety s . Notice that when all the varieties are defined by the same quality and taste mismatch, i.e. $\alpha_s = \alpha$ and $\beta_{s,i} = \beta$, the equation (2.6) coincides with the utility function used in Melitz and Ottaviano (2008). Given the budget constraint

$$\int_{S_i} q_{s,i} p_{s,i} ds + q_0 = y_i,$$

using (2.5) it can be readily seen that the demand for variety s is given by

$$q_{s,i} = \frac{\alpha_s - p_{s,i}}{\beta_{s,i}} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \gamma \mathbb{N}_i)} \quad (2.7)$$

where

$$\mathbb{N}_i \equiv \int_{S_i} \frac{dr}{\beta_{r,i}} \quad \mathbb{A}_i \equiv \int_{S_i} \frac{\alpha_r}{\beta_{r,i}} dr \quad \mathbb{P}_i \equiv \int_{S_i} \frac{p_{r,i}}{\beta_{r,i}} dr.$$

Thus, like in most models of monopolistic competition, the individual demand for a variety (2.7) depends on a few *market aggregates*, here $\mathbb{N}_i$, $\mathbb{A}_i$ and $\mathbb{P}_i$. Using the spatial interpretation of $\beta_{s,i}$ given above, it is straightforward that a group of varieties r , characterized by small (large) values of $\beta_{r,i}$, have a strong (weak) impact on the demand for variety s because consumers are (not) willing to buy much of them, as they (dis)like its horizontal characteristics better than those of r . This explains why $\beta_{s,i}$ appears in the denominator of the aggregates $\mathbb{N}_i$, $\mathbb{A}_i$ and $\mathbb{P}_i$.

Remark that, for the sake of tractability, the substitutability parameter has been considered constant across pairs of varieties in this Chapter, how in the next it will also be allowed to vary to show an additional layer of flexibility that can be added to the model.

2.4 Alternative approaches in the literature

It should be noticed that the approach presented in this Chapter blurs the boundaries between unit consumption models and continuous consumption models, extending the

results from one to the other. This objective is not achieved through the aggregation of discrete choices of individual consumers, as Anderson et al. (1992) do, but through the introduction of some degree of substitutability between the different varieties purchased in arbitrary quantities by one representative consumer. A discussion to clarify the differences between these two approaches is due.

First of all, it should be remembered that the unit consumption model, or the unit purchase model, are models where each consumer buys only one unit of a variety, which is characterized by specific "underlying hedonic attributes" (Mussa and Rosen, 1978) which can be defined over one or more dimensions. For example, Gabszewicz and Wauthy (2012) nest horizontal and vertical differentiation in a Hotelling framework and explore the properties of the resulting model where consumption is mutually exclusive (as opposed to the model presented in this Chapter).

Relaxing unit consumption of mutually exclusive goods in such a framework, while at the same time defining general properties and proving the existence and uniqueness of an equilibrium market outcome, has proven an extremely delicate exercise. It has been undertaken by Gabszewicz and Wauthy (2003) for substitutes goods and Gabszewicz et al. (2001) for complementary goods in a Hotelling model with the possibility of joint purchases, but in order to keep the preference settings general and tractable, the analysis is restricted to two varieties and unit consumption. Still, even this slight departure from Mussa and Rosen (1978) "is sufficient to dramatically alter the nature of price competition" (Gabszewicz et al., 2001).

Relaxing also the unit consumption and the definition of a finite number of varieties, as is done in this Chapter, makes a general characterization of the equilibrium properties of the setting in terms of the uniqueness and existence of a spatial equilibrium virtually impossible because of the multiple degrees of freedom (involving pricing, location and competitive interactions with the mass of other varieties).¹³ For this reason, the spatial metaphor linking the location theory and the continuous consumption model of monopolistic competition should not be interpreted as a micro-foundation based on a formal proof, but rather as an analogy aimed at interpreting the parameters of quadratic preferences in terms of an exogenous distribution of variety characteristics in the characteristics space. One way to look at it could be to assume each variety is assigned a random location in the characteristics space (determining its α and β in the representative consumer preferences) and the costs of adjustment are prohibitive.

Along these lines, but with the difference that consumers are assigned an exogenous location in the characteristics space, Carballo et al. (2013) propose a model where firms have to adapt their product to produce varieties that match consumer preferences in the horizontal characteristics space. Since consumers are assumed to purchase only varieties matching their taste, firms are willing to pay an adaptation cost to serve them. However, in that framework varieties with different locations in the horizontal characteristics space do not really compete with each other because non-ideal varieties are ignored by the

¹³Notice, however, that even the classic Hotelling problem has been shown by d'Aspremont et al. (1979) not to have a Nash equilibrium solution when selling prices and location are decided simultaneously and the costs associated with distance are low enough.

consumer. In fact, varieties with the same horizontal characteristics still compete in a way inspired by the location theory, à la Salop (1979) with consumers located around a circle, where each point of the circle indicate a possible variants of the same variety. Still, this means that the only difference between varieties is the size of the variant circle, which captures the possibility of differentiation of variants, and all variant in equilibrium enters symmetrically consumer preferences for a given variety, so the spatial dimension becomes irrelevant to the definition of the problem. In contrast, in the spatial analogy presented in this Chapter, consumers are allowed to purchase varieties that do not match their ideal, but do it a "walking cost" of β which makes their utility function more concave and their inverse demand function steeper, so they get sooner tired of consuming a variety, the further it is located from their ideal characteristics. The resulting total bundle of consumption, depending on individual horizontal and vertical characteristics of the mass of varieties consumed, has an impact on each variety through the substitutability parameter, γ .

One additional aspect of the analogy between the location and the trade theories presented here that deserves some attention is the scalar nature of the parameter β in quadratic utilities, which in reality derives from a vector in the characteristics space. The information on the particular space occupied by a variety in the characteristics space is not currently exploited in existing trade model based quadratic utilities. Concretely, this means that the substitutability parameter, γ , discounts the entire bundle of consumption, $Q = \int_{r \in S} q_r dr$, independently of its location. This information can be plugged back into the quadratic utilities (and application of this intuition are shown in the last Chapter of the Thesis), but the empirical tractability of the resulting model is substantially affected. Yet, in Chapter 4 it is shown how the vectorial nature of β and its components (potentially along different dimension of horizontal differentiation) can be taken into account through a factor analysis performed on a set of varieties. This means that, even if only the scalar component of the β resulting from the location metaphor is used for the definition of the consumer problem, it doesn't exclude the possibility of exploiting its spatial components in future developments of the theory.

There are, of course, alternative ways proposed in the literature to reconcile the location theory with non-localized competition mechanisms, even sticking to a unit consumption framework. For example Chen and Riordan (2007) proposes a "spokes model" where consumers have one favorite variety and have the same distance from all the others (having to walk from the tip of a spoke to the center and then back to the tip of another spoke), but the spatial dimension of the model they propose is very stylized and homogeneous (for all varieties except the consumer's favorite).

An alternative way to obtain a functional form describing the aggregate preferences of the representative consumer as in (2.4), starting from a unit consumption of a set of consumers would be the following, which is based on the intuition of Anderson et al. (1992).

Following the idea employed in Carballo et al. (2013), assume in each market i there is a share ϕ of consumers that are willing to buy a particular variety s . There is no heterogeneity in preferences and all the varieties are described by the same α and β in

every market, so that the only difference between markets is $\phi_{s,i}$, i.e. the number of consumers buy variety s in market i . In this case, the utility derived by each consumer from the consumption of any variety in any market is

$$u_{s,i} = \alpha q_{s,i} - \frac{\beta}{2} q_{s,i}^2 - \frac{\gamma}{2} q_{s,i} \left[\int_R q_r dr \right] + q_0, \quad (2.8)$$

where the last term represent the entire bundle of consumption of varieties $r \in R \in S$, with S being the total number of varieties in the market. Considering that a share $\phi_{s,i}$ of identical consumers buy the variety in each market, the preferences (2.8) can be aggregated as

$$u_{s,i} * \phi_{s,i} = (\alpha * \phi_{s,i}) q_{s,i} - \frac{(\beta_{s,i} * \phi_{s,i})}{2} q_{s,i}^2 - \frac{(\gamma * \phi_{s,i})}{2} q_{s,i} \left[\int_R q_r dr \right] + q_0 * \phi_{s,i}. \quad (2.9)$$

Substituting $\hat{u}_{s,i} = (u_{s,i} * \phi_{s,i})$, $\hat{\alpha}_{s,i} = (\alpha * \phi_{s,i})$, $\hat{\beta}_{s,i} = (\beta * \phi_{s,i})$, $\hat{\gamma}_{s,i} = (\gamma * \phi_{s,i})$ and $\hat{q}_0 = (q_0 * \phi_{s,i})$, then it is possible to rewrite (2.9) as

$$\hat{u}_{s,i} = \hat{\alpha}_{s,i} q_{s,i} - \frac{\hat{\beta}_{s,i}}{2} q_{s,i}^2 - \frac{\hat{\gamma}_{s,i}}{2} q_{s,i} \left[\int_R q_r dr \right] + \hat{q}_0. \quad (2.10)$$

Comparing the aggregate preferences expressed in (2.10) and in (2.4) there is one main difference: the parameters α and γ in (2.10) are market-variety-specific because they incorporate information on the market-variety-specific $\phi_{s,i}$. In other words, (2.10) can be interpreted as resulting from a market-variety-specific demand shock on each variety, yielding a functional form comparable to the one employed by Kneller and Yu (2008). From a theoretical point of view, one unfortunate property of this specification recognized by the authors is that it implies an inverted-U relationship between demand for a variety and its perceived quality, $\hat{\alpha}_{s,i}$ (i.e. above a certain threshold consumption levels, $q_{s,i}$, higher levels of $\phi_{i,s}$ would be associated with lower demand because of $\hat{\beta}_{s,i}$). One way to overcome this problem would be to have $\phi_{i,s}$ affecting only $\hat{\alpha}_{s,i}$ and not $\hat{\beta}_{s,i}$, but this would not be consistent with a standard aggregation of consumer utilities.

There is also an argument based on the stylized facts outlined at the beginning of the Chapter that would tip the balance in favor of the preferences as described in (2.4). In fact, quantities have been consistently found to be more variable than prices and markups in existing empirical studies. This argument will be explored in depth in Chapter 4, but even a cursory look at Figure 2.3 gives an idea of how price rankings correlate almost perfectly across markets while quantity rankings don't. The aggregation of individual utilities resulting (2.10) would not be consistent with the absence of variability in price rankings across markets, because of the market-variety-specific willingness to pay $\hat{\alpha}_{s,i}$ and substitutability $\hat{\gamma}_{s,i}$. However, this preliminary rejection of the model as derived from the aggregation of individual purchasing choices of unit quantities needs to be confirmed by a more careful analysis of the data. That will be done in Chapter 4, after having developed the model presented in this Chapter on the basis of the location theory into a full-fledged trade model.

2.5 From location theory to monopolistic competition: assumptions

In the next Chapter, the location model à la Hotelling presented here is turned into a trade model of monopolistic competition and solved as in a standard Chamberlinian setting. This approach deserves some discussion on the underlying model assumptions, in both the spatial setting and the non-spatial problem. In particular, two points are worth mentioning: the first is the impact of indivisibility in consumption on the interpretation of the parameters; the second is about the consideration of strategic interaction between producers.

As for the first point, the interpretation of the parameters is provided in a pure framework à la Hotelling, where consumers have to walk a certain distance β to reach a particular variety in the characteristics space in fixed quantities, $\bar{q}$. The cost associated with this distance is the purchased quantity, $\bar{q}$, which means that the larger the quantity consumer the more costly is to reach varieties that don't match perfectly consumer's taste. When quantities to consume are fixed exogenously in the model, as in the original Hotelling, the willingness to pay for a given variety is affected by distance β in a way that is not separable from the intrinsic quality level of the variety, α . For this reason, in unit consumption models is very difficult to design a way to disentangle empirically vertical from horizontal differentiation. Relaxing the assumption of fixed quantities, though, the price elasticity of demand ($\epsilon_{s,i}$) resulting from the preferences described in (2.4) is independent of β :

$$\epsilon_{s,i} = - \frac{p_{s,i}}{\alpha_s - p_{s,i} - \int_{S_i} q_{r,i} dr}.$$

Therefore, the first difference in assumptions between the location theory and the trade framework is the constraint on quantities to be consumed. The parameter β is thus interpreted as horizontal differentiation in the characteristics space in the trade model, but in practice it captures the convexity of the negative sub-utility derived from the consumption of a particular, which can be interpreted as an indicator of how quickly the consumer reaches satiation for a given variety (in terms of the numéraire). This is consistent with the interpretation given to the parameter β by the interpretation based on the location theory, because quantities consumed are there interpreted as the transport cost to reach the variety in the characteristics space. Hence, the more the consumer is purchasing of a variety that doesn't match her taste, the faster she reaches satiation.¹⁴ However, notwithstanding the coherence between the location-theory and trade-theory interpretation, it should be kept in mind that formally the β of the two settings are defined based on different modeling assumptions, which is way rather than a micro-foundation it would be suitable to describe the relation between the two as an analogy.

The second point, on strategic interactions, is also important in discriminating between the Chamberlinian framework and location theories. In the latter, competitors

¹⁴Needless to say, this distance in the characteristics space does not replace geographic distance in the trade model (even if geographic distance and taste mismatch are likely to be correlated, as discussed in the empirical Chapters 4 and 5), which is explicitly accounted for in setting the firms' pricing strategy.

are defined as a finite set of agents with whom the producer is supposed to enter into a sort of strategic interaction, be it in terms of location, or pricing strategy, or quality differentiation. When this number is assumed so high that each individual competitor is considered negligible, as in the theory of monopolistic competition, the trade framework departs significantly from standard location theories à la Mussa and Rosen (1978) and it poses some problems in finding a spatial equilibrium solution to the resulting model. While this issue will be better presented in the last Chapter, together with an outline of a possible solution left for future research, it should be reminded here that the location of firms is, for the moment, assumed exogenous, as discussed above. In practice, the trade model that is developed in the next Chapter can be used to identify the distance of each variety from the consumer in the characteristics space, $\beta_{s,i}$, and its quality, α_s , but these two parameters are taken as exogenous draws (consistently with the trade literature) and not as the result of an optimization process where firms locate in the characteristics space in a profit-maximizing way.

The discussion on these two points, together with the tradition of using a perfect competition setting in location theories, show how challenging still is to draw direct connections between the two frameworks and reducing the discrepancies between models inspired by Hotelling and Chamberlin, but hopefully it also shows that these differences can be dealt with in a clear and transparent way by identifying the critical links and solutions to fix them.

2.6 Concluding remarks

The discussion in this Chapter has shown one possible way of introducing heterogeneity across varieties on the consumer side of trade models in order to better fit the data. It has been claimed that it is possible to generalize spatial models à la Hotelling to develop functional forms that mimic Chamberlinian models of monopolistic competition while providing a justification for its sources of variability. Rather than providing a formal micro-foundation of a connection between monopolistic competition and location theories, this Chapter shows one possible way of generalizing the former into the latter.

The advantage of interpreting monopolistic competition models in terms of location theory is twofold: the first is to show that fruitful connections can be drawn between the fields of Industrial Organization and Trade by illustrating that the same functional form can describe the seemingly unrelated problems of spatial and monopolistic competition location by just adding or relaxing restrictions on consumer behavior. The second is that such, by looking at the product characteristics in terms of vertical and horizontal differentiation, the relations between each pair of varieties can be identified and studied (which would not be the case in an pure, abstract Chamberlinian differentiation space), as will be shown in the next Chapter. This new way of looking at "localized competition problems" in a typically non-localized monopolistic competition setting, paves the way to a whole new set of interesting research avenues, some of which are discussed in the last Chapter of this thesis, building upon the trade models presented in the next Chapter.

In particular, in Chapter 3 the insights presented in the Chapter are further developed

and combined with supply side heterogeneity to better investigate the most suitable variations of a quadratic utility to deal with different issues in the trade domain and their empirical relevance, which is then tested in Chapter 4.

Chapter 3

Quadratic flexibility: some alternative models

In this Chapter the preference structure presented in Chapter 2 is turned into a full-fledged trade model. After a brief clarification on the general framework and terminology adopted, it presents the technical innovations that can be introduced in a standard quadratic utility model, first presented in isolation and then together, resulting in eight variations of the model. The properties of each variation are discussed in terms of the underlying spatial problem described and market outcomes, followed by an illustration of the properties through simulations, to help intuition. In this way it will be possible to easily grasp the implications of each change in the original specification and to understand the role played by each individual source of heterogeneity, alone and combined.

General properties of the framework common to all the variations are then illustrated, focusing in particular on the implicit functional relation between firms' profits and consumer surplus in quadratic utilities and on the possibility of accounting explicitly for income differences in quadratic preference models. This is followed by a summary of all the properties discussed and a table where all the functional forms are juxtaposed to clarify the links between sources of heterogeneity and the corresponding properties of market outcomes.

Finally, a preferred variation, the verti-zontal model, is identified to be taken to the data in the next Chapters and some propositions on the policy and modeling implications of the choice are spelled out.

3.1 The general setting and definitions

The two main ingredients of the models presented in this Chapter are product differentiation and monopolistic competition. Given the diversity of contexts in which these concepts are employed and the slight variations in meaning, an operative definition of both is due. As for the latter, the exact meaning attributed to *monopolistic competition* is that firms in a particular sector are assumed to produce varieties that are not perfectly fungible and thus enjoy some degree of market power and have the ability to set prices

to maximize their profits. At the same time, their price setting capacity is constrained by the presence of other varieties in the market, whose aggregate impact is captured by market indices. Each variety is assumed to be small enough not to influence market indices on its own, which is why these are taken as exogenous even though resulting from the aggregation of endogenous choices.

Turning to product differentiation, clear definitions of horizontal and vertical differentiation until now only exist in discrete choice models with indivisible varieties and with consumers making mutually exclusive choices, used in Industrial organization (Tirole, 1988) and, more recently, in trade (Fajgelbaum et al., 2011; Khandelwal, 2010). Discrete choice models incorporate both types of differentiation (Anderson et al., 1992), but don't allow to distinguish between the two in terms of market outcomes, as discussed in the previous Chapter. In contrast, a clear distinction between horizontal (taste) and vertical (quality) differentiation is largely absent in models where consumers display love for variety and purchase many products in varying quantities. Borrowing the definition from Industrial Organization (Neven and Thisse, 1990), then, varieties of the same good are horizontally differentiated when there is no common ranking across consumers when varieties are equally priced. Horizontal differentiation thus reflects consumers' tastes that affect how much firms can sell of each variety. In contrast, varieties are vertically differentiated when all consumers agree on their ranking, and thus quality affects prices in all destination countries.

More precisely, the analysis undertaken in the previous Chapter points to the following operative definitions of the concept:

Definition 1. Vertical differentiation Two varieties in a market are *vertically differentiated* if consumers' willingness to pay for their first marginal unit is different. Profit maximizing firms producing superior varieties enjoy higher markups and sales. For equal marginal costs across firms, superior varieties will be sold at a higher price and, assuming equal horizontal differentiation, in larger quantities.

Definition 2. Horizontal differentiation Two varieties in a market are *horizontally differentiated* if, for equal level of vertical differentiation, they are demanded in different quantities for the same price by different consumers. Assuming equal marginal costs across firms and equal vertical differentiation across varieties, consumers will face the same price, but buy different quantities of horizontally differentiated varieties.

For the sake of intuition, the vertical dimension can be thought of as "quality" and the horizontal dimension as the "taste mismatch" between product characteristics and the consumers' ideal. In a linear demand framework, changes in quality imply parallel shifts in the demand function. Changes in tastes affect only the slope of the demand function and, thus, have no direct effects on the profit maximizing level of prices.

The focus of this Chapter is on modeling the demand side. In line with intra-industry trade literature, the supply side is approximated by fixed and variable costs of production, the first incurred to enter and stay in the market, the second proportional to the units produced. The combination of a fixed cost of entry and constant unit costs imply increasing returns to scale in the production of each particular variety. As usual, the focus is on one particular good and the consumption choices of a representative consumer over

the different varieties of that good, abstracting from income effects and normalizing the utility levels obtained from consumption in terms of a numéraire good. The numéraire can be interpreted as approximating an outside good used as a reference for value or, more generally, the expected utility from the consumption of a bundle of goods produced in all the other sectors of the economy. For this reason it is sometimes referred to as a "Hicksian Composite Commodity" in the literature (Asplund and Nocke, 2006; Gabszewicz et al., 1981; Shaked and Sutton, 1982) and is based on the assumption that the share of consumer income in the particular sector analyzed is small enough not to affect consumption in all the other sectors (so the composition of the bundle of consumption of goods and the utility derived from it) in a noticeable way.

Finally, turning to transport costs, in CES models it is common to assume an iceberg type of *transport costs* à la Samuelson (1952) when delivering a good to a different market. The most commonly reported reason for this choice is computational simplicity (Krugman, 1979). In the context of a quadratic utility, though, this argument is not compelling because linear transport costs can be simply summed to marginal costs of production, allowing for straightforward multi-country extensions of the model and no analytical complications. This choice entails two advantages: first, it allows to account for the fact that production costs and transport costs appear to have a similar weight in pricing decisions (Anderson and van Wincoop, 2004; Holmes and Stevens, 2012; Irarrazabal et al., 2010); second, it accommodates the mounting empirical evidence rejecting the iceberg transport cost hypothesis (Hummels and Skiba, 2004; Martin, 2009). In practice, that means that throughout the Chapter trade costs can be considered included in the variety-specific marginal costs c_s , which is then replaced with the market-variety specific $c_{s,i} = c_s + t_i$, where t_i is the cost of shipping one unit of variety s to country i .

Keeping this in mind and holding the general structure of the model fixed, the combination of different sources of heterogeneity is presented first alone, as building blocks of the possible model, then combined. Given its pervasive inclusion in virtually every modern theory of trade since the observations of Bernard et al. (2003) and Doms and Bartelsman (2000), heterogeneity of marginal costs is assumed throughout the Chapter. In addition, vertical differentiation, horizontal differentiation and varying patterns of substitution are introduced first alone and then in combination. Presenting them individually allows the reader to better grasp the role of each source of variability in the model. Their combination instead shows the high degree of flexibility associated with this class of utility functions. A brief summary of the properties and functional forms of the different variations follows their presentation, together with a stylized simulation intended to provide some intuition on the sources and implications associated with each variation.

3.2 Overview of the alternative models

First of all, an overview of the different preference structures is proposed, so it will be easier later on to spot similarities and differences among the models analyzed. In addition to the standard heterogeneity in productive efficiency, the following sources of

heterogeneity are considered:

- Model I: Baseline. Heterogeneity in productive efficiency but no heterogeneity in preference parameters, i.e. constant quality (α), taste mismatch (β) and substitutability (γ),

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0; \quad (3.1)$$

- Model II: Vertical Differentiation - Heterogeneity in α_s ,

$$U_i(s) = \int_{s \in S_i} \alpha_s q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0; \quad (3.2)$$

- Model III: Horizontal Differentiation - Heterogeneity in $\beta_{s,i}$,

$$U_i(s) = \alpha \int_{s \in S_i} q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0; \quad (3.3)$$

- Model IV: Different substitutability between pair of varieties - Heterogeneity in $\gamma_{s,i}$,

$$U_i(s) = \alpha \int_{s \in S_i} q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{s,i} q_{s,i} q_{r,i} ds dr + q_0; \quad (3.4)$$

- Model V: Vertizontal differentiation - Heterogeneity in α_s and $\beta_{s,i}$,

$$U_i(s) = \int_{s \in S_i} \alpha_s q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0; \quad (3.5)$$

- Model VI: Vertical differentiation with different substitutability - Heterogeneity in α_s and $\gamma_{s,i}$,

$$U_i(s) = \int_{s \in S_i} \alpha_s q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{s,i} q_{s,i} q_{r,i} ds dr + q_0; \quad (3.6)$$

- Model VII: Horizontal differentiation with different substitutability - Heterogeneity in $\beta_{s,i}$ and $\gamma_{s,i}$,

$$U_i(s) = \alpha \int_{s \in S_i} q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{s,i} q_{s,i} q_{r,i} ds dr + q_0; \quad (3.7)$$

- Model VIII: Verti-zontal differentiation, different substitutability - Heterogeneity in α_s , $\beta_{s,i}$ and $\gamma_{s,i}$,

$$U_i(s) = \int_{s \in S_i} \alpha_{s,i} q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{s,i} q_{s,i} q_{r,i} ds dr + q_0. \quad (3.8)$$

3.3 Building blocks: individual sources of heterogeneity

Before turning to the main focus of the Chapter, which is demand-side heterogeneity, the standard Ottaviano et al. (2002) with cost heterogeneity is presented, closely recalling Melitz and Ottaviano (2008) and its results. Then, Ottaviano et al. (2002) will be generalized to embrace pure vertical differentiation, leading to a model equivalent to Foster et al. (2008). The analysis of pure horizontal follows, shedding new light on the role of the parameters in Melitz and Ottaviano (2008) and introducing a new way of computing market indices. Finally, before interacting the different sources of variability, the importance of substitutability between varieties and its role in linking individual characteristics with market indices is discussed.

3.3.1 Model I - Differences in productive efficiency

Following Melitz and Ottaviano (2008), a simplification of the quadratic utility function proposed by Ottaviano et al. (2002) is used as the baseline framework on which the model is built. Focusing on a specific sector, the utility derived from the consumption of a mass of varieties, $s, r \in S_i$, for a representative consumer in market i , can be written as follows:

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_i^2(s) ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0 \quad (3.9)$$

Subject to the budget constraint $\int_{s \in S_i} q_{s,i} p_{s,i} ds + q_0 = \bar{q}_0 + Y_i$, which implies that consumers can use their initial endowment of numéraire or their exogenous income to buy goods in the differentiated sector. Income effects can thus be put aside, making the analysis of consumption patterns tractable without compromising generality.

The traditional way of interpreting this function is the following. The parameter α is the consumer's preference for any varieties in the differentiated sector in terms of the numéraire, q_0 . More precisely, it is the amount of units of numéraire that the representative consumer would be willing to trade against the first marginal unit of a particular variety of good in this sector. More concisely: her willingness to pay. The parameter γ expresses the substitutability between varieties: the higher γ , the closer substitutes the varieties. Melitz and Ottaviano (2008) note that the substitutability between varieties affect also their demand: increases in α and decreases in γ both shift out the demand for the differentiated varieties relative to the numéraire. Finally, the parameter β is traditionally seen as indexing the degree of generic product differentiation between varieties, a higher β implying higher differentiation.

Thus, two implicit assumptions are made in this first variation. First, all varieties face the same demand in each country. Second, any particular variety faces the same demand no matter which country it is sold in. In other words, *all varieties enter consumer preferences symmetrically around the world*, which is clearly restrictive.

While this interpretation of the parameters will be later refined, as allowing them to vary will provide new insights, the results of the model are now presented and interpreted through the lens of the traditional interpretation.

Maximizing a quasi-linear utility function with quadratic sub-utility leads to the following linear inverse demand:

$$p_{s,i} = \alpha - \beta q_{s,i} - \gamma Q_i \quad (3.10)$$

where Q_i is a compact way of writing $\int_{s \in S_i} q_{s,i} ds$.

This can be inverted and rewritten in terms of structural parameters and market indices as the following linear market demand:

$$q_{s,i} = \frac{\alpha - p_{s,i}}{\beta} - \frac{\gamma(\alpha N_i - P_i)}{\beta(\beta + \gamma N_i)} \quad (3.11)$$

where N_i represents the number of varieties present in the market or, to be more precise, their total mass, and $P_i = \int_{s \in S_i} p_{s,i} ds$ is a simple price index obtained just by summing up all the prices observed in this sector of the market. Note also that the average price can be simply computed as $\bar{p}_i = P_i/N_i$.

Firms exploit their market power on the specific variety they produce and set prices maximizing their profits subject to this demand function. As usual, firms are assumed to pay a fixed cost for starting production and a unitary cost of production. As the fixed cost is sunk, it does not affect directly the pricing strategy of the firms, but only determine equilibrium entry in the market. As for the unitary costs of production, they are here assumed to incorporate both production and transport, i.e. $c_{s,i} = c_s + t_{s,i}$, where c_s captures the marginal costs associated with the production of variety s and $t_{s,i}$ the cost of delivering one unit of variety s to market i . As the only source of heterogeneity analyzed at this stage is cost heterogeneity, a possible way of visualizing it would be to imagine a production activity entailing the same marginal costs of production for all the firms, but different costs of access to the market because of different origins.

The price maximizing the operating profit function $\Pi(s) = \sum_{i \in I} [p_{s,i} - c_{s,i}] q_{s,i}$ can then be written as:

$$p_{s,i}^* = \frac{\alpha\beta + \gamma P_i}{2(\beta + \gamma N_i)} + \frac{c_{s,i}}{2} \quad (3.12)$$

It is worth noting that the only idiosyncratic variable in the optimal price equation is $c_{s,i}$. Firms facing higher marginal costs will charge higher prices. Given the linearity of demand, firms will pass through exactly half of their costs. Note that this means that higher prices imply lower markups, besides lower quantities. The combination of these two effects leads to lower profits. A graphical intuition is provided in figure 3.1.

Taking into account that the average price in the market can be written as

$$\bar{p}_i = \frac{P_i}{N_i} = \alpha \frac{\beta}{2\beta + \gamma N_i} + \bar{c}_i \frac{(\beta + \gamma N_i)}{2\beta + \gamma N_i} \quad (3.13)$$

where $\bar{c}_i = C_i/N_i$ is the average cost and $C_i = \int_{s \in S_i} c_{s,i} ds$ a simple total cost index, the profit maximizing price for a variety s in market i can be written as a function of exogenous variables:

$$p_{s,i}^* = \frac{c_{s,i}}{2} + \frac{\alpha\beta + \gamma N_i \bar{c}_i}{2\beta + \gamma N_i} \quad (3.14)$$

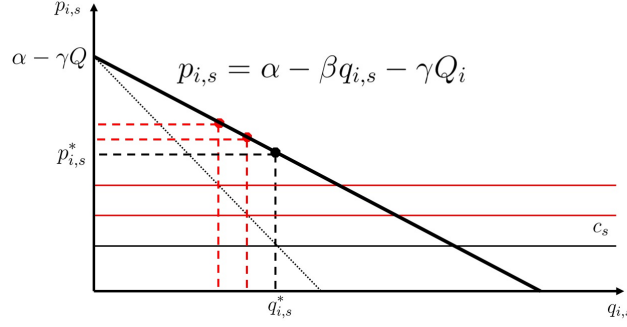


Figure 3.1: Cost Heterogeneity

And the corresponding amount of quantities sold to the representative consumer is:

$$q_{s,i}^* = \frac{1}{\beta} [p_{s,i}^* - c_{s,i}] \quad (3.15)$$

Therefore, the operating profits generated by a variety s in market i are strictly related to the efficiency in producing variety s :

$$\pi_{s,i} = \frac{1}{\beta} [p_{s,i}^* - c_{s,i}]^2 \quad (3.16)$$

Firms' expectations on operating profits can then be used as a free entry condition to determine a cost cutoff and long-run equilibrium mass of varieties in the market.¹

Some observations on the results driven by cost heterogeneity are due. Turning to the role of parameters, it can be easily seen that prices are increasing in both willingness to pay for goods in the sector, α , average costs, $\bar{c}_i$, and idiosyncratic costs, $c_{s,i}$. While the latter has a negative impact on quantities, though, the first two have not, as they simply relax price competition and, as can be seen from (3.15), the ratio between markups and quantities is constant in this version of the model. Toughness of competition in a particular market is determined by the interaction of mass of firms, substitutability and average marginal costs of production and delivery. Melitz and Ottaviano (2008) assume that different countries are characterized by the same cost distribution and substitutability patterns, so these two dimensions collapse to one, market size. However, even without imposing a particular distribution of parameters, it can be noticed that when $N \rightarrow \infty$ or $\gamma \rightarrow \infty$ in (3.14) then $p_{s,i}^* = \frac{c_{s,i}}{2} + \frac{\bar{c}_i}{2}$, which means that no firm can survive if less efficient than the simple average, but this means that all the firms are progressively driven out of the market, except the most efficient, which will then price to marginal cost. It is true that free entry condition can prevent N to reach that point, but no conditions apply on the patterns of substitutability γ . It is also interesting to note that, as $\gamma \rightarrow 0$, varieties approach their pure monopoly price in a context of linear demand: $p_{s,i}^* = \frac{c_{s,i}}{2} + \frac{\alpha}{2}$. Ev-

¹The additional steps and assumptions needed to obtain results in the long run are provided, among others, by Melitz and Ottaviano (2008). and are not analyzed here

ery competitive environment, from pure monopoly to perfect competition, can then be captured by this quadratic utility framework through the substitutability parameter.

The quadratic utility function with cost heterogeneity is the variation currently most used in the literature. By interacting idiosyncratic costs and market indices, for example, Mayer et al. (2014) show how multi-product firms change their product range and product mix as a reaction to differences in competition across market destinations. Also empirically, many studies rely solely on cost heterogeneity (see, for example Syverson, 2007, 2011).

However, a purely cost-based approach of firm heterogeneity does not provide much flexibility in terms of variety characteristics. The most evident limits are that high prices can stem only from high costs, low markups always coincide with low quantities sold, the ratio between optimal prices and quantities is fixed for all the varieties and, finally, firms with identical costs have to charge necessarily the same price for their products, when demand parameters are fixed and constant for all the varieties.

One possible way to reintroduce variety characteristics into the picture, while keeping a pure cost-heterogeneity framework, is to related the distance from the consumer to the producer to some adaptation costs, such as in Carballo et al. (2013). However, this solution does not to break the link between markups and quantities and imposes a negative relation between sales and prices. These issues are addressed by the departures from this baseline framework discussed in what follows.

3.3.2 Model II - Pure Vertical Differentiation

The first technical departure from the baseline model is to account for differences across varieties in the parameter capturing the willingness to pay for the first marginal unit of that specific variety in the absence of competition, α . An intuitive way to look at it is in terms of vertical differentiation, or quality, for the sake of conciseness. Differently from Antoniadou (2008), the issue of how quality is obtained, or why it may be differently distributed across markets is not considered here. Many alternative mechanisms could be envisaged, ranging from the quality of inputs (Verhoogen, 2012), to local institutions (Yamawaki, 2004), to specific investments (Iacovone and Javorcik, 2008; Picard, 2013), but the focus of the model is on the demand side and wants to be as general as possible. Thus it is just assumed that a variety-specific $\alpha(s)$ is drawn from a known distribution and is equal across markets, in order to be consistent with the idea of unanimity of consumers on the appreciation of vertical attributes of a product, and is not assumed to be related to the marginal costs of production of delivery.² It may be interpreted simply as a good idea for a new product, which does not need specific research to be invented, but just individual ingenuity.

²There are papers such as Picard and Okubo (2012) that assume that α can vary from market to market, thus behaving like a demand shock in a quality-augmented CES. This possibility is not followed in this variation to keep the analogy with respect to the location metaphor in which the parameter α captures the willingness to pay of consumers whose ideal variety coincides with the location of the variety.

Taking into account this additional source of heterogeneity, the representative consumer's utility can be rewritten as follows is taken into account, the baseline model can be generalized as follows:

$$U_i = \int_{s \in S_i} \alpha_s q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0 \quad (3.17)$$

Subject to the same budget constraint as before: $\int_{s \in S_i} q_{s,i} p_{s,i} ds = \bar{q}_0 + Y_i$.

This specification is similar to what Foster et al. (2008) propose, with the exception that they prefer to stick to (3.9) and transform $\int \alpha q_{s,i} ds$ into $\int (\alpha + \delta_{s,i}) q_{s,i} ds$, where $\delta_{s,i}$ is a demand shifter for a particular variety relative to the average level α . This $\delta_{s,i}$ may then be seen as capturing both variety-specific attributes over which consumers in different markets agree and market-variety-specific tastes for the particular attributes of a certain variety. However, if one is interested in disentangling these two dimensions, it is necessary to focus at a pure, market-invariant source of vertical differentiation.

The relative inverse demand function change slightly, if compared to (3.10), the only difference being the variety-specific willingness to pay:

$$p_{s,i} = \alpha_s - \beta q_{s,i} - \gamma Q_i \quad (3.18)$$

The same holds for the demand function:

$$q_{s,i} = \frac{\alpha_s - p_{s,i}}{\beta} - \frac{\gamma(A_i - P_i)}{\beta(\beta + \gamma N_i)} \quad (3.19)$$

with the only difference that, in addition to the mass of firms N_i and price index $P_i = \int_{s \in S_i} p_{s,i} ds$, now a quality index must be introduced $A_i = \int_{s \in S_i} \alpha_s ds$. Note that this quality index uncovers a relation between idiosyncratic demand and average quality in the sector that was hidden in (3.11) because of the imposed homogeneity in willingness to pay across varieties. The intuition behind the negative effect of average quality on the demand for a specific variety is that, as the competitors' quality increases, consumers buy more of their varieties and this maps into tougher indirect competition through the effect of γQ_i .

The profit maximizing price can therefore be written as:

$$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma(A_i - P_i)}{2(\beta + \gamma N_i)} \quad (3.20)$$

As expected, idiosyncratic and average qualities work in opposite directions in the definition of equilibrium prices as well. As stressed before, quality behaves as a pure demand shifter, pushing markups and sales in the same direction. A graphical illustration of the demand for varieties with different α in the same market is provided in figure 3.2

Thus, the average price in the market can be computed as:

$$\bar{p}_i = \frac{P_i}{N_i} = \bar{\alpha}_i \frac{\beta}{2\beta + \gamma N_i} + \bar{c}_i \frac{\beta + \gamma N_i}{2\beta + \gamma N_i} \quad (3.21)$$

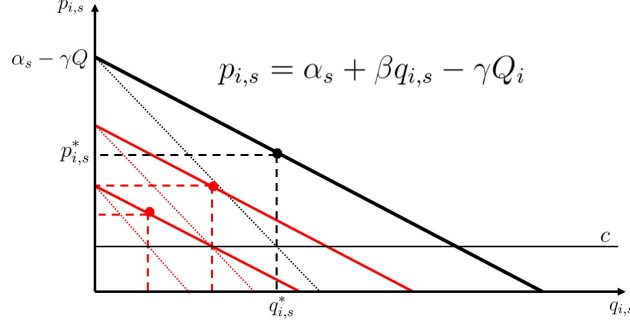


Figure 3.2: Vertical Differentiation

where $\bar{\alpha}_i = A_i/N_i$ and $\bar{c}_i = C_i/N_i$ are simple averages of quality and cost parameters across varieties, total costs being simply $C_i = \int_{s \in S_i} c_{s,i} ds$.

Substituting it into the optimal price,

$$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma N_i \left(\frac{\bar{\alpha}_i - \bar{c}_i}{2} \right)}{2\beta + \gamma N_i} \quad (3.22)$$

Finally, the optimal amount of quantities sold for each variety will be:

$$q_{s,i}^* = \frac{1}{\beta} [p_{s,i}^* - c_{s,i}] \quad (3.23)$$

The operating profits generated by a variety s in market i are directly related to the markups:

$$\pi_{s,i} = \frac{1}{\beta} [p_{s,i}^* - c_{s,i}]^2 \quad (3.24)$$

As compared to the baseline model with cost heterogeneity presented earlier, this extension allows to account for varieties whose high price is not a symptom of high inefficiency, but a consequence of high quality. As opposed to the case of cost heterogeneity alone, where high prices can be driven only by high costs and entail low markups, the introduction of vertical differentiation allows to account for higher prices associated with higher markups and quantities. An interesting new feature emerging from this generalization is that market size is not the only source of difference in competitive pressure between markets, but the average quality of products in that particular market plays a role as well. What is striking is that average quality also affects the price index in such a way that high-quality markets show higher prices than the ones with lower average quality, *ceteris paribus*. Hence, high quality may turn out to be as important as a trade barrier as low production costs. This may help solve some puzzles on why some markets may be so difficult to penetrate for low-cost firms (Yamawaki, 2004).

More formally, this claim can be proven by looking at the price index (3.21) and profit maximizing price (3.24), noting that $\frac{\partial \bar{p}_i}{\partial N_i} < 0$, $\frac{\partial p_{s,i}^*}{\partial N_i} < 0$ and $\frac{\partial \bar{p}_i}{\partial \alpha_i} > 0$, $\frac{\partial \bar{p}_i}{\partial \bar{c}_i} > 0$

, $\frac{\partial p_{s,i}^*}{\partial \alpha_i} = -\frac{\partial p_{s,i}^*}{\partial c_i} < 0$. Thus, while a higher number of competitors is associated with a lower price index and lower prices for each variety, a higher average quality forces each firm to charge a lower price, even if aggregate prices are higher. Assuming that, for whatever reason, products in richer countries are of a higher average quality than products in developing countries, these features would be consistent with the Balassa-Samuelson hypothesis of higher prices in developed economies and at the same time with the empirical observation that it is difficult for firms in the developing world to penetrate and thrive in some developed world markets, even if average prices are higher (Brooks, 2006).

In addition, as shown in Vandenbussche et al. (2013) to compare the evolution of Chinese and EU exports, a framework with quality differentiation can be exploited to investigate the presence of quality upgrading at an aggregate level (say, country or country-sector). Indeed, by assuming that only α_s and c_s may change over time, the relative evolution of either one or the other with respect to other countries or country-sectors can be extracted by analyzing the evolution of quantities and prices. Indeed, while having the same impact on prices, costs and quality have an opposite effect on quantities sold, which paves the way to develop an identification strategy. Profit maximizing firms would in fact charge higher prices if marginal costs increase, but then will sell less. On the contrary, when higher prices are the result of higher quality, the outward shift in demand results in higher sales too. Formally,

$$\frac{\partial p_{s,i}^*}{\partial \alpha_s} > 0 \quad ; \quad \frac{\partial p_{s,i}^*}{\partial c_{s,i}} > 0 \quad ; \quad \left| \frac{\partial p_{s,i}^*}{\partial \alpha_s} \right| = \left| \frac{\partial p_{s,i}^*}{\partial c_{s,i}} \right|,$$

but

$$\frac{\partial q_{s,i}^*}{\partial \alpha_s} > 0 \quad ; \quad \frac{\partial q_{s,i}^*}{\partial c_{s,i}} < 0 \quad ; \quad \left| \frac{\partial q_{s,i}^*}{\partial \alpha_s} \right| = \left| \frac{\partial q_{s,i}^*}{\partial c_{s,i}} \right|.$$

This means that looking at the relative export performance of two countries, say i and j , in a third market, it can be enough to observe the evolution unit prices and quantities to make some inference on the relative evolution of quality and costs. Focusing on one specific product s in a particular period of time t Vandenbussche et al. (2013) show indeed that

$$p_i^* - p_j^* = \frac{(\alpha_i + c_i) - (\alpha_j - c_j)}{2},$$

which means that also the difference over time ($\Delta_{t,t-1}$) in the relative price of i and j is related to the evolution of quality and costs:

$$\Delta_{t,t-1}(p_i^* - p_j^*) = \frac{\Delta_{t,t-1}(\alpha_i - \alpha_j) + \Delta_{t,t-1}(c_i - c_j)}{2}.$$

Similarly for quantities, focusing on one specific product s in a particular period of time t ,

$$q_i^* - q_j^* = \frac{(\alpha_i + c_i) - (\alpha_j - c_j)}{2\beta}$$

and

$$\Delta_{t,t-1}(q_i^* - q_j^*) = \frac{\Delta_{t,t-1}(\alpha_i - \alpha_j) + \Delta_{t,t-1}(c_i - c_j)}{2\beta}.$$

Looking at relative variations over time in prices and quantities, then, the following theoretical implications on the dominating effects can be drawn for each product s (which can then be aggregated at an industry or country level):

- If $\Delta_{t,t-1}(p_i^* - p_j^*) > 0$ and $\Delta_{t,t-1}(q_i^* - q_j^*) > 0$ then country i is improving its quality vis-à-vis country j relative faster than it is increasing its costs, which means that, even if both costs and quality are increasing, the former are outgrowing the former;
- If $\Delta_{t,t-1}(p_i^* - p_j^*) > 0$ and $\Delta_{t,t-1}(q_i^* - q_j^*) < 0$ then country i 's costs are growing faster than quality improvements, as compared to country j , which causes a loss of market shares;
- If $\Delta_{t,t-1}(p_i^* - p_j^*) < 0$ and $\Delta_{t,t-1}(q_i^* - q_j^*) > 0$ then country i 's costs reduction, as compared to country j are raising i 's market share and lowering its relative sales price for product s ;
- If $\Delta_{t,t-1}(p_i^* - p_j^*) < 0$ and $\Delta_{t,t-1}(q_i^* - q_j^*) < 0$ then country j is decreasing the relative quality of its export and thus reducing its markups and market share in the third market considered.

In Vandenbussche et al. (2013) this methodology is used to document the rise in Chinese quality of exports vis-à-vis the EU in the US market.³

Turning now to the other structural parameters of (3.22) and (3.22) to see how they affect market aggregates, it can be noted that $\frac{\partial \bar{p}_i}{\partial \gamma} < 0$ and $\frac{\partial \bar{p}_i}{\partial \beta} > 0$, while $\frac{\partial Q}{\partial \gamma} < 0$ and $\frac{\partial Q}{\partial \beta} < 0$. Therefore, while the substitutability parameter γ simply shifts all the demand functions in a parallel way, the parameter β increases prices but reduces the quantities sold in the market. As long as β is held constant across markets and varieties, it may be reasonable to interpret it as indexing the degree of product differentiation as in Melitz and Ottaviano (2008). A higher degree of differentiation would allow firms to enjoy more market power and then charge higher prices, even if selling less. However, treating β as an idiosyncratic parameter seems to suggest that the causal direction of the effect is reversed, going from quantities to prices. For a firm's competitors, a higher β is associated with lower quantities sold, this relaxes their indirect competitive pressure at a rate γ and allows the firm to charge higher prices. When β is forced to be the same

³The analysis focused on one market to be able to exploit the assumption of a market-wide effect common to European and Chinese exports and, more in general, to avoid that the country composition of exports may drive part of the results.

for all the varieties in this framework, though, this very effect applies to all the firms and brings about the result. Explicitly accounting for horizontal differentiation helps to make this point more transparent.

In addition, horizontal differentiation allows researchers to tackle an issue not resolved by pure vertical differentiation, where the ratio between equilibrium markups and quantities is constant across varieties and markets. The combination of cost heterogeneity and vertical differentiation is indeed able to break the inverse relationship between markups and prices, but not the constant ratio between markups and quantities. The implicit restriction that two varieties with equal markups are necessarily sold in exactly the same quantity is relaxed by introducing horizontal differentiation.

3.3.3 Model III - Pure Horizontal Differentiation

A pure horizontal differentiation framework can be seen as a generalization of the baseline model in which the parameter β in (3.9) is allowed to vary in each market for each variety.

In the Baseline and the Pure Vertical Differentiation Models, only a set I of homogeneous consumers has been considered. This assumption is now relaxed and consumers are allowed to be *heterogeneous*. Formally this means that the β -distribution can vary with $i \in I$. Thus, from this point forward, in the models in which β is indexed by market and variety identifiers, $\beta_{s,i}$, the taste-mismatch associated with a variety is consumer-specific and reflects the heterogeneity of consumers.

Taste mismatch is thus two-dimensional: it varies across varieties $s \in S$ as well as across consumers $i \in I$. That $\beta(s, i)$ varies with s means that the same consumer i has different attitudes toward different varieties (preferences are asymmetric), whereas $\beta(s, i)$ varies with i because different consumers have different attitudes toward the same variety s .

Since the main field of application of this Model is international trade and aggregate demands stemming from one country are traditionally derived from the maximization of a representative consumer's utility, also in this Model consumer heterogeneity is assumed across countries but not within countries. Although aggregating consumer preferences within a country is a priori doable, appropriate data is needed. Indeed, if the distribution of $\beta(s, i)$ with respect to i were known, it would be possible to aggregate individual demands across consumers living in the same country and capture consumer heterogeneity within countries. This is exactly what is accomplished in the discrete choice literature where demand shocks are idiosyncratic to individual consumers, while aggregating demands across individuals yields the market demand when the distribution of shocks is extreme value.⁴

An alternative approach is proposed here, which is more in line with the standard trade literature. In addition, the Model presented here allows for a simple description of consumers buying a variable number of units of each variety, something which is not easy to perform with discrete choice models. Note also that using discrete choice models

⁴Using Hotelling's spatial metaphor developed in the previous Chapter, the distance $\beta(1, i)$ between shop 1 and consumer i 's ideal differs from the distance $\beta(1, j)$ to consumer j 's ideal.

when preferences across varieties are asymmetric is not an easy task. Most of the existing theoretical literature developed in industrial organization uses the multinomial logit, which assumes symmetry. Using the probit with different covariances turns out to be especially cumbersome, whereas the vertical approach leads to simple and intuitive results. This is thus a strong comparative advantage of models based on quadratic preferences with heterogeneous consumers.

The model can be used at different levels of demand aggregation, i.e. a household, a city, or a country. This makes it a potentially useful tool to address alternative issues, especially when data are available at a very disaggregated level such as barcode data within cities (Handbury and Weinstein, 2011). In what follows, a consumer is interpreted as a country's representative consumer. To be precise, $I = \{1, \dots, n\}$ can be seen empirically as the set of destination countries and S_i as the set of varieties available in country i , thus offering new insights into competition effects.

It is worth noticing that the interpretation of β changes substantially when it is allowed to vary across consumers. Indeed the traditional way of looking at β , since Ottaviano et al. (2002), has been in terms of generic product differentiation, relaxing indirect competition between varieties and finally representing the quadratic utility equivalent of the rate of substitution in CES frameworks. Allowing it to vary, it can be shown that β does affect the quantities sold of a certain variety in equilibrium, but not its profit maximizing price. For the sake of concreteness, imagine a good exhibiting the same price across different markets, say an electronic book on Amazon, or a music piece on a digital library, its parameter β would capture the different sales for the same variety in different markets. Empirically this is usually captured by dummies for cultural, institutional or linguistic barriers to trade, which are typical controls when testing standard gravity variables, or simply by unexplained shocks on demand. In this framework, $\beta_{s,i}$ accounts explicitly for them and will be referred to as taste mismatch.

There are just a few other works in which $\beta_{s,i}$ alone are allowed to vary are Parenti (2010), where the existence of multi-product firms is explained by their possibility of relaxing competition between the varieties they produce by better differentiating them, and Altomonte et al. (2010), where a particular sector is divided into different subsets of varieties, each exhibiting a different subset-specific β , with consumers seeing varieties as substitutable only within each sector but not across sectors. They analyze the case of two sub-sectors, a high- and low-differentiation, showing that the latter is less competitive than the former, exhibiting lower prices and quantities sold. A different strategy is followed at this stage, which allows varieties to be continuously differentiated on the horizontal dimension, holding substitutability constant between all pairs of varieties.

Following the intuition of the localized competition literature (Lancaster, 1966), each variety is assumed to be located in one particular point on a multidimensional characteristics space. Each consumer has a preferred combination of characteristics in every sector. The parameter $\beta_{s,i}$ captures the distance between the consumer's favorite combination of characteristics and the location of variety s in market i . For simplicity, the L consumers in each market are assumed to share the same horizontal preferences over product characteristics, a way of looking at that is to imagine that individuals prefer to

live close with people with similar tastes and preferences or to suppose that β depends on the specific characteristics of a market, such as climate, language or culture. To see exactly how horizontal differentiation is modeled within the quadratic utility function, note that (3.9) is now written as follows:

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_i^2(s) ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0 \quad (3.25)$$

Subject to the usual budget constraint: $\int_{s \in S_i} q_{s,i} p_{s,i} ds = \bar{q}_0 + Y_i$.

This means that the distance from a consumer's favorite set of characteristics in market i , $\beta_{s,i}$, does not affect the price the willingness to pay for the first marginal unit of that particular variety due to its vertical attributes, α , but affects the rate of decay of marginal utility of each additional units of the same variety. In other words, horizontal differentiation affects the slope of the inverse demand function:

$$p_{s,i} = \alpha - \beta_{s,i} q_{s,i} - \gamma Q_i \quad (3.26)$$

Note that, holding quantities fixed, horizontal differentiation does affect prices and provides results consistent with traditional location theories à la Hotelling (1929), which are based on the assumption that only one unit of product is sold and that product sales are mutually exclusive. In order to adapt the horizontal differentiation to monopolistic competition and intra-industry trade, these two assumptions are clearly dispensed with and the demand for a variety s can be written as:

$$q_{s,i} = \frac{\alpha - p_{s,i}}{\beta_{s,i}} - \frac{\gamma(\alpha \mathbb{N}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \gamma \mathbb{N}_i)} \quad (3.27)$$

where both the mass of varieties and price index in (3.11) are now replaced by taste-weighted indices:

$$\mathbb{N}_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}} \quad ; \quad \mathbb{P}_i = \int_{s \in S_i} \frac{p_{s,i}}{\beta_{s,i}} ds.$$

The intuition behind the introduction of these new indices is that, in a framework in which quantities may vary even if prices don't, the weight of each variety in determining effective competition depends on how close it is to the local market tastes, as this directly influences the amount of sales. In other words, a variety with a high β will be sold in lower quantities than a low- β competitor and general indices have to take it into account, implying that the introduction of a very expensive variety in a market will not affect the price index significantly if nobody is going to buy it.

The problem of profit maximization being unaltered with respect to the previous cases, the price charged for variety s in market i is described by

$$p_{s,i}^* = \frac{\alpha + \gamma \mathbb{P}_i}{2(1 + \gamma \mathbb{N}_i)} + \frac{c_{s,i}}{2}. \quad (3.28)$$

Note that the only idiosyncratic variable affecting profit maximizing prices is the marginal cost of production and delivery. The other variables affect all the varieties in the market symmetrically, with no significant deviations from the baseline case: the willingness to pay for varieties in the sector, α , and the weighted price index, $\mathbb{P}_i$, both raise the equilibrium prices charged by firms, whereas product substitutability, γ , and the weighted mass of competitors, $\mathbb{N}_i$, lower it.

The reason why idiosyncratic demand parameters do not directly affect idiosyncratic optimal prices is that the market-variety-specific β affects only the slope of the demand function, thus affecting equilibrium quantities but not prices. A graphical intuition is provided in figure 3.3.

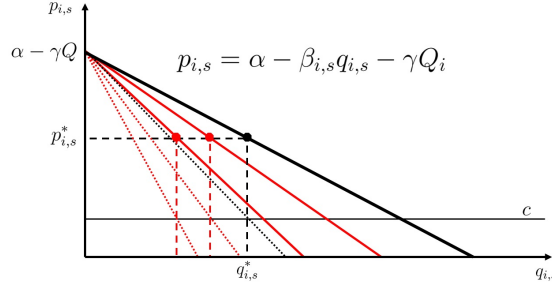


Figure 3.3: Horizontal Differentiation

The weighted average price, $\tilde{p}_i = \mathbb{P}_i/\mathbb{N}_i$, can be computed as follows:

$$\tilde{p}_i = \alpha \frac{1}{2 + \gamma \mathbb{N}_i} + \tilde{c}_i \frac{1 + \gamma \mathbb{N}_i}{2 + \gamma \mathbb{N}_i} \quad (3.29)$$

where $\tilde{c}_i = \mathbb{C}_i/\mathbb{N}_i$ is the weighted average of the weighted cost index $\mathbb{C}_i = \int_{s \in S_i} \frac{c_{s,i}}{\beta_{s,i}} ds$, in which the weighted is again provided by the distance of the relative variety from the preferred representative consumer's characteristics, $\beta_{s,i}$. It is worth lingering briefly on the implications of this specification of the price index. Imagine two markets, characterized by the same sector-wide willingness to pay and substitutability between varieties, which are served by firms producing the same varieties at the same marginal cost across markets. In these two markets, price can be different simply because of tastes. The price ranking will be the same in the two markets, as idiosyncratic prices depend only on costs, but the general price index that each variety is facing is weighted by consumer tastes. Therefore, markets where more productively inefficient varieties are more appreciated, in terms of horizontal attributes, will be characterized by higher weighted price and cost indices, which means that firms will face a lower indirect competitive pressure on prices. In this framework, it is not only productivity distribution that matters, but its interaction with tastes: if a variety is produced in an incredibly efficient way, but nobody likes it in the market, it is not going to greatly affect market indices and it will not exert much indirect competitive pressure on alternative varieties.

The weighted price index can then be substituted back into the formula describing idiosyncratic optimal pricing, leading to the following:

$$p_{s,i}^* = \frac{c_{s,i}}{2} + \frac{\alpha + \gamma \mathbb{N}_i \frac{\tilde{c}_i}{2}}{2 + \gamma \mathbb{N}_i} \quad (3.30)$$

Which is the horizontally differentiated equivalent of (3.14) and thus, similarly, depends only on market characteristics and individual costs, as horizontal differences will affect only the relative equilibrium amount of quantities sold:

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} [p_{s,i}^* - c_{s,i}] \quad (3.31)$$

And thus the operating profits generated by a variety s in market i are affected by taste mismatch only through volumes sold:

$$\pi_{s,i} = \frac{1}{\beta_{s,i}} [p_{s,i}^* - c_{s,i}]^2 \quad (3.32)$$

The most evident contribution of this generalization of the baseline model is that it breaks the relation between markups and quantities sold for a certain variety. Products with equal markups can be sold in different quantities because their marginal contribution to consumers' utility decreases in consumption of that specific variety at a different pace and this is shown to provoke adjustments on quantities rather than prices. The fact that consumers buy different amounts of a specific variety depending on its β generates indirectly another source of competitive pressure, as it affects the amount of total consumption of manufactured goods and this, in turn, affect markups of all varieties. The traditional competitive pressure generated by the mass of firms in the market has then to be weighted by how much each variety is actually appreciated by consumers. Markets of the same size with the same number of varieties do not need to be identically competitive in this variation, even if costs are distributed identically across firms.

Another interesting feature of having the parameter β variety-market specific is that varieties can observe each other's performance in difference markets to infer their own expected performance in terms of sales in new markets. For example, if two varieties can observe a similar level of markups and sales in one market where they are both present, one variety can expect to have a similar performance of the other also in markets where it has not entered yet. This learning process may explain why the simple geographic proximity to exporters may increase the probability to export, as noted by Mayneris and Poncet (2011).

However, as in the baseline model, though, this generalization is not able to account for highly priced goods generating high markups. Hence, in order to achieve variability in markups and quantities and match empirical evidence, it seems necessary to introduce both horizontal differentiation and vertical differentiation simultaneously, besides allowing for cost heterogeneity. These are the main ingredients of the model proposed, but before showing its results, it is worth having a quick glance at how different patterns of substitution across markets can be introduced in the model without changing it substantially.

3.3.4 Model IV - Different Substitutability Patterns

After having analyzed how idiosyncratic differences in variety-specific vertical attributes, α , and market-variety-specific distance horizontal characteristics, whose distance from the consumers' ideal is captured by β , it is shown how results would be affected by allowing for different patterns of substitution. There are two alternative ways of introducing this source of heterogeneity: it can be through market variation, γ_i , or through market-variety variation, $\gamma_{s,i}$.

The former way is the easiest. Following the suggestion of Hausman (1994) to "*divide products into segments and estimate a model that restricts substitution patterns across segments but allows flexibility within segments*", it can be done in this context by assuming no substitutability between varieties of different products, but a constant level of market-specific substitutability between pairs of varieties of the same product within a market i , γ_i . This level can then be allowed to vary across markets and cause even the same set of varieties in different markets to enjoy different levels of competition (for example, two brands of beer can be better substitutes in some markets than in others). A utility function describing this framework is the following:

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_i^2(s) ds - \frac{\gamma_i}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0. \quad (3.33)$$

Notably this specification is equivalent to (3.9) when focusing on one particular market i . The additional information it provides is that the constant rate of substitution across varieties may differ across markets, determining some variability in toughness of local competition independent of quality and taste differences. A higher rate of substitution will be associated with a parallel shift in demand, in a similar way as a decrease in quality (or rather an increase in competitors' quality).

However, the richest and most interesting way to introduce differences in substitutability patterns is to allow for different rates of substitution between each pair of varieties, for example through the following specification:

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{sr,i} q_{s,i} q_{r,i} ds dr + q_0, \quad (3.34)$$

which can be simplified into

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \gamma_{s,i} q_{s,i} Q_i ds + q_0, \quad (3.35)$$

where, relating substitutability to the distance in terms of horizontal differentiation between varieties, interpreting the characteristics space as in Lancaster (1966), $\gamma_{s,i}$ can be seen as an index capturing the extent to which the characteristics of a certain product s are similar to the ones of other varieties in the market. A convenient way to capture this concept is through a summation of inverse distances between variety s and the others, measured in the same way as β :

$$\gamma_{s,i} = \int_{r \in S_i} \frac{1}{d_{sr,i}} dr \quad (3.36)$$

where $d_{sr,i}$ captures the distance in terms of horizontal (or horizontal and vertical) characteristics between each pair of varieties resulting in an index similar to the effective number of firms N_i presented in Model III, except that now it is based on the viewpoint of firm s instead of consumer i .

A further refinement could be to include also additional information on the competitors' characteristics to account for the fact that more successful competitors may exert more competitive pressure than the others. Expressing it in terms of the exogenous basic parameters common to all the models presented here, it could be expressed as follows:

$$\gamma_{s,i} = \int_{r \in S_i} \frac{(\alpha_r - c_{r,i})}{\beta_{r,i} d_{sr,i}} dr, \quad (3.37)$$

which states competing varieties with higher quality (α_s), lower costs ($c_{s,i}$), better match with consumer taste ($\beta_{s,i}$) or are closer in the characteristics space ($d_{sr,i}$) exert more competitive pressure in terms of an increase value of the substitutability parameter.

The intuition in both cases is that the farther away two varieties are from each other, the lower indirect competitive pressure they exert on each other. One clear advantage of this formulation is that it would allow focusing not only on different varieties of the same good or sector, but to consider each variety in relation with the entire set of goods in the market. The implications and possible research questions that can arise from an approach linking the value of substitutability to the localization of firms in the characteristics space are better developed in Chapter 6, where future avenues of research are outlined. Indeed, when $\gamma_{s,i}$ is assumed to be constant across varieties, implicitly a constant rate of substitution is assumed. On the contrary, if $\gamma_{s,i}$ is allowed to vary with product characteristics. In other words, $\gamma_{s,i}$ may be seen as capturing the extent of remoteness from competition, in terms of distance and, possibly, in terms of the appeal of the competitors for consumers.

While intellectually intriguing and theoretically sound, the specification in (3.35) poses serious empirical challenges because, at least in principle, it requires the measurement of the distance between each pair of varieties and thus some prior knowledge on the rate of substitution between all the varieties in the market, but as noted by Einav and Levin (2010), "*work on demand modeling has centered on the trade-off between allowing flexible substitution patterns and the lack of variation in typical data that allows such substitution patterns to be flexibly identified*".

It can be noted that the utility written as in (3.33) has the advantage, as compared to (3.34) to be directly implementable from an empirical perspective, as it does not imply variety-specific effects within a market. The main implication would be that exactly the same group of varieties in different markets may be associated with different levels of competition just because of market specific effects. More empirically complex would be to deal with the heterogeneity in substitutability as introduced in (3.34), but on the other hand it may provide a powerful theoretical tool to deepen the understanding of the

quadratic utility framework and, as will be further explored in Chapter 6, to endogenize location or quality choices. Its demand function can be thus written as:

$$q_{s,i} = \frac{\alpha}{\beta} - \frac{\gamma_{s,i}(\alpha N_i - P_i)}{\beta(\beta + M_i)} - \frac{p_{s,i}}{\beta} \quad (3.38)$$

where

$$M_i = \int_{s \in S_i} \gamma_{s,i} ds \quad ; \quad N_i = \int_{s \in S_i} ds \quad ; \quad P_i = \int_{s \in S_i} p_{s,i} ds \quad (3.39)$$

are unweighted indices similar to the ones developed in the context of Model I, with the only addition of the substitutability index M_i . This demand function yields the following pricing strategy:

$$p_{s,i} = \alpha + \frac{\gamma_{s,i}[P_i - \alpha N_i]}{\beta + M_i} - \beta q_{s,i}, \quad (3.40)$$

which yields, once profit maximization has been taken into account,

$$p_{s,i}(P_i) = \frac{\alpha + c_{s,i}}{2} - \frac{\gamma_{s,i}(\alpha N_i - P_i)}{2(\beta + M_i)}, \quad (3.41)$$

which highlights the complex interactions between each varieties' distance from the other varieties, in terms of substitutability, and the market aggregates. In terms of individual varieties, the impact on demand is not very different from the case of vertical differentiation, whereas in aggregate the specification is somehow less intuitive than the vertical differentiation case. The main novelty of the model is indeed the introduction of the substitutability index in the denominator of the pricing function. It can be interpreted as stressing the fact that if the competitors of variety s in market i are not too close to each other, then they will be selling more and thus exert more competitive pressure on variety s .

It can also be noted the role played by the quality of the particular variety s in market i in increasing its price, $\frac{\alpha}{2}$, and the role played by the quality of all the other varieties in market i in decreasing it, $\frac{\alpha N_i}{2(\beta + M_i)}$, whereas this competition effect is weighted by the substitutability between that particular variety and the others in the market, $\gamma_{s,i}$.

Considering that the equilibrium price index in market i is

$$P_i^* = C_i + \frac{\beta(\alpha N - C_i)}{2\beta + M_i}, \quad (3.42)$$

where

$$C_i = \int_{s \in S_i} c_{s,i} ds, \quad (3.43)$$

the profit-maximizing price of a variety s in market i can be described as

$$p_{s,i}^* = \frac{\alpha + c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \left(\frac{\alpha N_i - C_i}{2\beta + M_i} \right) \quad (3.44)$$

and the markup

$$p_{s,i}^* - c_{s,i} = \frac{\alpha - c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \left(\frac{\alpha N_i - C_i}{2\beta + M_i} \right) \quad (3.45)$$

Notice that in this equation only the marginal cost of production and delivery, $c_{s,i}$, and the substitutability parameter, $\gamma_{s,i}$, are market-variety specific. The rest of the parameters apply to all the varieties in market i .

Equilibrium quantities are as usual

$$q_{s,i}^* = \frac{(p_{s,i}^* - c_{s,i})}{\beta} \quad (3.46)$$

and the resulting operating profits are

$$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta}. \quad (3.47)$$

Therefore, in the case of heterogeneity in substitutability alone, the differences between varieties in markups will result in equal differences in quantities, as in the case of pure vertical differentiation.

Empirically, it can be difficult to find a proxy for the different levels of substitutability, but one possible idea is to look for qualitative indicators such as the ones employed by Hoberg and Phillips (2010), who look at the words that firms use to describe their products and build indices of proximity based on the similarity of the words used.

3.4 Combining different sources of heterogeneity

The first four models presented show how the quadratic utility framework can be extended to capture features that may be empirically relevant, depending on the specific markets and products considered. The sources of heterogeneity surveyed up to this point are now combined to provide an even higher degree of flexibility in modeling. In particular, all the possible combinations are considered before identifying one variation as the best suited to rationalize trade patterns. Considering the trade-off between modeling efficiency and completeness, the choice will fall on Model V, which is the theoretical background on which the two following empirical Chapters are based. The more complete combination of sources of heterogeneity, Model VIII, will only be used in Chapter 6 when describing promising future avenues of research.

3.4.1 Model V - Verti-zontal differentiation

Being this the specification on which the rest of the Thesis is based, it will be analyzed a little bit more in detail than the previous ones, but its presentation will follow a similar structure. Substitutability is assumed to be product-specific and not to vary from market to market, as is normally the case in all the trade theories based on CES

utility function. The utility function corresponding to the case in which varieties are differentiated horizontally and vertically is

$$U_i = \int_{s \in S_i} \alpha_s q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0, \quad (3.48)$$

yielding the demand function

$$q_{s,i} = \frac{\alpha_s - p_{s,i}}{\beta_{s,i}} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \gamma\mathbb{N}_i)} \quad (3.49)$$

where

$$\mathbb{N}_i \equiv \int_{s \in S_i} \frac{ds}{\beta_{s,i}} \quad \mathbb{A}_i \equiv \int_{s \in S_i} \frac{\alpha_s}{\beta_{s,i}} ds \quad \mathbb{P}_i \equiv \int_{s \in S_i} \frac{p_{s,i}}{\beta_{s,i}} ds \quad (3.50)$$

Thus, each variety is weighted by the inverse of its taste mismatch $\beta_{s,i}$ to determine the *effective* mass of varieties, given by $\mathbb{N}$. It is $\mathbb{N}$, and not the unweighted mass of varieties N , which affects the consumers' demand for a given variety. Indeed, adding or deleting varieties with bad taste matches does not affect much the demand for the others, whereas the opposite holds when the match is good. Note also that the effective mass of varieties $\mathbb{N}$ may be larger or smaller than the unweighted mass of varieties N in the product market, according to the distribution of taste mismatches. Similarly, the quality and price of a variety are weighted by the inverse of its taste mismatch to determine the effective quality index $\mathbb{A}$ and the effective price index $\mathbb{P}$. In particular, varieties displaying the same quality (or price) may have a very different impact on the demand for other varieties according to their taste mismatches. The aggregate indices in (3.49) show that taste heterogeneity across varieties affects demand and, therefore, the market outcome. This shows that preferences (3.48) are *asymmetric* and capture several of the main features of the Lancasterian approach to product differentiation, such as different degrees of substitution between varieties, when varieties are asymmetrically located in the product characteristics space.

Note also that (3.49) implies that the total mass of varieties consumed is given by

$$Q_i = \frac{\mathbb{A}_i - \mathbb{P}_i}{1 + \gamma\mathbb{N}_i}. \quad (3.51)$$

which shows once more how the utility of a variety depends on the distribution of the taste parameter $\beta_{s,i}$ since all the aggregate indices enter into Q_i . Incidentally, note that the definition of Q_i corresponds to the second term in the right-hand side of (3.49), where it is weighted by the ratio $\gamma/\beta_{s,i}$. Thus, the larger Q , the tougher the competition that each variety s faces and the smaller its demand. For example, competition effects are stronger whenever the aggregate quality $\mathbb{A}$ is higher. As a result, if the aggregate quality goes up this will reduce the demand for each variety. This may lower the WTP for a particular variety by so much that the choke price of this variety falls below its costs, thus driving this variety out of business. This channel of firm-product exit was

hitherto missing in models where the level of quality was not included in the competition effects and, therefore, could not affect the exit (or entry) of products.

The above discussion shows that it is possible to introduce asymmetry across varieties in demand in a very simple way. As will be seen, preferences (3.48) also generate a large array of new effects. The demand for a variety s now depends on its own horizontal and vertical attributes as well as on the effective mass of competing varieties ($\mathbb{N}$), the aggregate effective quality ($\mathbb{A}$) and the effective price index ($\mathbb{P}$). The interplay between these aggregate indices determine how a particular variety *meets the competition*.

Standard definitions of horizontal and vertical differentiation exist for indivisible varieties and with consumers making mutually exclusive choices. But these concepts until now were largely absent in models guiding the majority of empirical works in trade. Therefore, vertical preferences can be considered particularly useful for those researchers who are interested in measuring and distinguishing horizontal (taste) from vertical (quality) attributes in trade. In contrast, in the standard quadratic utility, the common β assigned to all the varieties affects both price and quantity sold of each variety, which makes it difficult to interpret it as a true parameter of horizontal differentiation. With the new and richer set of preferences introduced here, that distinction can now be made more clearly.

The operating profits earned from selling variety s in country i can be written as follows:

$$\pi_{s,i} = (p_{s,i} - c_{s,i}) q_{s,i}.$$

Remember that markets are assumed to be segmented, so that $q_i(s)$ and $p_i(s)$ differ according to the destination country the firm exports its variety to.

As in the previous models, since the variety s is negligible to the market, differentiating $\pi_{s,i}$ with respect to $p_i(s)$ yields:

$$p_{s,i}(\mathbb{P}_i) = \frac{\alpha_s + c_{s,i} - \gamma Q_i(\mathbb{P}_i)}{2}. \quad (3.52)$$

The natural interpretation of this expression is that it represents firm s ' best-reply to the market conditions. These conditions are defined by the aggregate behavior of all producers, which is summarized here by the price index $\mathbb{P}_i$. The best-reply function is upward sloping because varieties are substitutable: a rise in the effective price index $\mathbb{P}_i$ relaxes price competition and enables each firm to sell its variety at a higher price. Even though the price index is endogenous, $\mathbb{P}_i$ is accurately treated parametrically because each variety is negligible to the market.

In contrast, since firms' quality and location choices are taken exogenously, $\mathbb{A}_i$ and $\mathbb{N}_i$ are simply determined by the distributions of quality (α_s) and tastes ($\beta_{s,i}$) over S_i . In particular, by shifting the best reply downward, a larger effective mass $\mathbb{N}_i$ of firms makes competition tougher and reduces prices. Similarly, when the quality index $\mathbb{A}_i$ rises, each firm faces competing varieties which together represent a higher aggregate quality, thus making the market penetration of a particular variety harder. Note also that $\mathbb{A}_i$ affects prices positively, even though it affects each individual variety's price

negatively. This implies that an increase in aggregate quality in a country raises price levels, but makes it harder for an individual variety to survive. Thus, through market aggregates, monopolistic competition's weak interactions, typical of the Chamberlin-like models, can be reconciled with several of the main features of Hotelling-like models of product differentiation.

Integrating (3.52) over S shows that the equilibrium price index can be expressed in terms of three market indices:

$$\mathbb{P}_i^* = \mathbb{C}_i + \frac{\mathbb{A}_i - \mathbb{C}_i}{2 + \gamma \mathbb{N}_i} \quad (3.53)$$

where the cost index is defined as

$$\mathbb{C}_i = \int_{s \in S_i} \frac{c_s}{\beta_s} ds.$$

Hence, as in the other market indices, varieties' costs are weighted by the taste distribution in the country of destination. The interpretation is that efficiently produced varieties may have a low impact on the cost index when they have a bad match with local taste. In sum, each destination country is characterized by a different set of market aggregates ($\mathbb{N}_i$, $\mathbb{A}_i$, $\mathbb{C}_i$, and $\mathbb{P}_i$), which are all weighted by the destination-specific taste distribution.

As in the other variations, The market process is described by an aggregative game involving a continuum of players (the variety suppliers) and a single market aggregate $\mathbb{P}_i$ per destination country. The equilibrium outcome is given by a Nash equilibrium, which is determined as follows. Plugging (3.53) into (3.52), equilibrium prices of variety s in country i can be written as

$$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \mathcal{T}_i \left(\frac{\tilde{a}_i - \tilde{c}_i}{2} \right) \quad (3.54)$$

where taste-weighted average quality and cost indices are obtained by dividing cost and quality indices by the effective number of varieties in the market:

$$\tilde{a}_i \equiv \mathbb{A}_i / \mathbb{N}_i \quad \tilde{c}_i \equiv \mathbb{C}_i / \mathbb{N}_i$$

and where

$$\mathcal{T}_i \equiv \frac{\gamma \mathbb{N}_i}{2 + \gamma \mathbb{N}_i} \in [0; 1]. \quad (3.55)$$

Clearly, the equilibrium price of a single variety depends on the market aggregates $\mathbb{A}_i$, $\mathbb{C}_i$ and $\mathbb{N}_i$, which in turn depend on the whole distribution of the taste mismatch parameter $\beta_i(\cdot)$ as well as on the cost ($c(\cdot)$) and quality ($\alpha(\cdot)$) parameters of the competitors in country i .

As for the parameter $\mathcal{T}_i$, it reflects the *toughness* of competition in country i , which can make the equilibrium price range from perfect competition to pure monopoly. This is an important additional feature of the preferences presented in this Chapter: it offers

the possibility of studying different types of market structure in trade models by varying the toughness of competition. To see this, consider the following example. When γN_i is arbitrarily small, which means that variety s has only poor substitutes in country i , each variety is supplied at its monopoly price because $\mathcal{T}_i \rightarrow 0$. On the other hand, when $\mathcal{T}_i \rightarrow 1$, country i is crowded by many good substitutes, which means that the market outcome converges toward perfect competition and only the varieties with the highest social value will survive, very much as in oligopolistic models of product differentiation (Shaked and Sutton, 1983).

The benefits of assuming that γ is the same between any pair of varieties are reaped by capturing the intensity of competition within a particular product and country through $\mathcal{T}_i$. In addition, the toughness of competition may vary from one country to another because $\mathcal{T}_i$ depends on the effective mass of competing varieties in each country, which depends itself on the country-specific taste distribution.⁵

It follows from (3.54) that higher quality results in higher prices, but the opposite need not hold. Prices can rise for other reasons such as higher costs or lower competition. This points at the need to complement unit values with cost controls to properly measure quality at the variety level, which is not always possible without access to additional firm-level information.

Note also that the first term of (3.54) is variety-specific (the parameters are all indexed s). These variety-specific determinants of prices and per-capita quantities, such as cost and quality, do not vary by destination country and influence prices and quantities in a similar way in all countries. However, the second term in (3.54) is not variety-specific but depends on destination market aggregates that are identical for all the varieties (beer) sold in a particular country i . Since these indices are country-specific variables (all indexed i) we refer to the second term in (3.54) as a *market effect*.

The (absolute) markup is given by

$$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2} - \mathcal{T}_i \left(\frac{\tilde{\alpha}_i - \tilde{c}_i}{2} \right) \quad (3.56)$$

As expected, the markup increases (decreases) with $\alpha(s)$ ($c(s, i)$). More importantly, it also increases (decreases) with $\tilde{\alpha}_i$ ($\tilde{c}_i$). Hence, when varieties available in country i have a high quality (a low cost) and a good match with country i 's consumer tastes, the price at which variety s can be sold in country i is low. By contrast, when the same varieties have a bad match, variety s can be sold at a high price. Therefore, quality as such is not enough for a variety to be successful in a specific country. What (3.56) tells is that *the markup of a specific variety is strongly affected by the way competing varieties meet consumers' tastes in country i .*

Last, suppose that the average effective quality $\mathbb{A}_i/N_i$ increases by $\Delta > 0$. Then, if the quality upgrade Δ_s of variety s is such that

⁵This parameter can be nicely related to the existence of different price ranges across sectors observed by Khandelwal (2010). Noting that each variety is characterized by an idiosyncratic quality and cost parameter, we can show that, paraphrasing Khandelwal (2010), it is *the length of the markup ladder* that varies across sectors in the verti-zonal model: the tougher the competition, the shorter the ladder.

$$\Delta_s > \mathcal{T}_i \Delta$$

its price and markup will increase, even though the quality upgrade Δ_s may be lower than Δ . In contrast, if the quality upgrade of variety s is smaller than $\mathcal{T}_i \Delta$, then its markup and price will decrease, even though the quality upgrade Δ_s is positive. Thus, what matters for the "competitiveness" of a firm is its relative quality at the level of the product market.

Using the properties of linear demand functions, it can be readily verified that the equilibrium output of each variety is given by

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} \left[\frac{\alpha_s - c_{s,i}}{2} - \mathcal{T}_i \frac{\bar{\alpha}_i - \bar{c}_i}{2} \right]. \quad (3.57)$$

The first term in parentheses on the right-hand side of (3.57) is variety-specific, whereas the second term shows that quantities shipped can differ across countries due to the (beer) market effect that is common to all the varieties (beers) present in country i . However, the entire expression in brackets is weighted by the taste parameter $\beta_{s,i}$, which is variety- and country-specific turning (3.57) into a non-linear expression. The equilibrium quantity equation (3.57) can be rewritten as a function of its price:

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} [p_{s,i}^* - c_{s,i}]. \quad (3.58)$$

Combining (3.54) and (3.57) also provides a description of the market outcome predicted by the model in terms of the export price and quantity of a variety shipped by a firm to country i . The quantity exported $q_i^*(s)$ differs depending on the characteristics of the destination country, which are captured here by a series of market aggregates. Important to realize is that even when countries are identical in terms of their size and the number of varieties sold, they can still have very different demand for variety s due to the taste differences (distribution of $\beta_i(s)$) in different countries.

Using (3.58) shows that the profits earned on variety s sold in country i are as follows:

$$\pi_{s,i} = \frac{1}{\beta_{s,i}} [p_{s,i}^* - c_{s,i}]^2. \quad (3.59)$$

What this expression shows is that *a variety can be very successful in a particular country while doing poorly on another* for reasons that are both plausible and easy to pin down in the model, i.e., the quality of the match with local tastes, consumer idiosyncrasies across countries, and the toughness of competition within countries. Thus, a firm facing similar markups in two countries may have different profit levels depending on how much its product is liked in each country. In the same vein, (3.59) also reveals that a variety may be sold at a high markup, thus suggesting that its producer has much market power. However, this variety may generate low profits. As a result, *the level of a markup does not necessarily mean that the corresponding variety is selling well.*

The selection issue in CES-like models requires a fixed costs of exporting. This is different in quadratic utility models. Melitz and Ottaviano (2008) already pointed out that with firm heterogeneity in cost, selection and zero trade flows may result from a cost above the choke price in a country. The model introduced here sheds additional light on entry issues due to the role of taste. The novelty here is that, in addition to low productivity, low quality and competition effects, exports of a variety may be zero because of its *high taste mismatch in the destination country*. A zero trade flow may thus stem from any of these aforementioned reasons, or combination of them, thus rendering the identification of individual parameters problematic. This differs from standard models in which productivity is the main parameter to explain entry into export markets (Helpman et al., 2008).

The market effect implies that fob prices can differ depending on destination countries through the β -weighted market aggregates. However, $\beta_{s,i}$ does not enter the price equation (3.54) directly, whereas it does enter directly in the equilibrium quantity equation (3.57).⁶ This is important for several reasons. First, it offers an opportunity for the identification of parameters $\alpha(s)$ and $\beta_{s,i}$ based on the fact that taste affects directly quantities but not prices. Second, it confirms the interpretation of the parameter $\beta_i(s)$ as capturing horizontal differentiation. Also, whereas the price equation (3.54) is a linear and separable equation, the quantity equation (3.57) is not. The reason is that $\beta_{s,i}$ is both country- and variety-specific.

It is also interesting to notice how cost, quality and taste interact in determining the market share of a certain variety, in terms of quantities sold:

$$\frac{q_{s,i}}{Q_i} = \frac{\gamma}{2\beta_{s,i}} \left(\frac{\alpha_s - c_{s,i}}{\tilde{a}_i - \tilde{c}_i} \frac{1}{\mathcal{T}_i} - 1 \right).$$

The relative sales of a particular variety in a market is here shown to depend not only on the quality and cost of a particular variety with respect to the rest of the market, but also on variety-specific taste mismatch, $\beta_{s,i}$, market specific toughness of competition, $\mathcal{T}_i$, and product substitutability, γ . Specifically, varieties with higher quality, α_s , or lower costs, $c_{s,i}$, or a better match with local taste, $\beta_{s,i}$, will have higher market shares. The more so, the lower is the toughness of competition in the market or the higher is product substitutability.

Note, finally, that the equilibrium price of variety s is independent of $\beta_{s,i}$ because the price elasticity itself is independent of this parameter:

$$\epsilon_{s,i} = - \frac{p_{s,i}}{\alpha_s - \gamma Q_i - p_{s,i}}.$$

This expression ranges from 0, when $p_s = 0$, to $-\infty$, when prices equal the intercept of the inverse demand function, $\alpha_s - \gamma Q_i$. Note that β_s does not affect $\epsilon_{s,i}$ and, therefore, has no impact on $p_{s,i}$. However, the whole β -distribution matters because it influences

⁶The parameter β does not enter prices because firms in their profit maximization trade-off setting a higher price when taste is strong and having smaller sales, to setting a price independent of taste but getting a large market share when taste is strong.

the equilibrium value of Q_i , as shown in (3.51). This shows once more how the variables of the model can be affected differently by the taste mismatch parameter.

The features of the verti-zontal model V can thus be summarized as follows.

First, equilibrium prices depend on variety-specific cost and quality as well as on the market-specific degree of competitiveness. Market effects, which can be captured by taste-weighted price, quality and cost indices as well as by the effective mass of competitors, vary with the destination country, but are common to all varieties exported there. Thus, export prices of the same variety across countries only vary through market-specific effects.

Second, equilibrium quantities (sales) depend on market-specific and variety-specific tastes. Thus, export quantities of the same variety across countries shows additional variability, as compared to prices, because of idiosyncratic tastes.

The implications of these properties can be better understood by having a look at the simulation that follows.

3.4.2 Model VI - Vertical differentiation and substitutability

The first combination considered is the variation of the quadratic utility model with vertical differentiation and different patterns of substitutability. The corresponding utility function is

$$U_i = \int_{s \in S_i} \alpha_s q_{s,i} ds - \frac{\beta}{2} \int_{s \in S_i} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{s,i} q_{s,i} q_{r,i} ds dr + q_0 \quad (3.60)$$

yielding the demand function

$$q_{s,i} = \frac{\alpha_s}{\beta} - \frac{\gamma_{s,i}(A_i - P_i)}{\beta(\beta + M_i)} - \frac{p_{s,i}}{\beta}, \quad (3.61)$$

where

$$A_i = \int_{s \in S_i} \alpha_s ds \quad ; \quad M_i = \int_{s \in S_i} \gamma_{s,i} ds \quad ; \quad P_i = \int_{s \in S_i} p_{s,i} ds \quad (3.62)$$

are substitution-weighted indices similar to the ones presented in the context of heterogeneity in substitutability and vertical differentiation. This demand results in the following pricing strategy:

$$p_{s,i} = \alpha_s - \frac{\gamma_{s,i}[A_i - P_i]}{\beta + M_i} - \beta q_{s,i} \quad (3.63)$$

which, taking marginal costs into account can be rewritten as

$$p_{s,i} = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma_{s,i}(A_i - P_i)}{2(\beta + M_i)}. \quad (3.64)$$

This result is quite neat, as it clearly shows not only the role played by idiosyncratic quality and costs, but it also shows how the market aggregates affect any individual

variety only as far as that variety is a close enough substitute with respect to the other varieties in the market. In turn, the degree of substitutability between all the other pairs of varieties in the market will indirectly affect the other varieties through the substitution-weighted number of firms M_i .

Noticing that

$$P_i^* = C_i + \frac{\beta (A_i - C_i)}{2\beta + M_i}, \quad (3.65)$$

where

$$C_i = \int_{s \in S_i} c_{s,i} ds, \quad (3.66)$$

the profit-maximizing price of a variety s in market i can be written as

$$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \frac{(A_i - C_i)}{(2\beta + M_i)}, \quad (3.67)$$

where, similarly to the verti-zontal (3.56), the price of variety s depends not only on its marginal costs and quality, but also on the market aggregate costs and quality. The only difference is that, in the case of the number of competitors, M_i , the weighting parameter is the substitutability parameter, γ , instead of the horizontal differentiation one, β .

Equilibrium markups are then

$$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \frac{(A_i - C_i)}{(2\beta + M_i)} \quad (3.68)$$

and quantities are

$$q_{s,i}^* = \frac{p_{s,i}^* - c_{s,i}}{\beta}, \quad (3.69)$$

resulting in operating profits equal to

$$\pi_{s,i}^* = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta} \quad (3.70)$$

It would then be fair to say that this variation of the quadratic utility has a great potential for development in theoretical modeling and simulations, even if admittedly it has the important drawback of not being easily identifiable empirically, as the two parameters, α_s and $\gamma_{s,i}$ affect prices and quantities in a similar way. One way to overcome this obstacle would be to have access to a proxy to infer substitutability without having to infer it from price and quantities. A notable example in this direction is Hoberg and Phillips (2010), in which the authors use a text-based analysis of 10-K product descriptions to examine whether firms that use a more similar language to describe their products are more likely to engage in mergers and acquisitions, possibly to reduce the competitive effects highlighted in the profit-maximizing pricing function.

3.4.3 Model VII - Horizontal differentiation and substitutability

Another possible way of combining the heterogeneity in the degree of substitutability is with the horizontal differentiation parameter. In this case, the corresponding utility function is

$$U_i = \alpha \int_{s \in S_i} q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{s,i} q_{s,i} q_{r,i} ds dr + q_0 \quad (3.71)$$

which yields the demand function

$$q_{s,i} = \frac{\alpha}{\beta_{s,i}} - \frac{\gamma_{s,i}(\alpha \mathbb{N}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \Gamma_i)} - \frac{p_{s,i}}{\beta_{s,i}} \quad (3.72)$$

where

$$\Gamma_i = \int_{s \in S_i} \frac{\gamma_{s,i} ds}{\beta_{s,i}} \quad ; \quad \mathbb{N}_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}} \quad ; \quad \mathbb{P}_i = \int_{s \in S_i} \frac{p_{s,i} ds}{\beta_{s,i}} \quad (3.73)$$

are indices weighted by substitution and horizontal differentiation parameters which capture the idea that each variety in the market has to be weighted at the same time by its proximity to the consumer ideal and by how many competitors are offering a variety with similar characteristics.

Remember from equation (3.37) that one reasonable way to determine $\gamma_{s,i}$ is

$$\gamma_{s,i} = \int_{r \in S_i} \frac{(\alpha - c_{r,i})}{\beta_{r,i} d_{sr,i}} dr, \quad (3.74)$$

where $d_{sr,i}$ is the distance in the characteristics space between variety s and r . This expression implies that the horizontal characteristics of the variety, β , now affect $\gamma_{s,i}$.

The demand function is associated with the following pricing strategy:

$$p_{s,i} = \alpha - \frac{\gamma_{s,i}[\alpha \mathbb{N}_i - \mathbb{P}_i]}{1 + \Gamma_i} - \beta_{s,i} q_{s,i}, \quad (3.75)$$

yielding to the following optimal pricing

$$p_{s,i}^* = \frac{\alpha + c_{s,i}}{2} - \frac{\gamma_{s,i}(\alpha \mathbb{N}_i - \mathbb{P}_i)}{2(1 + \Gamma_i)}. \quad (3.76)$$

Notice that prices in this variation do depend on the horizontal characteristics of the variety through $\gamma_{s,i}$.

Like in the previous variations, the price index for market i can be computed as

$$\mathbb{P}_i^* = \mathbb{C}_i + \frac{\alpha \mathbb{N}_i - \mathbb{C}_i}{2 + \Gamma_i}, \quad (3.77)$$

where

$$\mathbb{C}_i = \int_{s \in S_i} \frac{c_{s,i} ds}{\beta_{s,i}}, \quad (3.78)$$

to get the profit-maximizing price of a variety s in market i , which can be written as

$$p_{s,i}^* = \frac{\alpha + c_{s,i}}{2} + \frac{\gamma_{s,i}}{2} \frac{(\alpha \mathbb{N}_i - \mathbb{C}_i)}{(2 + \Gamma_i)}. \quad (3.79)$$

The markup associated with this profit-maximizing price is then

$$p_{s,i}^* - c_{s,i} = \frac{\alpha - c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \frac{(\alpha \mathbb{N}_i - \mathbb{C}_i)}{(2 + \Gamma_i)}. \quad (3.80)$$

Again, notice that markups of each variety in this variation indirectly depend on β of the same variety, which was not the case in model III.

The resulting quantities are

$$q_{s,i}^* = \frac{p_{s,i}^* - c_{s,i}}{\beta_{s,i}} \quad (3.81)$$

and operating profits

$$\pi_{s,i}^* = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta_{s,i}} \quad (3.82)$$

This variation is promising, at least in theoretical development terms, because it highlights a tension between the need for firms to get as close as possible to the consumer, to reduce their β and sell more of their varieties, but at the same time the threat of clustering in the same place, as the substitutability parameter γ has a direct negative impact on their capacity to extract profits from each unit sold. Empirically, it would be possible to implement a trade model with these two sources of heterogeneity alone, but the researcher should first be sure that quality heterogeneity can be ruled out because, as mentioned already above, it would be hard to disentangle higher quality from lower substitutability in terms of prices and quantities alone, as the two would have similar effects on the varieties, unless an external source is used to determine the levels of substitutability, as discussed for model IV.

3.4.4 Model VIII - Verti-zontal differentiation and substitutability

Finally, the last variation analyzed consists in the adoption combination of all the possible sources of heterogeneity in a standard quadratic preference framework. The resulting utility function is

$$U_i = \int_{s \in S_i} \alpha_s q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{1}{2} \int_{s \in S_i} \int_{r \in S_i} \gamma_{s,i} q_{s,i} q_{r,i} ds dr + q_0, \quad (3.83)$$

whose optimization leads to the demand function:

$$q_{s,i} = \frac{\alpha_s}{\beta_{s,i}} - \frac{\gamma_{s,i}(\mathbb{A}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \Gamma_i)} - \frac{p_{s,i}}{\beta_{s,i}} \quad (3.84)$$

where

$$\mathbb{A}_i = \int_{s \in S_i} \frac{\alpha_s ds}{\beta_{s,i}} \quad , \quad \Gamma_i = \int_{s \in S_i} \frac{\gamma_{s,i} ds}{\beta_{s,i}} \quad , \quad \mathbb{P}_i = \int_{s \in S_i} \frac{p_{s,i} ds}{\beta_{s,i}} \quad (3.85)$$

are again substitution- and horizontal-differentiation weighted indices, as in the previous cases, with the only difference that in this framework also the distribution of the quality parameter, α , has to be weighted by the relative position in the horizontal characteristics space of all the varieties to yield the quality index $\mathbb{A}$.

As for the previous models with heterogeneity in substitutability, following equation (3.37), the parameter $\gamma_{s,i}$ can be measured as

$$\gamma_{s,i} = \int_{r \in S_i} \frac{(\alpha_{r,i} - c_{r,i})}{\beta_{r,i} d_{sr,i}} dr, \quad (3.86)$$

where $d_{sr,i}$ is the distance in the characteristics space between variety s and r .

The pricing strategy pursued by the firms in this context would be

$$p_{s,i} = \alpha_s - \frac{\gamma_{s,i}[\mathbb{A}_i - \mathbb{P}_i]}{1 + \Gamma_i} - \beta_{s,i} q_{s,i} \quad (3.87)$$

corresponding to the following pricing strategy, once marginal costs are taken into account:

$$p_i^*(s) = \frac{\alpha_s}{2} - \frac{\gamma_{s,i}(\mathbb{A}_i - \mathbb{P}_i)}{2(1 + \Gamma_i)} + \frac{c_{s,i}}{2}. \quad (3.88)$$

The price index for market i is

$$\mathbb{P}_i^* = \mathbb{C}_i + \frac{\mathbb{A}_i - \mathbb{C}_i}{2 + \Gamma_i}, \quad (3.89)$$

where

$$\mathbb{C}_i = \int_{s \in S_i} \frac{c_{s,i} ds}{\beta_{s,i}}. \quad (3.90)$$

The profit-maximizing price of a variety s in market i can then be written as

$$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \frac{(\mathbb{A}_i - \mathbb{C}_i)}{(2 + \Gamma_i)}. \quad (3.91)$$

Notice that the markup function,

$$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \frac{(\mathbb{A}_i - \mathbb{C}_i)}{(2 + \Gamma_i)} \quad (3.92)$$

is also very similar to the verti-zontal markup function in (3.56), where the price of variety s depends not only on its marginal costs and quality, but also on the market aggregate costs and quality. In addition, the index capturing the effective number of firms, Γ_i , depends on the overall distribution of the substitutability parameter, $\gamma_{s,i}$, and taste mismatch with local taste, $\beta_{s,i}$.

Quantities are described, as usual, by the relation

$$q_{s,i}^* = \frac{p_{s,i}^* - c_{s,i}}{\beta_{s,i}} \quad (3.93)$$

and operating profits as

$$\pi_{s,i}^* = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta_{s,i}} \quad (3.94)$$

As for the verti-zontal variation, or Model V, also here it is interesting to notice how cost, quality, taste and substitutability interact in determining the market share of a certain variety, in terms of quantities sold:

$$\frac{q_{s,i}}{Q_i} = \frac{\gamma_{s,i}}{2\beta_{s,i}} \left(\frac{\alpha_s - c_{s,i}}{\tilde{a}_i - \tilde{c}_i} \frac{1}{\mathcal{T}_i} - 1 \right),$$

where now

$$\mathcal{T}_i \equiv \frac{\gamma_{s,i} \mathbb{N}_i}{2 + \Gamma_i} \in [0; 1],$$

which highlights the role played by substitutability in determining the market shares of each variety.

The three dimensions of differentiation are here displayed in all their complexity. At the variety level, firms benefit in terms of pricing capacity from producing high quality varieties (high α_s), being far away from the competition (low $\gamma_{s,i}$), but at the same time close to the consumers (low $\beta_{s,i}$ in order to sell more). However, the fact that other varieties follow have those characteristics has a negative externality on the demand for all the other varieties. In this Thesis no direct relation is imposed between the substitutability parameter and the differentiation parameters, but it may be possible to imagine that the three dimensions have to be somehow related. For example, if two varieties are very close to a consumer taste, they are also very likely to be close to each other in the characteristics space, thus trading off a lower $\beta_{s,i}$ against a higher $\gamma_{s,i}$. This idea is further explored in Chapter 6 when outlining possible future avenues of research.

Finally, as discussed above, it should be noted that this theoretically sophisticated version of the quadratic utility has the disadvantage of not being easily identifiable in empirical terms by using standard trade data on prices and quantities. And it is extremely complicated to find datasets having information on trade, firm characteristics and a description of product characteristics as precise as the one used by Hoberg and Phillips (2010), where varieties are described individually, without restricting the sample to the major US firms.

3.5 Illustration of market outcomes with simulations

After having presented all the variations, a simulation exercise is proposed here to provide some intuition on the properties and features discussed in the text. Based on the model presented in Chapter 1, without any source of heterogeneity except the firms' location, Figure 3.4 is used to describe the structure of all the following simulations.

In the table on the left of Figure 3.4, all the preference parameters and market outcomes are reported, assuming a two-dimensional horizontal differentiation framework of the kind presented in Chapter 2. First information on the exogenous location of firms in the characteristics space is provided following the approach of Lancaster (1966), the X and Y axis thus represent two abstract determinants of horizontal differentiation with equal weight on the definition of taste mismatch, assuming the representative consumer located at the origin. Thus in the characteristics the distance from the consumer can be measured as

$$d_{0s,i} = \sqrt{X_{0s,i}^2 + Y_{0s,i}^2}$$

In order to transform this distance into the taste mismatch parameter β , though, a further consideration is needed. Since the own rate of substitution, for each variety, is reasonably expected to be higher than the cross rate of substitution, the parameter β should take into account on the overall rate of substitution in the market, γ . Therefore,

$$\beta_{0s,i} = d_{0s,i} + \gamma$$

where an arbitrary (or estimated) value is attributed to γ when substitutability is not determined endogenously (as, for example, in Models IV, VI, VII, VIII). This value is assumed higher than unity (the value of the numéraire) to ensure more substitutability between varieties of the same good than with outside goods. The value used in the simulations is 1.2, but the qualitative results are robust to any other value: the only difference would concern the price and quantity distributions affecting all the varieties, which would be shifted by the same amount. In the models where the distance from the consumer is the same for all the varieties, the coordinates of each variety are chosen in such a way to yield the same value, 5, resulting in $\beta = 6.2$.

As for the other parameters, in the models without quality differentiation (Models I, III, IV, VII) variety-specific quality parameters are attributed the value $\alpha = 10$. Costs, while assumed market-variety specific in the text, are held constant in the simulations to show the impact of preference parameters to their full extent, $c_{s,i} = c$. The only exception is the baseline model I, which is characterized only by cost heterogeneity.

These are all the primitives of the simulation. Summing them up, they consist in: the variety's location in the characteristics space, X and Y , measuring the distance of each variety from the representative consumer, located in $(0;0)$; the substitutability between pairs of varieties, γ ; the variety-specific quality parameter α_s ; the market-variety specific taste mismatch $\beta_{s,i}$; the productive efficiency c .

Baseline (no heterogeneities)								
	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8
Horizontal differentiation								
X axis (Beta1)	5.0	3.5	0.0	-3.5	-5.0	3.5	0.0	-3.5
Y axis (Beta2)	0.0	3.5	5.0	3.5	0.0	-3.5	-5.0	-3.5
Preference parameters								
Alpha (quality)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Gamma (substitutability)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Distance from consumer	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Beta (taste mismatch)	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
c (marginal costs)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Market indices								
N (number of firms)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
C (cost index)	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
A (quality index)	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9
M (substitutability index)	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Gamma (weighted substitutability index)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Price components								
Variety-specific ($\alpha / 2 + c / 2$)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Market-specific ($\gamma \alpha Q / 2$)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Market outcomes								
Prices	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Markups	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Quantities	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Operating profits	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Aggregate market outcomes								
P (price index)	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Q (total quantities)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Total market profits	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Additional statistics								
Markups/costs	42%	42%	42%	42%	42%	42%	42%	42%
Quantity shares	13%	12%	13%	12%	13%	12%	13%	12%
Profit shares	13%	12%	13%	12%	13%	12%	13%	12%

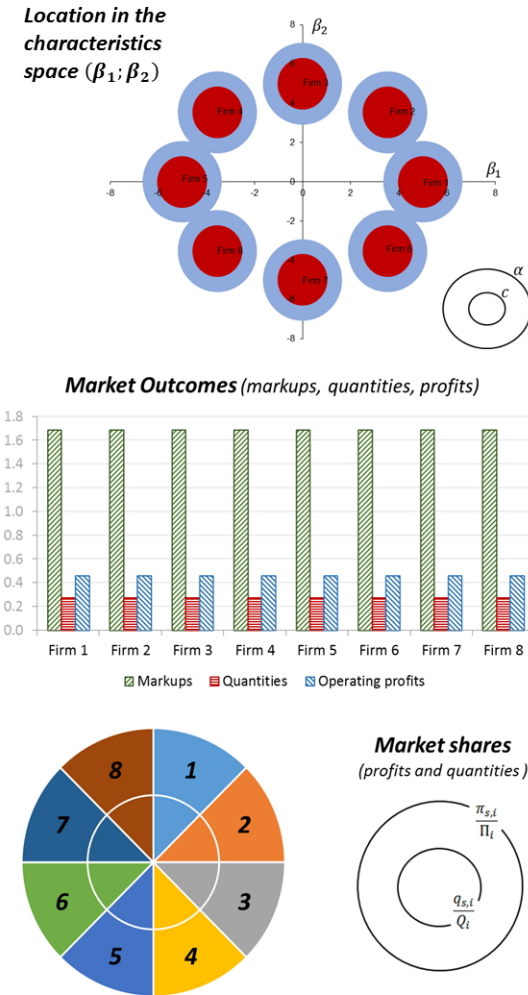


Figure 3.4: Simulation with baseline model without cost heterogeneity

Description of the simulation Tables

These primitives map into different market indices in each simulation. The ones reported in the Tables are the effective number of firms N_i , the cost index C_i , the quality index A_i and the substitutability index Γ_i . Since these indices are in some models just a sum of the market parameters but in most of them a weighted sum of parameters where each terms is divided by the corresponding taste mismatch parameter, for comparability the weighted sum is reported in all the Tables (i.e., all the indices are calculated as shown in Model 8, implicitly considering all the other models as special cases where some parameters are held fixed).

After market indices, the price components are shown. In quadratic utilities equilibrium prices can always be divided into a variety-specific component and a market component, affecting all the varieties in the same way and capturing competition effects. These two components are reported separately.

Then, the standard variety-specific market outcomes are reported: prices; markups; quantities; operating profits. Aggregate market outcomes ensue: the price index; total quantities sold; total operating profits generated in the market. Notice that the price index is again computed as in Model 8, i.e. discounting each price by the corresponding taste mismatch. Quantities are instead reported as the simple sum of quantities sold, as there is no quantity index in the model built similarly to the other indices (i.e., discounting the terms by the taste mismatch value). The same holds for total operating profits.

Finally, some interesting additional statistics are proposed, such as markups as a percentage of marginal costs of production (to show that they are not fixed in the quadratic utility framework) and the quantity and profit shares.

Description of the simulation Graphs

Turning to the three graphs to the right of Figure 3.4, they represent visually the information provided in the table, which makes it then easily comparable across models.

On the top right, the varieties' location in the horizontal characteristics space is represented, where the representative consumer is located in $(0;0)$ and $(X;Y)$ axes reflect the $(\beta_1;\beta_2)$ characteristics space described in Chapter 2. It is important to remember that a visual representation as in Chapter 2 requires the same assumptions used in the context of location theory, and in particular the constraint on fixed quantities discussed in 2.3.4. In addition, information is provided on the relative value of marginal costs, represented through the size of the inner circles, and the relative value of quality, represented through the size of the outer circles. In this way almost all the primitive values of the simulation can be represented in one graph (with the only exception of substitutability, which requires a separate representation device when made endogenous).

The size of the circles is proportional to the values of α_s and c . The perimeter of the outer circle (α) can be interpreted as the locus of consumers who would be indifferent between buying a fixed mount $\bar{q}$ of variety s in exchange for a unit of the numéraire and keeping the numéraire, in the absence of substitution effects (i.e., assuming $\gamma Q = 0$).

Notice that in the examples the representative consumer is unique and located in $(0;0)$, so the locus of indifferent consumers refers only to potential consumers described in terms of the location of their ideal characteristics in the $(X;Y)$ space. Notice also that consumer $(0;0)$ is not forced to consume $\bar{q}$ units of the varieties, i.e. she will buy also the varieties whose outer circle does not include $(0;0)$ but in smaller quantities than the $\bar{q}$ used for the illustration.

As for costs, represented in the inner circle (c) , there is no similar interpretation in terms of consumers' location, but its size follows the proportion between c and α for each variety. The difference between the radius of the outer circle and the radius of the inner circle is therefore an indication of the level of markups, which are equal to $1/2$ of the distance between quality and cost, net of competition effects (i.e., when $\gamma Q = 0$)

The second graph on the right shows the absolute value of markups, quantities sold and operating profits for each variety. The relative share of profits (outer pie) and quantities (inner pie) are then shown on the bottom right graph.

Simulation of market outcomes - Model I (cost heterogeneity)

The properties of Model I are exemplified in the corresponding simulation shown in Figure 3.5. As compared to Figure 3.4, the only difference is that marginal costs of production are now assumed different for each variety, as easily visible from the inner circle differences in the top-right graph. In terms of market outcomes, the first difference that can be spotted is that, comparing any pair of varieties, say s and r , and looking at their cost difference,

$$\Delta_{c_{s,i},c_{r,i}} = c_{s,i} - c_{r,i},$$

it can be observed that the corresponding absolute value of price and markup differences of the same pair of varieties is equal to half of the absolute value of $\Delta_{c_{s,i},c_{r,i}}$. Defining

$$\Delta_{p_{s,i},p_{r,i}} = p_{s,i} - p_{r,i} ; \Delta_{(p-c)_{s,i},(p-c)_{r,i}} = (p_{s,i} - c_{s,i}) - (p_{r,i} - c_{r,i}),$$

it can be noted indeed that

$$|\Delta_{p_{s,i},p_{r,i}}| = |\Delta_{(p-c)_{s,i},(p-c)_{r,i}}| = \left| \frac{\Delta_{c_{s,i},c_{r,i}}}{2} \right|,$$

with the important difference that markups will be higher for the most efficiently produced variety and prices lower by the same amount. This result highlights the notion that only half of the marginal costs are passed-through to the final consumers in a quadratic utility framework. Another notable property of Model I can also be easily seen in Figure 3.5. Relative markup, quantity and profit levels keep the same ranking across varieties. In other words, the variety with the lowest level of markups is also the one with the lowest sales and profits and so on.

Still, the fact that ranks are kept doesn't imply that changes are proportional. Indeed, from the bottom-right graph it can be noticed that profit shares are more concentrated than quantity shares, i.e varieties that enjoy a larger share of quantities sold are associated with a more than proportional share of profits and vice versa for varieties sold less.

This is due to the fact that higher markups and quantities sold reinforce each other in determining profitability.

Simulation of market outcomes - Model II (α heterogeneity)

Figure 3.6 simulates market outcomes under the assumptions of Model II. The values of α have been attributed randomly with the only aim of illustrating the properties of the model. It can be noticed that there is a certain degree of symmetry between the properties of Models I and II. In particular, defining

$$\Delta_{\alpha_{s,i},\alpha_{r,i}} = \alpha_s - \alpha_r,$$

it is again true, as for Model I, that

$$|\Delta_{p_{s,i},p_{r,i}}| = |\Delta_{(p-c)_{s,i},(p-c)_{r,i}}| = \left| \frac{\Delta_{\alpha_{s,i},\alpha_{r,i}}}{2} \right|,$$

as can be observed by comparing any pair of varieties in the simulation.

The main difference is that now also the signs of the price and markup differences are equal, reflecting the fact that firms charge consumers half of the additional utility that the higher quality of their varieties implies for the consumers.

Notice also that, similarly to Model I, markups and quantities reinforce each other in determining the profit levels, as can be again seen from the bottom-right graph.

Simulation of market outcomes - Model III (β heterogeneity)

The simulation shown in Figure 3.7 differs substantially from the previous ones in three important aspects. First, differently from the previous simulations, varieties are now scattered in the space without any particular order, resulting in different distances from the consumer. This results in each variety having a different distance from the consumer and from the other varieties. Second, since varieties are differentiated only horizontally, markups and prices turn out to be exactly the same for all. Third, since markups are constant but quantities sold are not, profit and quantity shares coincide, i.e. there the profit magnification effect seen in Models I and II.

The first aspect can be seen from the top-right graph in Figure 3.7, where circles have all the same size because of the assumed homogeneity in costs and quality across varieties. The second feature can be observed from the middle graph on the left, where identical markups across varieties are associated with different quantity and operating profit levels, which notably keep the same proportions across varieties. This last feature is made even more evident in the bottom-right graph, where each variety is shown to have a different share of total market profits, but profit and quantity shares coincide, which is a feature observed only in Model 3.

Simulation of market outcomes - Model IV (γ heterogeneity)

The simulation exercise associated with Model IV has an additional layer of complexity if compared with the previous ones. Qualities, costs and location on the characteristics

space are assumed constant across varieties, so that no heterogeneity is visible on the top-right graph of Figure 3.8, yet the other two graphs on the right show that variation in substitutability causes a great extent of variability in market outcomes.

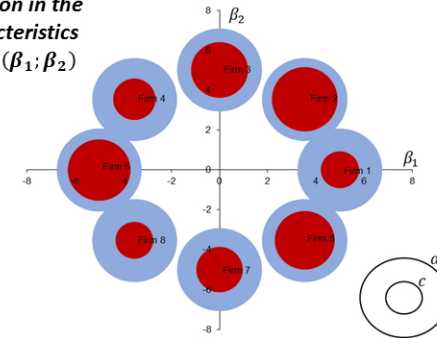
Normally the heterogeneity in γ should be associated with other sources of heterogeneity in the spatial configuration of the market, in the characteristics space, to justify the different levels of substitutability as discussed in Section 3.3.4. To illustrate the theoretical case of heterogeneity in γ alone, here values are assigned randomly. As a consequence, given the constant distance of varieties from the consumer in the characteristics space and the definition of β as the sum of substitutability and distance from the consumer for this simulation, also the β in the Table ends up being affected.⁷

The reason for the random assignment of values for β is that, given the absence of any other source of heterogeneity, the formulas proposed in (3.36) and (3.37) would yield the same value for each variety. This is shown in Figure 3.9, where the two tables indicate the steps to follow to determine the value of parameter $\gamma_{s,i}$ in its weighted and unweighted versions. First, a matrix of bilateral distances is measured, as shown on the left table for weighted and unweighted distances; then, all the elements of the matrices are inverted; finally, the rows are summed for each variety to represent the imputed distance of each variety from the competition in the market, displayed in the last two rows of the table to the right and in the graphs at the bottom.

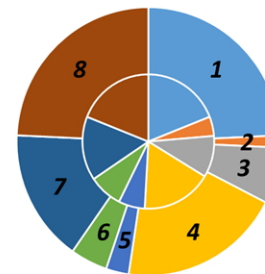
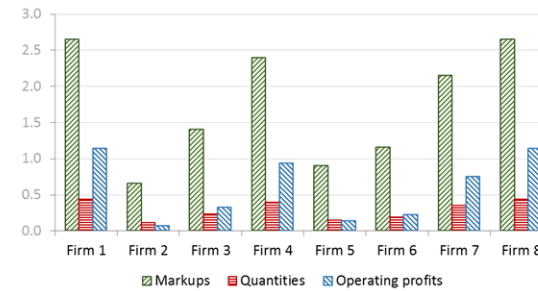
As in the previous model simulations, it can be noticed that ranks in markups, quantities and operating profits are constant across varieties in the sense that the ranking of varieties in terms for one characteristic is equal to the ranking for the others. At the same time, also in this case as in Model I and II profit shares are more concentrated than quantity shares because of markups and quantities being both affected similarly by $\gamma_{s,i}$.

⁷Distance from the consumer could be altered to keep β constant, but that would not qualitatively change the outcomes of the example, which is meant to be just an illustration.

Model 1 (only cost heterogeneity)								
	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8
Horizontal differentiation								
X axis (Beta1)	5.0	3.5	0.0	-3.5	-5.0	3.5	0.0	-3.5
Y axis (Beta2)	0.0	3.5	5.0	3.5	0.0	-3.5	-5.0	-3.5
Preference parameters								
Alpha (quality)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Gamma (substitutability)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Distance from consumer	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Beta (taste mismatch)	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
c (marginal costs)	2.0	6.0	4.5	2.5	5.5	5.0	3.0	2.0
Market indices								
N (number of firms)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
C (cost index)	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
A (quality index)	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9
M (substitutability index)	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Gamma (weighted substitutability index)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Price components								
Variety-specific ($\alpha / 2 + c / 2$)	6.0	8.0	7.3	6.3	7.8	7.5	6.5	6.0
Market-specific ($\gamma Q / 2$)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Market outcomes								
Prices	4.7	6.7	5.9	4.9	6.4	6.2	5.2	4.7
Markups	2.7	0.7	1.4	2.4	0.9	1.2	2.2	2.7
Quantities	0.4	0.1	0.2	0.4	0.1	0.2	0.3	0.4
Operating profits	1.1	0.1	0.3	0.9	0.1	0.2	0.7	1.1
Aggregate market outcomes								
P (price index)	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Q (total quantities)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Total market profits	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Additional statistics								
Markups/costs	133%	11%	31%	96%	16%	23%	72%	133%
Quantity shares	19%	5%	10%	17%	6%	8%	15%	19%
Profit shares	24%	1%	7%	20%	3%	5%	16%	24%

Location in the characteristics space ($\beta_1; \beta_2$)

Market Outcomes (markups, quantities, profits)



Market shares (profits and quantities)

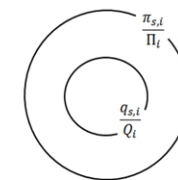
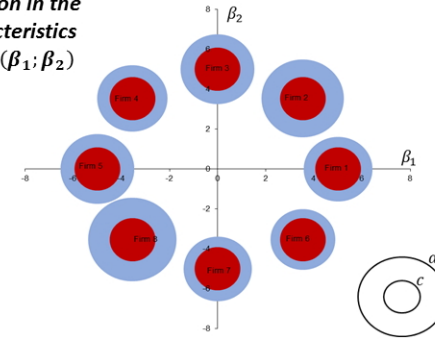
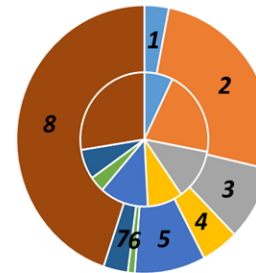
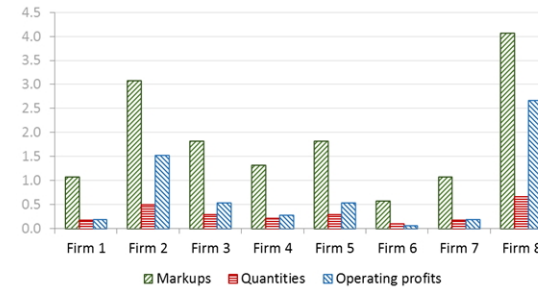


Figure 3.5: Simulation with model 1: heterogeneous costs

Model 2 (only quality heterogeneity)								
	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8
Horizontal differentiation								
X axis (Beta1)	5.0	3.5	0.0	-3.5	-5.0	3.5	0.0	-3.5
Y axis (Beta2)	0.0	3.5	5.0	3.5	0.0	-3.5	-5.0	-3.5
Preference parameters								
Alpha (quality)	9.0	13.0	10.5	9.5	10.5	8.0	9.0	15.0
Gamma (substitutability)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Distance from consumer	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Beta (taste mismatch)	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
c (marginal costs)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Market indices								
N (number of firms)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
C (cost index)	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
A (quality index)	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6
M (substitutability index)	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Gamma (weighted substitutability index)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Price components								
Variety-specific ($\alpha / 2 + c / 2$)	6.5	8.5	7.3	6.8	7.3	6.0	6.5	9.5
Market-specific ($\gamma \alpha Q / 2$)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Market outcomes								
Prices	5.1	7.1	5.8	5.3	5.8	4.6	5.1	8.1
Markups	1.1	3.1	1.8	1.3	1.8	0.6	1.1	4.1
Quantities	0.2	0.5	0.3	0.2	0.3	0.1	0.2	0.7
Operating profits	0.2	1.5	0.5	0.3	0.5	0.1	0.2	2.7
Aggregate market outcomes								
P (price index)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Q (total quantities)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Total market profits	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Additional statistics								
Markups/costs	27%	77%	45%	33%	45%	14%	27%	102%
Quantity shares	7%	21%	12%	9%	12%	4%	7%	27%
Profit shares	3%	25%	9%	5%	9%	1%	3%	45%

Location in the characteristics space ($\beta_1; \beta_2$)

Market Outcomes (markups, quantities, profits)



Market shares (profits and quantities)

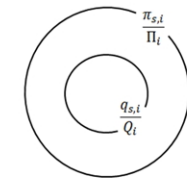


Figure 3.6: Simulation with model 2: heterogeneous quality

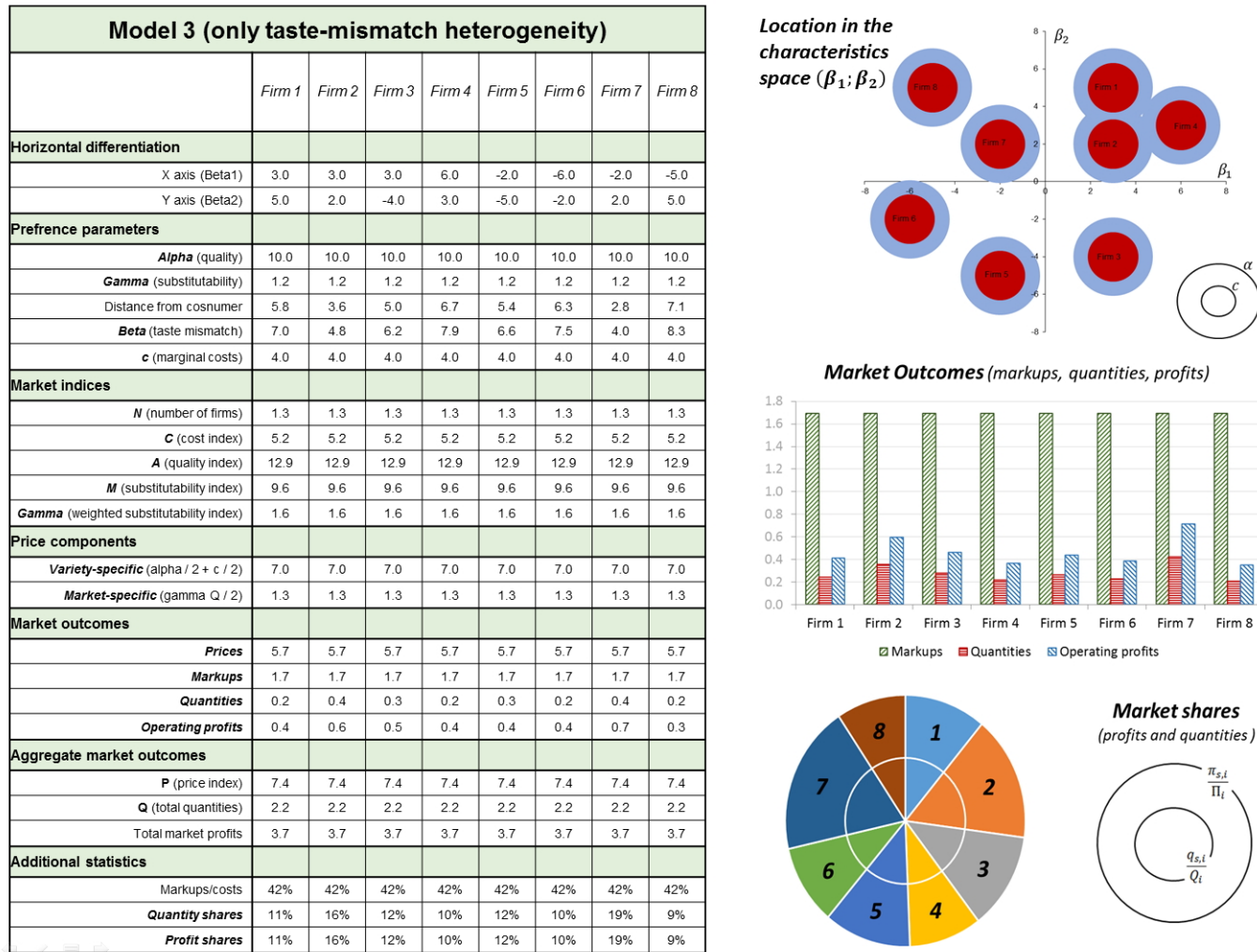
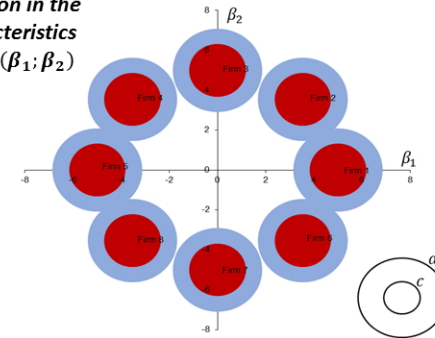
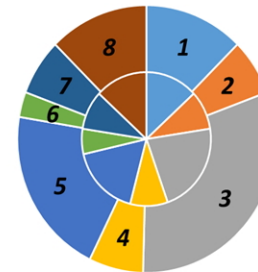
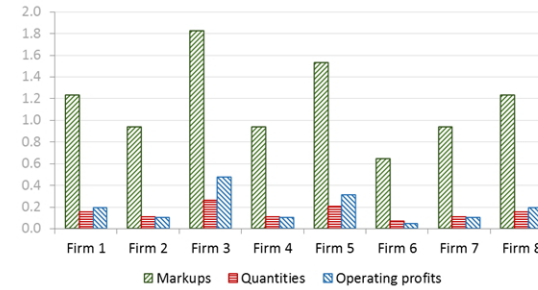


Figure 3.7: Simulation with model 3: heterogeneous taste mismatch

Model 4 (only substitutability heterogeneity)								
	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8
Horizontal differentiation								
X axis (Beta1)	5.0	3.5	0.0	-3.5	-5.0	3.5	0.0	-3.5
Y axis (Beta2)	0.0	3.5	5.0	3.5	0.0	-3.5	-5.0	-3.5
Preference parameters								
Alpha (quality)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Gamma (substitutability)	3.0	3.5	2.0	3.5	2.5	4.0	3.5	3.0
Distance from consumer	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Beta (taste mismatch)	8.0	8.5	7.0	8.5	7.5	9.0	8.5	8.0
c (marginal costs)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Market indices								
N (number of firms)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
C (cost index)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
A (quality index)	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9
M (substitutability index)	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Gamma (weighted substitutability index)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Price components								
Variety-specific ($\alpha / 2 + c / 2$)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Market-specific ($\gamma \alpha Q / 2$)	1.8	2.1	1.2	2.1	1.5	2.4	2.1	1.8
Market outcomes								
Prices	5.2	4.9	5.8	4.9	5.5	4.6	4.9	5.2
Markups	1.2	0.9	1.8	0.9	1.5	0.6	0.9	1.2
Quantities	0.2	0.1	0.3	0.1	0.2	0.1	0.1	0.2
Operating profits	0.2	0.1	0.5	0.1	0.3	0.0	0.1	0.2
Aggregate market outcomes								
P (price index)	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Q (total quantities)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total market profits	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Additional statistics								
Markups/costs	31%	24%	46%	24%	38%	16%	24%	31%
Quantity shares	13%	9%	22%	9%	17%	6%	9%	13%
Profit shares	12%	7%	31%	7%	20%	3%	7%	12%

Location in the characteristics space ($\beta_1; \beta_2$)

Market Outcomes (markups, quantities, profits)



Market shares (profits and quantities)

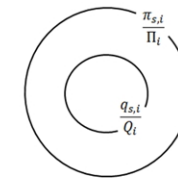


Figure 3.8: Simulation with model 4: heterogeneous substitutability

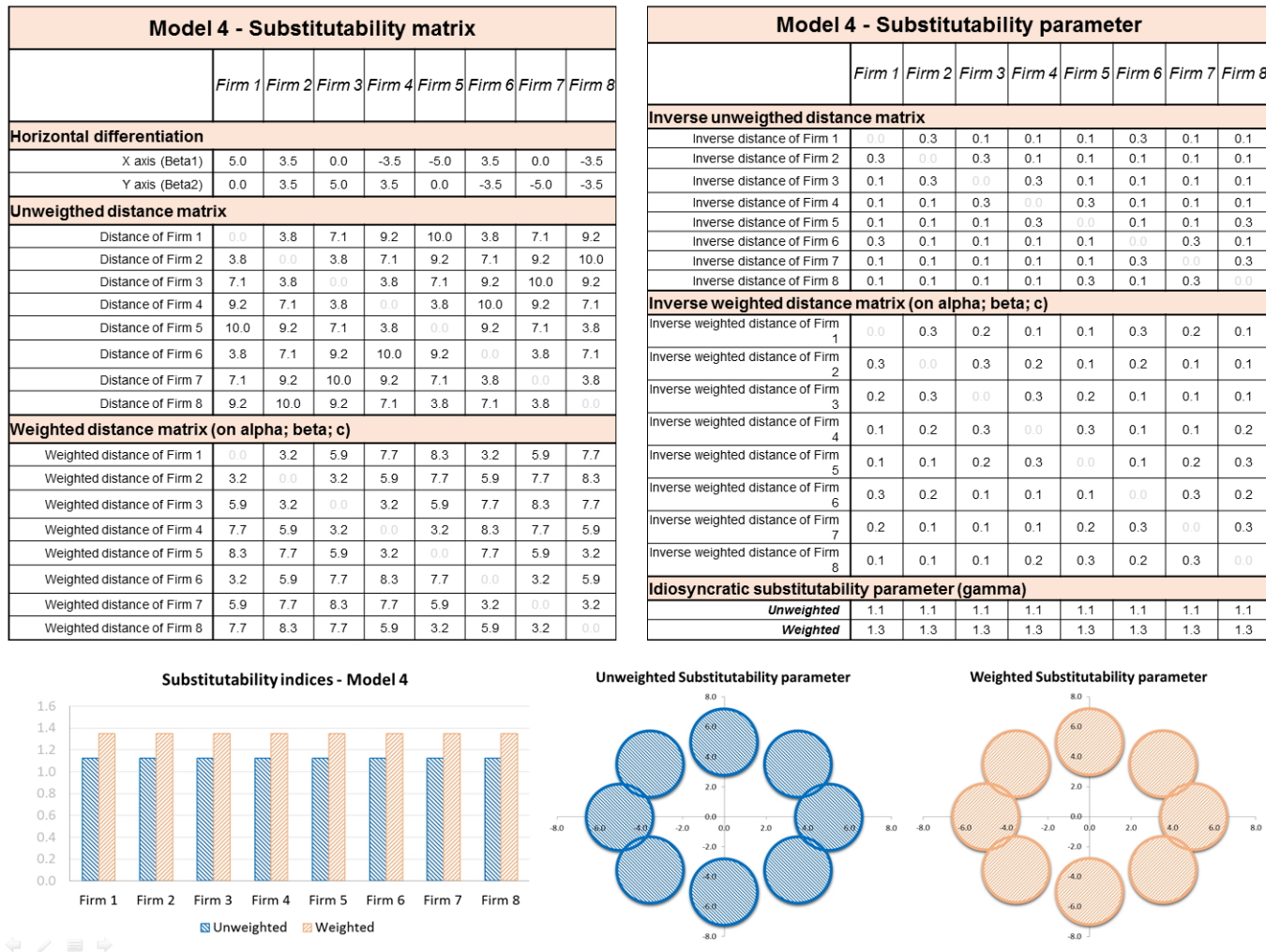


Figure 3.9: Idiosyncratic substitutability parameter in model 4

Simulation of market outcomes - Model V (α, β heterogeneity)

The simulation of market outcomes corresponding to Model V are shown in Figure 3.10. By looking at the graph on the top right, it can be observed that this simulation combines the location of varieties in the characteristics space of Model III (Figure 3.7) and the quality levels assigned to varieties in Model II (Figure 3.6).

While tractable, Model V is shown in the simulation to be able to accommodate complex market outcomes. For example, comparing the varieties produced by Firm 2 and Firm 8, it can be noticed that markups, prices and quantities don't display the same ranking. Firm 8 produces a variety of a much higher quality than all the others and therefore, given the constant distribution of costs, has higher markups and prices than any other firm. Still, it is not the variety selling the most. Firm 2's characteristics are indeed closer to the consumer's ideal and the lower $\beta_{s,i}$ associated with this low taste mismatch makes the variety produced by Firm 2 the most sold in the market.

This can be easily seen from the bottom-right graph, showing quantities (inner circle) and profits (outer circle) as shares of market total. Firm 2 sells indeed more than Firm 8, even if the profit share of the latter is slightly higher than the former.

Still, the ranking of quantities is not completely independent of the ranking of markups. As can be seen from (3.58), markups still play a fundamental role in determining quantities sold. As shown in next chapter, this feature matches quite neatly some basic trade patterns observed in the data, besides being consistent with the empirical evidence found in the literature and reported in Chapter 2.

Comparing Model V with the previous ones, it can thus be noted that it manages to break the constant ranking of profits, markups and quantities sold displayed in Model II with only quality heterogeneity (or in the baseline model with cost heterogeneity, the only difference being that prices and markups move in opposite directions), but it also manages to break the perfect correspondence between profit shares and quantity shares observed in Model III, which is also a convenient feature when dealing with real data.

Simulation of market outcomes - Model VI (α, γ heterogeneity)

The simulation of Model VI shown in Figure 3.11 combines the sources of heterogeneity used in Model II (Figure 3.6) and Model IV (Figure 3.8). Varieties are thus equidistant from the consumers' ideal, as shown in the top-right graph, but the different quality levels alter the substitution patterns in ways that generate results which would not be possible with the previous models presented.

To see the most interesting result of the combination of quality and substitution heterogeneity, focus on two specific varieties: the one produced by Firm 1 and Firm 7. The two are characterized by exactly the same distance from the consumer and the same quality level, so in any model of non-localized competition à la Dixit and Stiglitz (1977) they would be associated with the same prices, markups and quantities sold. But it is not the case in the simulation presented here.

Even if they share one closest neighbor, Firm 6, they differ in the characteristics of the other closest neighbor, which is Firm 8 in the case of Firm 7 and Firm 2 in the

case of Firm 1. Even though these two firms have the same distance from the consumer (i.e., the same β) and the same distance vis-à-vis the two Firms 7 and 2, they have one important difference: their quality level. Firm 8 displays a higher quality than Firm 2 and therefore the competitive pressure exerted on Firm 7 by Firm 8 is stronger than the impact of Firm 2 on Firm 1.

The specific impact on the overall substitution level of each bilateral relation can be seen from Figure 3.12. Browsing the determinants of the substitution parameter for Firm 1 and Firm 7 it is possible to see the higher impact of their closest neighbors. So it can be noticed that Firm 6 does indeed cause the same erosion of margins to Firms 1 and 7 in both the weighted and the unweighted distance matrices. The same is not true for the impact of Firm 8 on Firm 7 and of Firm 2 to Firm 1. They are the same in the case of the unweighted matrix, i.e. when quality and the other variety characteristics are not factorized in the measurement, but they differ when the quality difference is taken into account. The weighted distance of Firm 8 from Firm 7 is indeed 1.7, which compares with a distance of 2.1 of Firm 1 from Firm 2. Notice that the weighted distance matrix is asymmetric. For example, since Firms 2 and 7 have the same quality, their weight on their neighbors is the same (3.8 in both the case of Firm 2 for Firm 1 and of Firm 7 for Firm 8).

In the graphs at the bottom of Figure 3.12, the difference between the weighted and the unweighted substitutability parameter is displayed in bar (to the left) and on the characteristics space, to the right, where the size of the circle indicates the competitive pressure implied by the variety's location.

Going back to Figure 3.11, the impact on quantities and profits is very similar to Model II with quality heterogeneity alone. The impact of substitutability in this simulation is quite marginal, also because all the varieties have the same distance from each other (which is relaxed, for example, in Model VIII). However, the impact of substitutability also depends on the calibration choices and all the other parameters, so it is impossible to say a priori whether heterogeneity in substitutability implies only a second-order effect on market outcomes.

Finally, remark that Model VI can merge nicely the insights of localized competition à la Salop (1979) without limiting the impact to the closest neighbors alone, but extending it to the entire universe of firms in the market, which is rather a feature of non-localized competition.

Simulation of market outcomes - Model VII (β, γ heterogeneity)

The simulation of Model VII in Figure 3.13 has a few distinguishing features as opposed to the previous ones, and notably on Model III (Figure 3.7) and Model IV (Figure 3.8) based on the same sources of heterogeneity not combined.

First of all, it should be noticed that the combination of horizontal differentiation and location-driven substitutability patterns generate endogenously a difference in prices, which was not present in Model III and was artificially introduced in model IV by assigning different substitutability parameters to the varieties even in the absence of any

other source of heterogeneity would have meant the same value for the parameter in for all the varieties (see Figure 3.9, for example).

This feature has relevant implications. Even in a market where there is no scope for vertical differentiation and where each firm would sell at the same price in a situation of pure monopoly (i.e. even when all the firms have the same costs and quality), prices may differ because of a firm specific competitive pressure exerted by the market. This concept mixes the insights of localized and non-localized competition in an innovative way, resulting in results that would not be easy to obtain without making ad hoc assumptions on the interaction between one particular variety and one market. This is because in models of non-localized competition all the firms must be treated symmetrically and in models of localized competition firms are not affected by market aggregates but just by their neighbors behavior (which in the monopolistic competition assumption is considered irrelevant, even if for the sake of illustration in the simulations the market is populated by only 8 firms, which should rather be considered classes of firms).

In terms of market outcomes, results are similar to the vertical model V, with the taste mismatch parameter being able to change the quantity ranking as opposed to the markup ranking. It may thus be more interesting to focus on the definition of the variety-specific substitution parameter in this context, shown in Figure 3.14. Here indeed both the weighted and unweighted matrices display variety-level variability because of the different location of firms in the characteristics space.

Remember that the unweighted matrix only takes into account the distance between each pair of varieties as in equation (3.36), so that being in a crowded spot, as for example Firm 2 is, causes the utility derived from the variety to be discounted the most because of the presence of the neighbors. In terms of unweighted substitutability, thus, Firm 2 would be the one suffering the most, as shown in the graphs at the bottom of Figure 3.14, followed by Firms 1 and 7, which are also quite central.

The interactions are more complex in the case of the weighted distance matrix, as shown in the formula in equation (3.37). Because the weight of each variety on the others depends on their characteristics, the most central varieties exert more pressure on the other than before. For example, Firm 2, which under the unweighted setting was suffering from being very central in the characteristics space, now exerts such a high competitive pressure on Firm 1 as to make it the one with the highest substitutability parameter in the market (1.59 for Firm 1 against 1.57 for Firm 2). Also other pairs of varieties change their relative ranking moving from the unweighted to the weighted measure as for example Firm 8 and 3 (the former going from 0.89 to 1.24 and the latter from 0.92 to 1.17).

A legitimate question would then be how to decide which measure of substitutability is more appropriate. The choice throughout the simulations has been to use the weighted index, as it conveys more information on the spatial distribution of the market participants and on their characteristics. In addition, it has the appealing feature of yielding a "localized corrective" ($\gamma_{s,i}$) to non-localized aggregate indices (the market specific determinants of Q_i), so that *the description of the market is always objective, even if the impact of market indices on each specific variety is subjective, in the sense that it will*

depend on its location in the characteristics space.

Simulation of market outcomes - Model VIII (α, β, γ heterogeneity)

The last simulation exercise involves all the sources of demand heterogeneity explored in the previous models. Their interaction generates complex patterns in terms of market outcomes and provides a great deal of flexibility in modeling market structures.

From the top-right graph in Figure 3.15 it can be noticed indeed that varieties are located in the horizontal characteristics space as in Models III, V and VII. At the same time, the distribution of quality follows the allocation chosen for Models II, V and VI. Finally, substitutability parameters are allowed to vary as in Models IV, VI and VII.

It is worth noting that most of the features that can be observed in terms of market outcomes (markups, quantities and profits) have already been observed in the previous simulations, so that it may be said that the advantage of Model VIII lies not much in its capacity to suit empirical observations (as probably more parsimonious models, such as the vertical, may suffice), but rather to provide a full characterization of a virtual economy which may be useful to study theoretical properties. For example, in Chapter 6 it will be illustrated how Model VIII may be fruitfully used to study the issue of endogenous location of new entrants in a rich yet tractable way.

Also the definition of the substitutability parameter in Figure 3.16 recalls closely the simulation of Model VII in Figure 3.14 (see, for example, the value of the substitutability parameter for the Firms 1 and 2), with the only difference that now also quality levels are included in the definition of the weighted distance matrix resulting, for example, in an even tougher competitive environment for Firm 1, suffering from both the proximity of Firm 1 to consumer's taste and from its high quality. Of course, the unweighted distance matrix shows exactly the same values as Model VII (as it would do for Model III and V, since it only depends on the location of firms), which can also be considered a point in favor of the weighted distance, even though there is undoubtedly a certain degree of arbitrariness in the definition of what should determine the weight.

Summing up, Model VIII may represent an upper bound on the modeling flexibility that can be introduced in a quadratic utility framework keeping it tractable. However, the additional richness of the framework should be traded off against the parsimony of the alternative models. A summary of the models and their properties follow to help the reader make up her mind depending on the specific empirical need she is faced with.

Model 5 (quality and taste mismatch heterogeneity)								
	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8
Horizontal differentiation								
X axis (Beta1)	3.0	3.0	3.0	6.0	-2.0	-6.0	-2.0	-5.0
Y axis (Beta2)	5.0	2.0	-4.0	3.0	-5.0	-2.0	2.0	5.0
Preference parameters								
Alpha (quality)	9.0	13.0	10.5	9.5	10.5	8.0	9.0	15.0
Gamma (substitutability)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Distance from consumer	5.8	3.6	5.0	6.7	5.4	6.3	2.8	7.1
Beta (taste mismatch)	7.0	4.8	6.2	7.9	6.6	7.5	4.0	8.3
c (marginal costs)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Market indices								
N (number of firms)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
C (cost index)	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
A (quality index)	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6
M (substitutability index)	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Gamma (weighted substitutability index)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Price components								
Variety-specific ($\alpha / 2 + c / 2$)	6.5	8.5	7.3	6.8	7.3	6.0	6.5	9.5
Market-specific ($\gamma Q / 2$)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Market outcomes								
Prices	5.1	7.1	5.8	5.3	5.8	4.6	5.1	8.1
Markups	1.1	3.1	1.8	1.3	1.8	0.6	1.1	4.1
Quantities	0.2	0.6	0.3	0.2	0.3	0.1	0.3	0.5
Operating profits	0.2	2.0	0.5	0.2	0.5	0.0	0.3	2.0
Aggregate market outcomes								
P (price index)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Q (total quantities)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Total market profits	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Additional statistics								
Markups/costs	27%	77%	46%	33%	46%	14%	27%	102%
Quantity shares	6%	27%	12%	7%	12%	3%	11%	21%
Profit shares	3%	34%	9%	4%	9%	1%	5%	35%

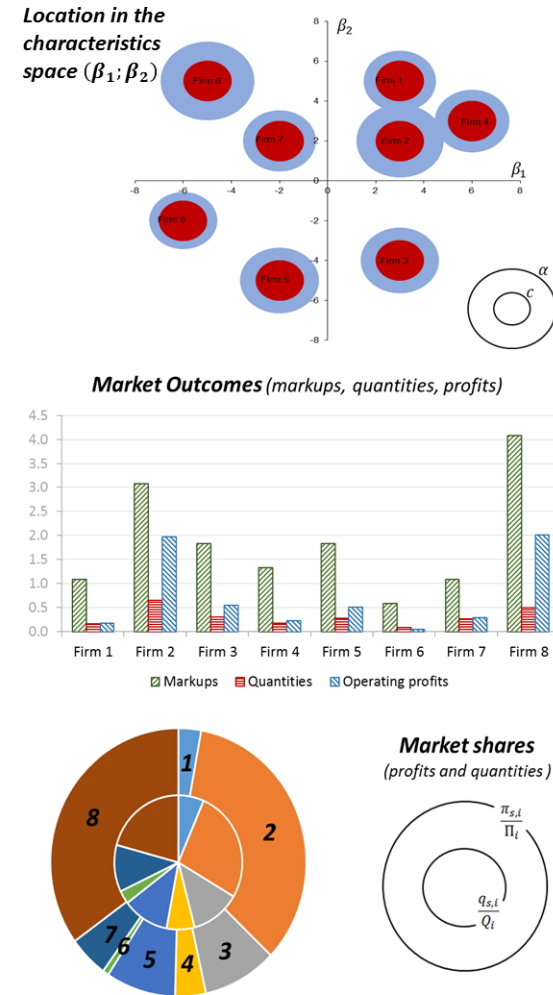


Figure 3.10: Simulation with model 5 (verti-zonal): heterogeneous quality and taste mismatch

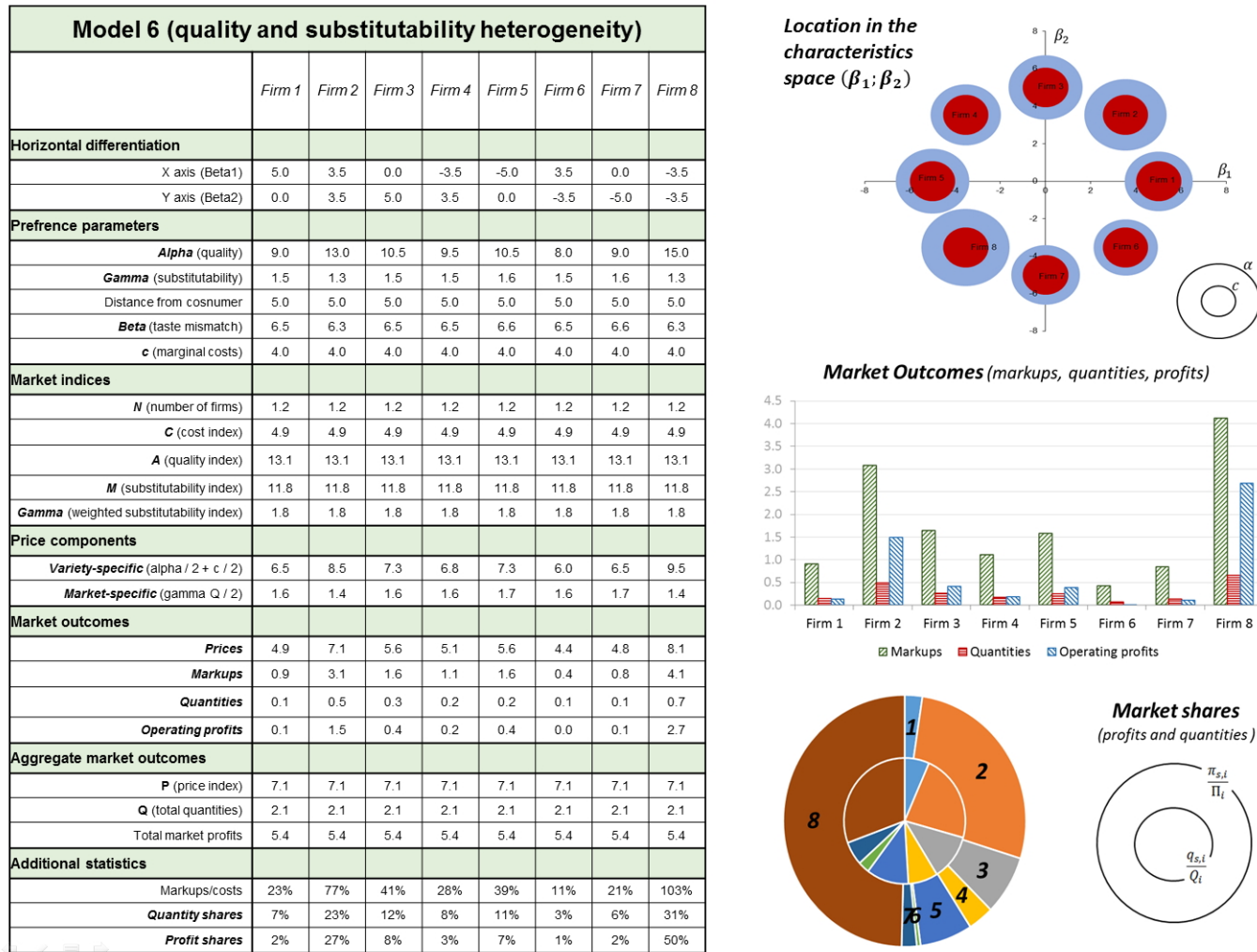


Figure 3.11: Simulation with model 6: heterogeneous quality and substitutability

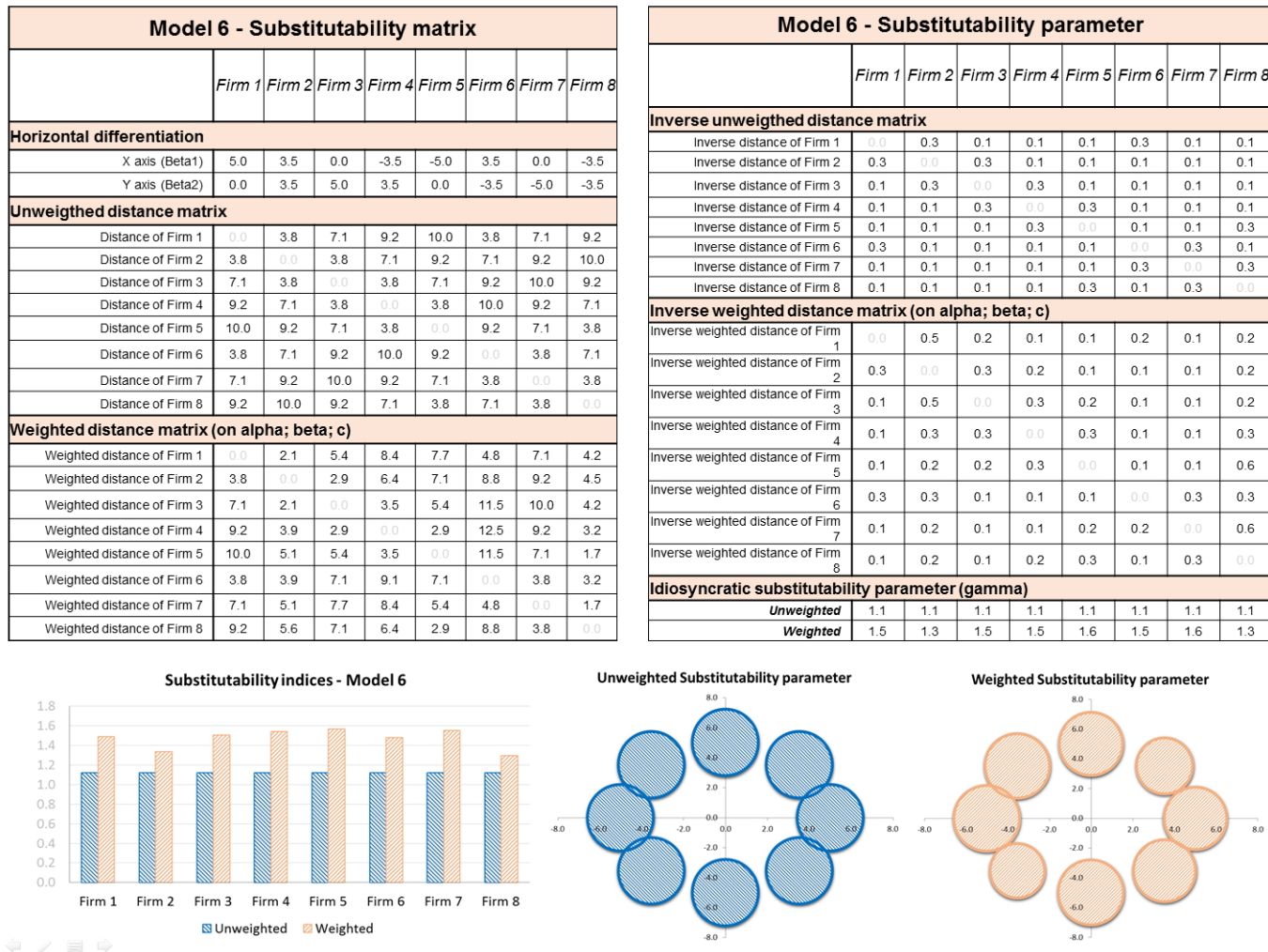


Figure 3.12: Idiosyncratic substitutability parameter in model 6

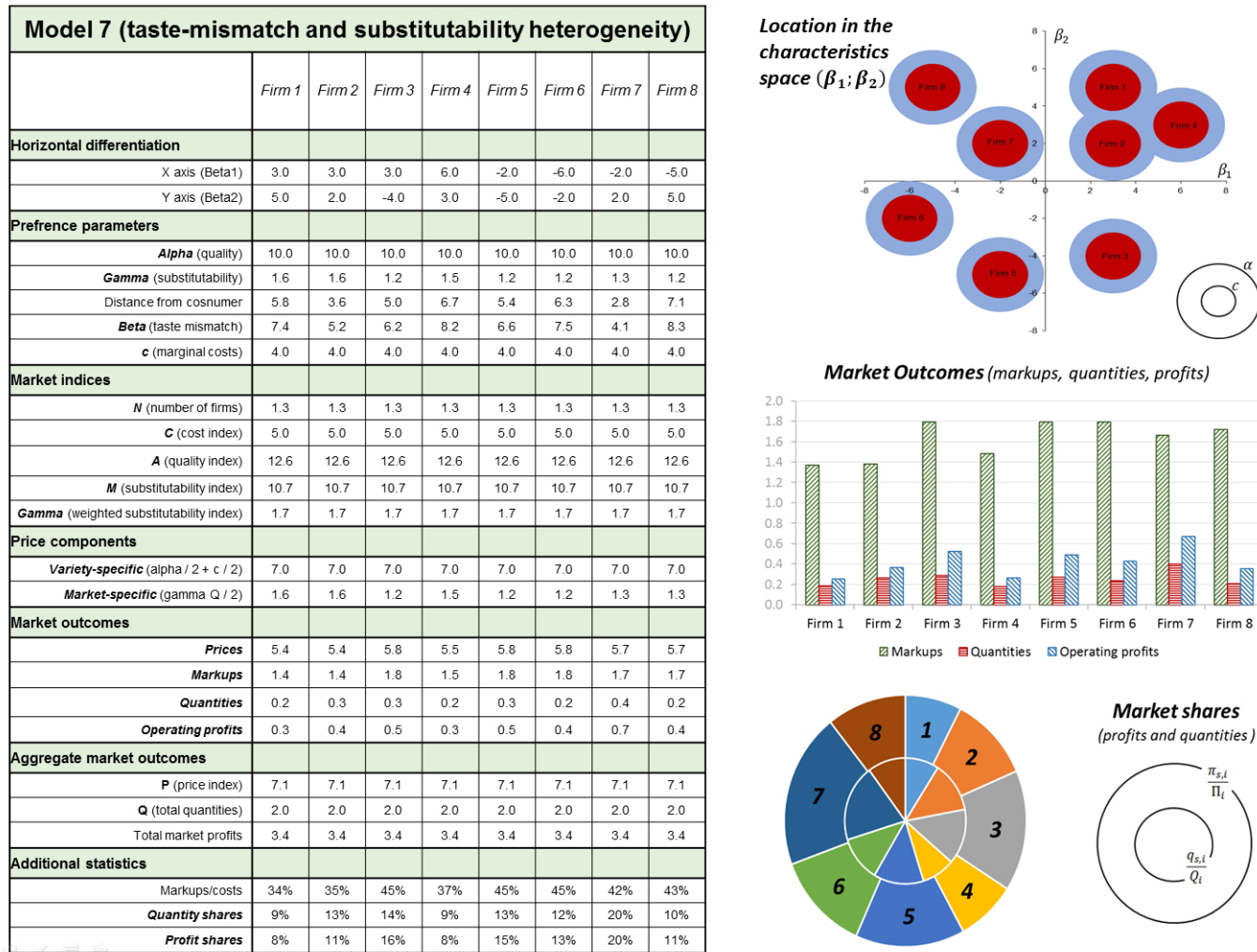


Figure 3.13: Simulation with model 7: heterogeneous taste mismatch and substitutability

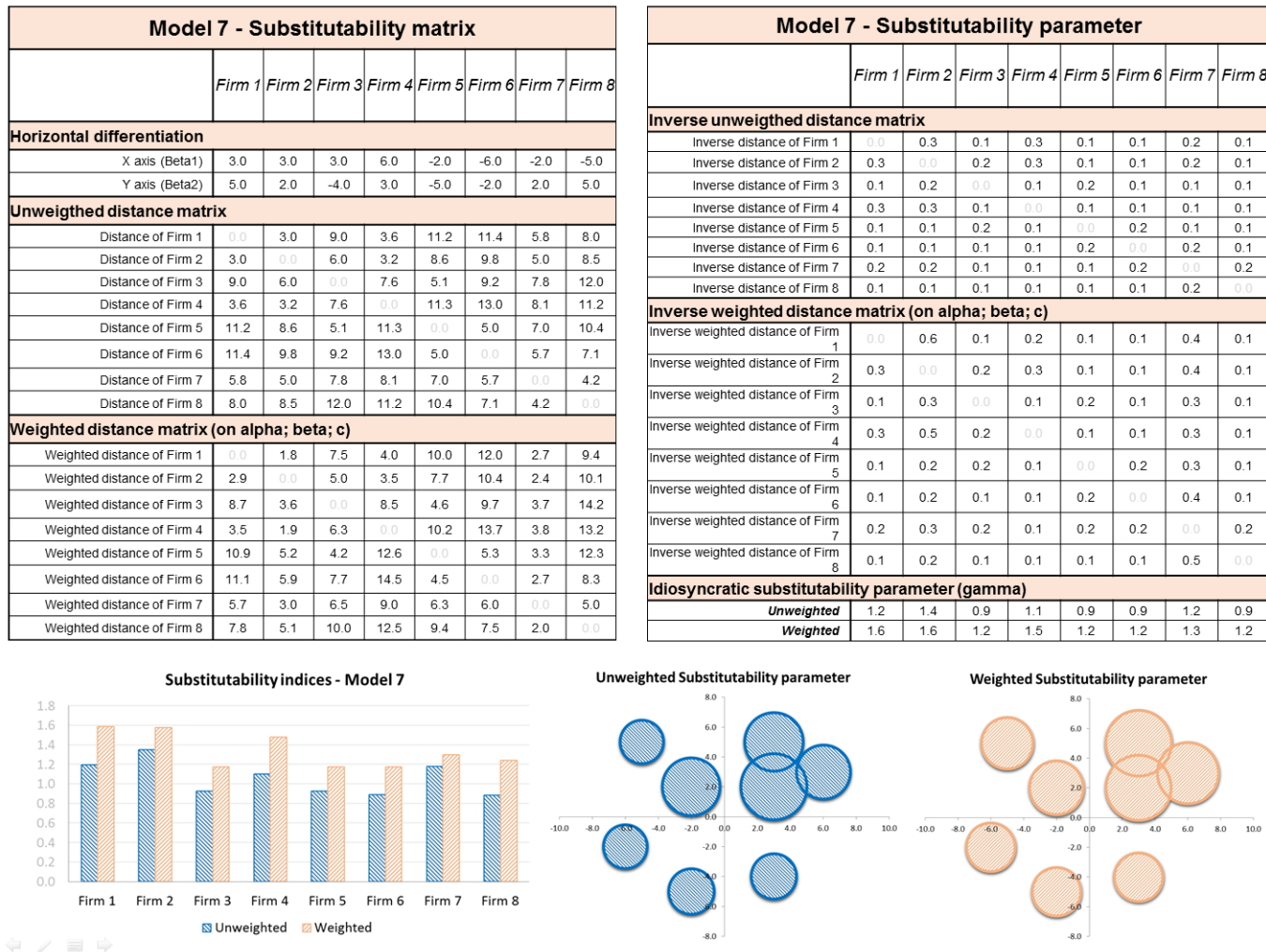
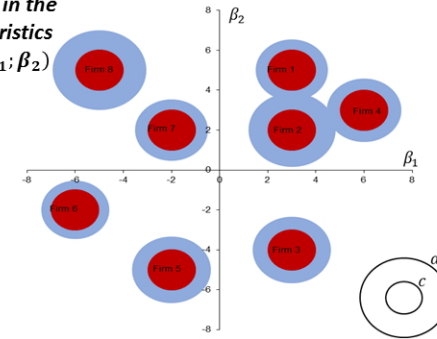
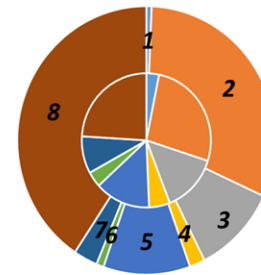
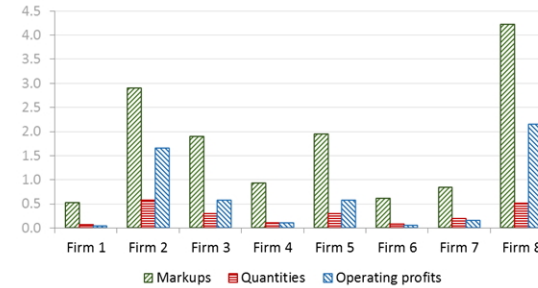


Figure 3.14: Idiosyncratic substitutability parameter in model 7

Model 8 (quality, taste-mismatch and substitutability heterogeneity)								
	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Firm 7	Firm 8
Horizontal differentiation								
X axis (Beta1)	3.0	3.0	3.0	6.0	-2.0	-6.0	-2.0	-5.0
Y axis (Beta2)	5.0	2.0	-4.0	3.0	-5.0	-2.0	2.0	5.0
Preference parameters								
Alpha (quality)	9.0	13.0	10.5	9.5	10.5	8.0	9.0	15.0
Gamma (substitutability)	1.9	1.5	1.3	1.7	1.2	1.3	1.6	1.2
Distance from cosumer	5.8	3.6	5.0	6.7	5.4	6.3	2.8	7.1
Beta (taste mismatch)	7.7	5.1	6.3	8.4	6.6	7.6	4.4	8.3
c (marginal costs)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Market indices								
N (number of firms)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
C (cost index)	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
A (quality index)	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
M (substitutability index)	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7
Gamma (weighted substitutability index)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Price components								
Variety-specific ($\alpha / 2 + c / 2$)	6.5	8.5	7.3	6.8	7.3	6.0	6.5	9.5
Market-specific ($\gamma \alpha Q / 2$)	2.0	1.6	1.4	1.8	1.3	1.4	1.7	1.3
Market outcomes								
Prices	4.5	6.9	5.9	4.9	6.0	4.6	4.8	8.2
Markups	0.5	2.9	1.9	0.9	2.0	0.6	0.8	4.2
Quantities	0.1	0.6	0.3	0.1	0.3	0.1	0.2	0.5
Operating profits	0.0	1.7	0.6	0.1	0.6	0.0	0.2	2.2
Aggregate market outcomes								
P (price index)	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Q (total quantities)	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Total market profits	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Additional statistics								
Markups/costs	13%	73%	47%	23%	49%	15%	21%	106%
Quantity shares	3%	27%	14%	5%	14%	4%	9%	24%
Profit shares	1%	31%	11%	2%	11%	1%	3%	41%

Location in the characteristics space (β_1, β_2)

Market Outcomes (markups, quantities, profits)



Market shares (profits and quantities)

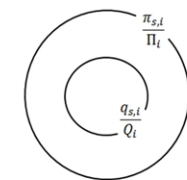


Figure 3.15: Simulation with model 8: heterogeneous quality, taste mismatch and substitutability

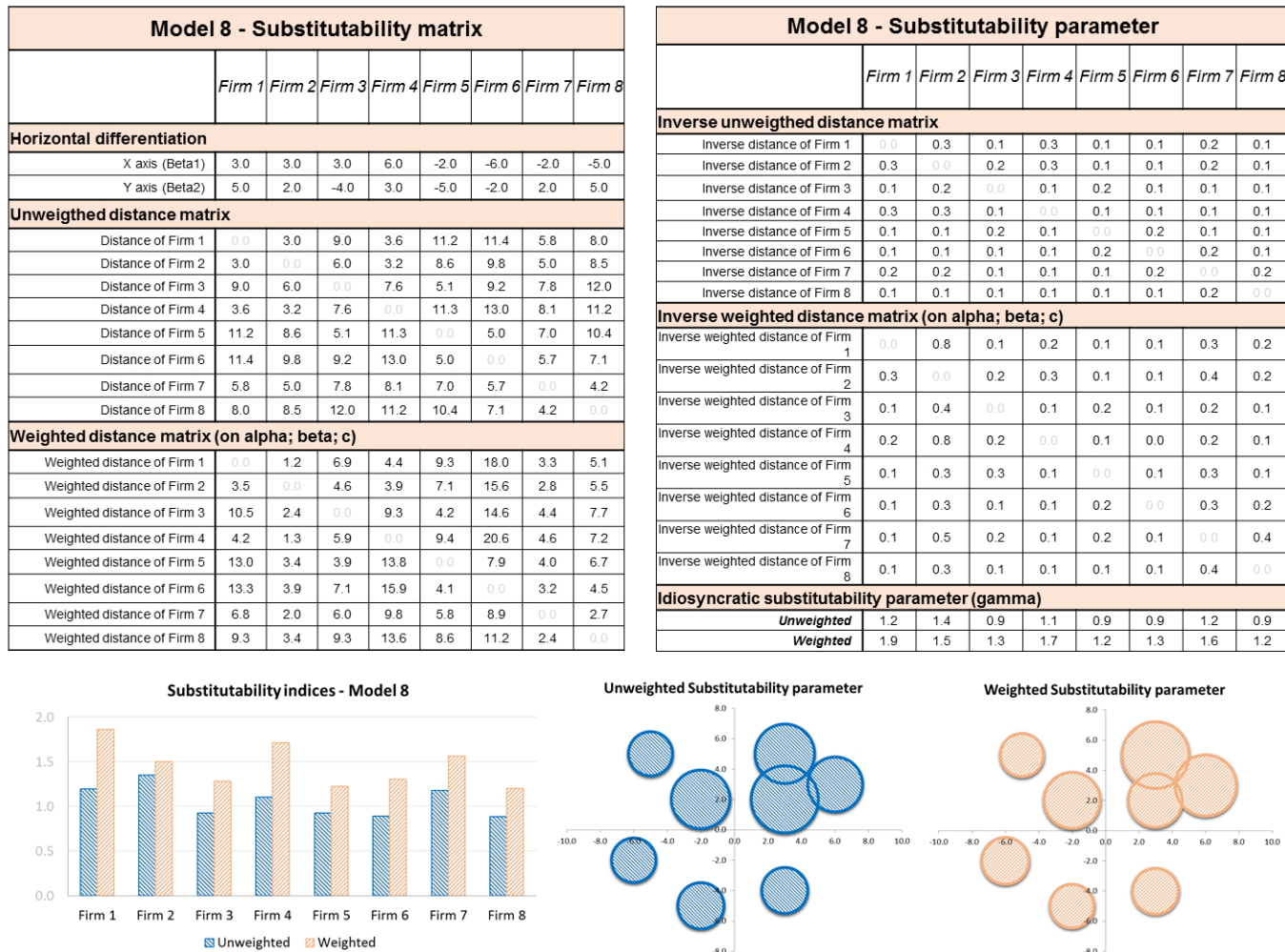


Figure 3.16: Idiosyncratic substitutability parameter in model 8

3.6 Summary of variations' functional forms and properties

Up to this point, the different variations of a standard quadratic utility and their individual properties have been presented in isolation, not allowing for an easy comparison across model and for a clear definition of the trade-offs involved. This Section is therefore meant to fill this gap by comparing the different models and show the main differences and commonalities. In particular, Table 3.1 displays all the equilibrium markup formulas together with the corresponding equilibrium quantities and profits. Table 3.2 instead focuses on the variety-specific and market-specific components of the equilibrium price functions, highlighting the main empirical properties of each model.

Starting from Table 3.1, it can be noticed that markup functions can be rearranged into a comparable format for all the specifications. In every model, in fact, equilibrium markups result from the difference between two terms: the positive "variety-specific social value" term represented by the difference between the quality of the variety produced and its cost and the negative "market-aggregate social value" term representing the difference between the average quality and cost of the market competitors, weighted by the degree of substitution between variety s and the rest of the varieties on the market. The three sources of demand variability analyzed in this Chapter (besides cost heterogeneity) play a different role in determining markups. The quality parameter of variety s increases its markup, but the quality of market competitors decrease it. When α does not vary across varieties the interaction with the substitution parameter disappears (see equation (3.12)) and a common increase in quality in the market is associated with a common increase in markups. To the contrary, when α_s is allowed to vary across varieties one variety's quality has to be discounted against market (weighted) average quality to determine the overall effect on markups.

As for the horizontal differentiation parameter, $\beta_{s,i}$, when constant across varieties it implies a common discounting of market aggregates by entering into the denominator of the second market-specific term of the markup equations. In other words, the invariant parameter β indicates how close are all the varieties to the consumer and hence to each other. The impact of β on markups hence depends on the strength of the parameters determining the toughness of competition in the market, and notably on the substitution parameter γ . When competition is tougher, varieties enjoy higher markups by staying further away from the consumer but also further away from each other, and vice versa. When $\beta_{s,i}$ is allowed to vary across varieties instead, the dynamics are more complex. First of all, markups of each variety are unaffected by its distance from the consumer, i.e. $\beta_{s,i}$ does not enter into the markup equation of variety s . Only the overall distribution of $\beta_{s,i}$ matters in determining the toughness of competition and thus markups. However this is not true of operating profits, since the equilibrium amount of quantities sold of variety s is indeed affected by $\beta_{s,i}$ (which is why it affects market aggregates).

Finally, the substitutability parameter plays a subtler role than the other two demand parameters in that it only enters in the market-specific term of the markup function and its role is basically to determine to which extent market indices affect individual varieties. If γ is common across varieties then it just captures the general degree of substitutability

between pairs of varieties within a market. When $\gamma_{s,i}$ is instead market-variety specific it determines to which extent the individual variety s is affected by market aggregates. Notice that, however, also the distribution of $\gamma_{s,i}$ is relevant when it is market specific, because it indirectly affects the quantities that will be sold of each variety and so it plays a similar role to the distribution of $\beta_{s,i}$ in determining what in the case of $\beta_{s,i}$ is called the "effective number of competitors", but it can also be referred to as the "weighted number of competitors".

Turning to Table 3.2, before describing the properties of each model, it is worth looking at the column on equilibrium price functions, whose elements have been split into variety-specific sources of price variation (the first term) and market-specific sources of variation (the second term or, alternatively, the part of the equation within square brackets). This distinction highlights the role played by quality differences (possibly along cost differences) in generating within-market variability in prices across varieties. It also shows how market aggregates affect prices in the different models and notably it underlines the role played by the substitution parameter γ in translating market indices into price effects, which are common to all the varieties when γ is not allowed to vary and are variety-specific for idiosyncratic $\gamma_{s,i}$. Of course, when $\gamma_{s,i}$ is market-variety specific, the distinction between market-wide effects on prices and variety-specific component is less clear-cut, but it has been classified as a market-wide effect in this case under the implicit assumption that $\gamma_{s,i}$ is constant over time and are market indices instead which are expected to vary, so that variability in market indices does cause individual prices to vary, even if the extent of the change is determined by the value of $\gamma_{s,i}$.

As for the selection of which variation of a quadratic utility to employ in a particular situation, three main properties have been included in the table to help the reader make a data driven choice. In other words, depending on the observed outcomes in the market to study, different variations of the quadratic utility may be more or less suitable. Starting from the general principle that empirical models should be as parsimonious as possible and that any additional source of variability should be justified by a specific need, the desired properties of the model to use can be decided as follows.⁸

The first element to consider is whether the variability of prices and quantities across markets (or equivalently the variability of prices and profits across market) is similar. If this is the case, there is no need of include a market-variety-specific parameter of horizontal differentiation such as $\beta_{s,i}$. In fact, in the absence of this source of differentiation higher prices can be driven either by higher costs (in which case quantities sold will be lower) or by higher quality (in which case quantities sold and markups will be higher), resulting in a similar level of variation (unless a relation is assumed between costs and quality across markets, which is also a possibility explored in some papers, especially considering the cost of inputs). To the contrary, if quantities are observed to vary systematically more than prices, there may be the need to introduce a source of quantity variation as in Models III, V, VII and VIII, where this role is played by $\beta_{s,i}$. The exact determination of a threshold above which the difference in variability between prices and

⁸Notice that in this Section only quadratic utilities are compared. In Chapter 4, a particular variation of the quadratic utility, the vertical, is instead compared with alternative modeling frameworks.

quantities can be ascribed to the characteristics of the market rather than measurement error is an empirical question which should be tackled on a case-by-case basis.

The second feature that can be readily verified using firm-level data is whether within the destination markets a strong correlation is observed between prices and quantities. If no quality differences are present in the market and all the heterogeneity in prices is driven by productive efficiency, then quantities sold (or market shares) of the varieties should be systematically negatively associated with higher prices. Similarly, in the absence of differences in productive efficiency, including quality differences the relation should be equally strong, with the only difference that higher prices will be associated with more quantities sold. If this is not the case in the data, then it may be necessary to consider the possibility of adding both cost heterogeneity and a quality shifter, such as α_s , to break the relation between prices and quantities within each market (such as Models II, V, VI, VIII). In alternative, a combination of cost or quality heterogeneity and horizontal differentiation can also obtain the same result (therefore also Models III and VII may work). In practice, only models based on productive efficiency differences alone (Model I) or models with productive efficiency and substitutability differences (Model IV) would be excluded.

Finally, having information on marginal costs of production and prices, it would be possible to observe whether markups and prices are strongly related. If that is the case, the alternative of using models with one source of price heterogeneity (costs or quality) and horizontal differentiation (Models III and VII) would not suffice anymore, leaving only Models II, V, VI, VIII as viable alternatives. Notice that, in the absence of variability in horizontal differentiation ($\beta_{s,i}$), markups and quantities are perfectly correlated, so that some inference of markup variability can be made even in the absence of direct information on production costs

A rigorous analysis based on firm-product-destination data on Belgian exports is undertaken in Chapter 4. However, up to this point it can already be noted that the empirical observations found in the literature about price and quantity variation across and within markets and the preliminary analysis of the European car market (which is also deepened in the next Chapter) suggest that the most suitable variation to study international trade patterns is likely to be the one respecting the three properties reported in Table 3.2, which leaves Models V and VIII as the preferred choices. However, appealing to the principle of parsimony, the model with the smallest number of sources of heterogeneity needed to accommodate the observed patterns is selected to be taken to the data. Therefore the preferred Model for the empirical analysis of trade when the whole manufacturing is considered in the rest of the Thesis is Model V, the vertical model. It will guide all the analyses in Chapter 4 and 5 and will only be altered in the final Chapter, where future avenues of research are spelled out exploiting further alterations to the quadratic utility and the monopolistic competition framework.

Table 3.1: Summary of model variations' functional forms

	Equilibrium markups	Quantities	Profits	Notes
Model I ($c_{s,i}$)	$p_{s,i}^* - c_{s,i} = \frac{\alpha - c_{s,i}}{2} - \frac{\alpha - \bar{c}_i}{2} \left(\frac{\gamma N_i}{2\beta + \gamma N_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta}$	$N_i = \int_{s \in S_i} ds$ $\bar{c}_i = \frac{1}{N_i} \int_{s \in S_i} c_{s,i} ds$
Model II ($c_{s,i}, \alpha_s$)	$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2} - \frac{\bar{\alpha}_i - \bar{c}_i}{2} \left(\frac{\gamma N_i}{2\beta + \gamma N_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta}$	$N_i = \int_{s \in S_i} ds$ $\bar{c}_i = \frac{1}{N_i} \int_{s \in S_i} c_{s,i} ds$ $\bar{\alpha}_i = \frac{1}{N_i} \int_{s \in S_i} \alpha_s ds$
Model III $c_{s,i}, \beta_{s,i}$	$p_{s,i}^* - c_{s,i} = \frac{\alpha - c_{s,i}}{2} - \frac{\alpha - \tilde{c}_i}{2} \left(\frac{\gamma \mathbb{N}_i}{2 + \gamma \mathbb{N}_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta_{s,i}}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta_{s,i}}$	$\mathbb{N}_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}}$ $\tilde{c}_i = \frac{1}{\mathbb{N}_i} \int_{s \in S_i} \frac{c_{s,i}}{\beta_{s,i}} ds$
Model IV ($c_{s,i}, \gamma_{s,i}$)	$p_{s,i}^* - c_{s,i} = \frac{\alpha - c_{s,i}}{2} - \frac{\alpha - \bar{c}_i}{2} \left(\frac{\gamma_{s,i} N_i}{2\beta + M_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta}$	$N_i = \int_{s \in S_i} ds$ $M_i = \int_{s \in S_i} \gamma_{s,i} ds$ $\bar{c}_i = \frac{1}{N_i} \int_{s \in S_i} c_{s,i} ds$
Model V ($c_{s,i}, \alpha_s, \beta_{s,i}$)	$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2} - \frac{\tilde{\alpha}_i - \tilde{c}_i}{2} \left(\frac{\gamma \mathbb{N}_i}{2 + \gamma \mathbb{N}_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta_{s,i}}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta_{s,i}}$	$\mathbb{N}_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}}$ $\tilde{c}_i = \frac{1}{\mathbb{N}_i} \int_{s \in S_i} \frac{c_{s,i}}{\beta_{s,i}} ds$ $\tilde{\alpha}_i = \frac{1}{\mathbb{N}_i} \int_{s \in S_i} \frac{\alpha_s ds}{\beta_{s,i}}$
Model VI ($c_{s,i}, \alpha_s, \gamma_{s,i}$)	$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2} - \frac{\bar{\alpha}_i - \bar{c}_i}{2} \left(\frac{\gamma_{s,i} N_i}{2\beta + M_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta}$	$M_i = \int_{s \in S_i} \gamma_{s,i} ds$ $\bar{c}_i = \frac{1}{N_i} \int_{s \in S_i} c_{s,i} ds$ $\bar{\alpha}_i = \frac{1}{N_i} \int_{s \in S_i} \alpha_s ds$
Model VII ($c_{s,i}, \beta_{s,i}, \gamma_{s,i}$)	$p_{s,i}^* - c_{s,i} = \frac{\alpha - c_{s,i}}{2} - \frac{\alpha - \tilde{c}_i}{2} \left(\frac{\gamma_{s,i} \mathbb{N}_i}{2 + \Gamma_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta_{s,i}}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta_{s,i}}$	$\Gamma_i = \int_{s \in S_i} \frac{\gamma_{s,i} ds}{\beta_{s,i}}$ $\mathbb{N}_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}}$ $\tilde{c}_i = \frac{1}{\mathbb{N}_i} \int_{s \in S_i} \frac{c_{s,i} ds}{\beta_{s,i}}$
Model VIII ($c_{s,i}, \alpha_s, \beta_{s,i}, \gamma_{s,i}$)	$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2} - \frac{\tilde{\alpha}_i - \tilde{c}_i}{2} \left(\frac{\gamma_{s,i} \mathbb{N}_i}{2 + \Gamma_i} \right)$	$q_{s,i} = \frac{p_{s,i}^* - c_{s,i}}{\beta_{s,i}}$	$\pi_{s,i} = \frac{(p_{s,i}^* - c_{s,i})^2}{\beta_{s,i}}$	$\mathbb{N}_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}}$ $\Gamma_i = \int_{s \in S_i} \frac{\gamma_{s,i} ds}{\beta_{s,i}}$ $\tilde{c}_i = \frac{1}{\mathbb{N}_i} \int_{s \in S_i} \frac{c_{s,i} ds}{\beta_{s,i}}$ $\tilde{\alpha}_i = \frac{1}{\Gamma_i} \int_{s \in S_i} \frac{\alpha_s ds}{\beta_{s,i}}$

Table 3.2: Summary of model variations' properties

	Equilibrium prices	Notes	Across markets variability of $p_{s,i} \neq q_{s,i}$	Within markets variation of $p_{s,i}$ almost $\perp q_{s,i}$	Markups and prices almost unrelated
Model I ($c_{s,i}$)	$p_{s,i}^* = \frac{c_{s,i}}{2} + \left[\frac{\alpha}{2} - \frac{\gamma}{2} \frac{(\alpha N_i - C_i)}{(2\beta + \gamma N_i)} \right]$	$N_i = \int_{s \in S_i} ds$ $C_i = \int_{s \in S_i} c_{s,i} ds$	N	N	N
Model II ($c_{s,i}, \alpha_s$)	$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma}{2} \frac{(A_i - C_i)}{(2\beta + \gamma N_i)}$	$N_i = \int_{s \in S_i} ds$ $C_i = \int_{s \in S_i} c_{s,i} ds$ $A_i = \int_{s \in S_i} \alpha_s ds$	N	Y	Y
Model III $c_{s,i}, \beta_{s,i}$	$p_{s,i}^* = \frac{c_{s,i}}{2} + \left[\frac{\alpha}{2} - \frac{\gamma}{2} \frac{(\alpha N_i - C_i)}{(2 + \gamma N_i)} \right]$	$N_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}}$ $C_i = \int_{s \in S_i} \frac{c_{s,i}}{\beta_{s,i}} ds$	Y	Y	N
Model IV ($c_{s,i}, \gamma_{s,i}$)	$p_{s,i}^* = \frac{c_{s,i}}{2} + \left[\frac{\alpha}{2} - \frac{\gamma_{s,i}}{2} \frac{(\alpha N_i - C_i)}{(2\beta + M_i)} \right]$	$N_i = \int_{s \in S_i} ds$ $M_i = \int_{s \in S_i} \gamma_{s,i} ds$ $C_i = \int_{s \in S_i} c_{s,i} ds$	N	N	N
Model V ($c_{s,i}, \alpha_s, \beta_{s,i}$)	$p_s^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma}{2} \frac{(A_i - C_i)}{(2 + \gamma N_i)}$	$N_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}}$ $C_i = \int_{s \in S_i} \frac{c_{s,i}}{\beta_{s,i}} ds$ $A_i = \int_{s \in S_i} \frac{\alpha_s ds}{\beta_{s,i}}$	Y	Y	Y
Model VI ($c_{s,i}, \alpha_s, \gamma_{s,i}$)	$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \frac{(A_i - C_i)}{(2\beta + M_i)}$	$M_i = \int_{s \in S_i} \gamma_{s,i} ds$ $C_i = \int_{s \in S_i} c_{s,i} ds$ $A_i = \int_{s \in S_i} \alpha_s ds$	N	Y	Y
Model VII ($c_{s,i}, \beta_{s,i}, \gamma_{s,i}$)	$p_{s,i}^* = \frac{c_{s,i}}{2} + \left[\frac{\alpha}{2} - \frac{\gamma_{s,i}}{2} \frac{(\alpha N_i - C_i)}{(2 + \Gamma_i)} \right]$	$N_i = \int_{s \in S_i} \frac{ds}{\beta_{s,i}}$ $\Gamma_i = \int_{s \in S_i} \frac{\gamma_{s,i} ds}{\beta_{s,i}}$ $C_i = \int_{s \in S_i} \frac{c_{s,i} ds}{\beta_{s,i}}$	Y	Y	N
Model VIII ($c_{s,i}, \alpha_s, \beta_{s,i}, \gamma_{s,i}$)	$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma_{s,i}}{2} \frac{(A_i - C_i)}{(2 + \Gamma_i)}$	$\Gamma_i = \int_{s \in S_i} \frac{\gamma_{s,i} ds}{\beta_{s,i}}$ $C_i = \int_{s \in S_i} \frac{c_{s,i} ds}{\beta_{s,i}}$ $A_i = \int_{s \in S_i} \frac{\alpha_s ds}{\beta_{s,i}}$	Y	Y	Y

Features of the verti-zontal model

The adoption of the verti-zontal model results in a number of appealing features, which have been mentioned in the foregoing but are now summed up.

First, it captures horizontal differentiation through one single parameter that varies across varieties and consumers for which an interpretation is proposed that goes back to spatial models of product differentiation à la Hotelling (1929), affecting demand and sales *asymmetrically*.

Second, it allows for the separate identification of horizontal and vertical differentiation in a particular sense: the consumer-specific parameter of horizontal differentiation only affects equilibrium quantities but not prices. Thus, horizontal differentiation can be separated from vertical differentiation at the firm-product-country level and can empirically be distinguished by any researcher with access to data on firm characteristics. Horizontal differentiation in CES models cannot explain variation in sales for the same firm-product across countries because the elasticity of substitution is constant across varieties. To remedy for this, one can introduce a firm-product specific demand shock per country that accounts for sales variation of the same firm-product across countries without affecting prices. Horizontal differentiation between products is then the combination of a constant parameter of substitution and a variable shock at the firm-product level. Because the parameter of substitution also enters the price equation, a clear separation of horizontal and vertical differentiation is difficult to attain with the CES and quality differences between varieties can be confounded with taste differences.

Third, asymmetric preferences in quadratic utility also result in a rich set of country-specific competition effects. With symmetric preferences, competition effects are a sole function of the number of firms in the destination country, which depends on market size. Allowing for asymmetric preferences generates competition effects that also depend on the quality of the varieties on offer in the destination country and their interaction with local tastes. In addition, allowing for consumer heterogeneity across countries implies that two countries of similar size and GDP can still be subject to varying levels of competition. Even when the quality on offer in these two countries is the same, competition effects can differ because in one country high quality varieties meet better local tastes. Allowing for asymmetric preferences in quality and taste across varieties and taste heterogeneity across countries also generates market structures ranging from monopoly to perfect competition. This is shown in its market aggregates, which together capture the extent of country-specific competition effects.

3.6.1 Parameter identification

As mentioned above, an interesting feature of the verti-zontal model is that it can be used to address many specific empirical questions because its parameters are easily identifiable. However, for this to be possible, not just information on quantities and prices is required, but also on costs (or markups), which is not often readily available. Its particular functional form allows researchers to directly measure quality differences between varieties (firm-products or export-products) and taste mismatch at the market-variety

level. In addition, it can be used to estimate the absolute level of quality (i.e. the vertical-axis intercept of the inverse demand function in the absence of competition) and the degree of substitutability between varieties.

The parameter capturing taste mismatch, $\beta_{s,i}$, is the most easily identifiable. It can be interpreted as the distance in the horizontal characteristics space between the consumer i 's ideal combination of product attributes and the actual characteristics of a particular variety s , as discussed above. To determine its value, equation (3.57) can be rewritten to show that it is equal to the ratio between each variety's markups and its quantities sold, at any given point in time, t :

$$\beta_{s,i,t} = \frac{p_{s,i,t}^* - c_{s,t}}{q_{s,i,t}^*} \quad (3.95)$$

As for the parameter capturing intrinsic quality, α_s , it can be either measured in relative terms or estimated in absolute terms, together with the substitutability parameter γ_s . Notice that α_s is the value in terms of numéraire attributed by all consumers to the vertical characteristics of a particular variety s . In relative terms, quality differentials between any couple of varieties (say, α_s and α_r) can be readily obtained by exploiting the property that relative prices of different varieties in a market depend only on differences in costs and quality (as shown in equation (5.9)):

$$\Delta\alpha_{sr,t} = \alpha_{s,t} - \alpha_{r,t} = 2(p_{s,i,t}^* - p_{r,i,t}^*) - (c_{s,t} - c_{r,t}) \quad (3.96)$$

Measuring the distance between the quality of all the varieties, α_s, t , and the quality of the worst variety, $\alpha_{0,t}$, one can identify the relative quality distribution of the varieties present in a market at time t and eventually normalize it to have an idea of the relative distribution of varieties' quality in a market. This means that no additional information or indirect estimation methodology is needed to capture the relative quality of each variety in a market.

However, it is empirically possible to go beyond relative quality and identify absolute level of quality, defined independently of other varieties' quality. As can be observed from equation (3.53), aggregate quality and cost levels positively affects the price index. But one can see from equation (3.52) that a quality-driven increase in prices will have very different implications as compared to a cost-driven price increase in terms of markups. Specifically, a market where prices increase because a range of firms upgrade the quality of their products becomes more competitive, thus reducing the markup of the firms that keep the quality of their products unchanged. The opposite would happen in the case of a cost-driven price rise. Thus, in order to assess the performance of a firm it is important to be able to disentangle quality from costs in its price setting. Absolute levels of quality can be estimated following a procedure that exploits the time dimension of the data, such as variety-level prices and costs as well as total sales of a certain product in a market (i.e., Q_i).⁹ To this end, equation (3.52) can be rewritten as:

⁹To this end, information on the total quantities consumed of a certain good, Q_i , is needed. For example, this information can be obtained by merging trade datasets, such as UN COMTRADE or

$$p_{s,t}^*(Q_{i,t}) = \frac{\alpha_{s,t} + c_{s,t} - \gamma Q_{i,t}}{2}. \quad (3.97)$$

where t denotes the time dimension. This can be further seen as:

$$2p_{s,t}^* - c_{s,t} = \alpha_s - \gamma Q_{i,t}. \quad (3.98)$$

Note that the left-hand side of the equation consists of observables, i.e. time-varying variety-specific prices and costs. On the right-hand side, however, neither α_s nor γ are directly observable. But holding the substitution parameter fixed over time and maintaining that the worst-quality variety, $s = 0$, is worth always the same amount of the numéraire, $\hat{\gamma}$ can be estimated through a simple regression analysis. By regressing the left-hand side of (3.98) for this worst-quality variety on Q_i , a value is obtained for the substitution parameter, γ , as the coefficient associated with Q_i and α_0 as the constant of the regression.¹⁰ Notice that the identity of the worst variety can be determined from equation (3.96).

Plugging then back $\hat{\gamma}$ into equation (3.97), since all the other variables are now observed or identified, one can determine the absolute quality levels for all the varieties of a particular product at a particular time and have all the parameters of the model empirically identified.

As long as individual prices, quantities and costs (or markups) can be observed or estimated, all the idiosyncratic and market variables can be fully identified and be used to address empirical questions on quality upgrading or cost increases.

3.7 Verti-zontal differentiation: some properties and propositions

After having identified Model V (the verti-zontal model) as the variation displaying the most interesting properties for the empirical analysis, a few propositions follow on the implications of policy shocks on market indices and firm performance. In this way it will be possible to verify whether the implications of the model differ substantially from alternative models or from empirical observations in the literature. Roughly speaking, these propositions can thus be interpreted as a reality check on the model.

As usual in the trade literature, the policy shock analyzed is a process of trade liberalization. The propositions thus concern the verti-zontal model predictions on markets' characteristics and firms' performance. The simplifying assumptions of segmented markets and marginal costs independent of the scale of production imply that each variety

Eurostat COMEXT, which capture total imports of a good in a market, with production datasets such as Eurostat PRODCOM, which reports total consumption in a market.

¹⁰The interpretation of such a parameter as constant over time amounts to considering the numéraire as a Hicksian composite good representing a bundle of all the other goods purchased by the consumer and allowing that the evolution of the worst variety's quality of a particular good follows the evolution of quality of the economy at large, as captured by the Hicksian composite good and implicitly normalized to 1 in the numéraire (or linked to income levels, as stressed in Section 3.7.4).

in each market can be analyzed in isolation, i.e. independently of what happens in the other markets. In addition, firms are assumed to produce only one product, but the analysis would not be altered by assuming multi-product firms given the assumption of market irrelevance of each variety (which means that market indices cannot be distorted by behaving strategically).

In this framework, trade liberalization just amounts to altering the distribution of the varieties' supply and demand parameters, as captured by market indices. In the first three propositions, the impact of changes in trade policy on market indices is described. Then, in the following three propositions, the implications of these changes on firms' performance are analyzed.

3.7.1 Propositions on trade and market indices

It is commonly understood that, as larger markets are *ceteris paribus* associated with tougher competition and lower prices, opening up to trade and increasing the mass of varieties available in a certain market is likely to yield the same effects¹¹. Theoretically, this view is confirmed by all the models employing homogeneously differentiated quadratic utility functions and by quality-augmented CES models (Verhoogen, 2012). The vertical model does not contend this claim, but it qualifies it in order to account for the empirically weak relation between prices and market size documented in Chapter 2.

The first observation that can be made by looking at equation (3.53) is that an increase in the mass of firms, N_i , holding everything else fixed, is indeed expected to lead to a decrease in prices. This confirms that the common result, also shown in the baseline Model in equation (3.13) and in the models with vertical or horizontal differentiations, as shown in equations (3.21) and (3.29). Therefore, if two countries, identical in terms of cost and quality distribution across varieties in their markets, start to trade with each other, abstracting from the moment from trade costs, prices in the two markets are expected to decrease.¹² This leads to the first proposition.

Proposition 1. Holding weighted average cost and quality indices constant, an increase in the effective mass of firms in a market is associated with lower weighted average prices. This market-size effect is equivalent to an increase in the degree of substitutability between varieties.

More interesting results may emerge when the varieties produced by the two countries are asymmetric, though. Imagine the same two identical countries starting to trade with each other, but suppose that shipping the goods from one market to the other implies high linear transport costs. As profit-maximizing firms don't distinguish between production and delivery when maximizing profits, but simply look at their total marginal costs, imported varieties in the two countries will be more costly than the same varieties in

¹¹With the notable exception of Zhelobodko et al. (2012) who show that this result depends on the consumers' attitude towards product variety as consumption levels increase, captured by the concavity of their utility, which can be interpreted as a measure of relative love for variety.

¹²Note that two countries are considered for the sake of exposition, but the quadratic utility framework allows for a straightforward generalization to a multi-country setting, at least in the short run.

their domestic markets. This raises the weighted cost index, $\mathbb{C}_i$, and eventually the weighted price index, $\mathbb{P}_i$, abstracting in the short run from entry and exit and assuming for the moment that all the varieties in the two economies can be profitably sold in the two markets. The two offsetting effects can be seen from equation (3.53), where is evident that $\mathbb{N}_i$ and $\tilde{c}_i$ work in opposite directions.

In general, however, weighted average costs need not increase when opening to trade, even if imported good will have to incur transport costs, as the two countries may have very different distributions of marginal costs because of, say, different infrastructural development, factor costs or labor productivities. In a similar fashion, if the two countries have a different distribution of α_s , the weighted average quality index, $\tilde{\alpha}_i$, may increase or decrease in the two countries, offsetting or reinforcing the effect of $\mathbb{N}_i$.

Proposition 2. As formerly separated markets integrate, the price-abating effect of a larger market size may be reinforced or offset by changes in weighted average cost or quality indices in the different markets, higher quality and higher costs being associated with higher prices.

An insightful way of looking at (3.53) is to rewrite it in terms of what can be defined as the aggregate markup, $\mathbb{P}_i - \mathbb{C}_i$, proportional to the total mass of operating profits generated in the sector, or to its total value added:

$$\mathbb{P}_i - \mathbb{C}_i = \frac{\mathbb{A}_i - \mathbb{C}_i}{2 + \gamma_i \mathbb{N}_i} = \frac{\Phi_i}{2 + \gamma_i \mathbb{N}_i}, \quad (3.99)$$

where Φ_i can be interpreted as an index of social value associated with the entire production of varieties $s \in S$ in market i .

In weighted average terms, it can be rewritten as

$$\tilde{p}_i - \tilde{c}_i = \frac{\tilde{\alpha}_i - \tilde{c}_i}{2 + \gamma_i \mathbb{N}_i} = \frac{\tilde{\phi}_i}{2 + \gamma_i \mathbb{N}_i}, \quad (3.100)$$

where $\tilde{\phi}_i$ can be the weighted average equivalent of Φ_i , so it can be seen as the weighted average social value associated with the varieties available in market i .

Besides showing the role of substitutability in determining profits, equation (3.100) shows that quality and effective mass of competing varieties keep on offsetting each other even when aggregate markups are considered instead of prices. This is no longer true of costs, though.

Proposition 3. As formerly separated markets integrate, the markup-abating effect of a larger market size may be reinforced or offset by changes in weighted average cost or quality indices in the different markets, higher quality and lower costs being associated with higher markups.

Note that the free-trade market indices resulting from the integration of two previously separated markets may not lie in the space between the two autarkic indices, as the impact of costs and quality is always weighted by the taste mismatch in the local market, $\beta_{s,i}$. Thus, a mass of varieties characterized by a very inefficient productive process and sold in small quantities at home, can still match the tastes of some export markets in

such a successful way as to end up playing an important role in their weighted cost indices.

The empirical weakness of the link between market size and prices may then be caused by the fact that these potential offsetting effects have not been controlled for (Gorg et al., 2010; Martin, 2009). A corollary of this interaction is that importing high quantities (N_i) of low-quality varieties ($\tilde{\alpha}_i$) from markets where marginal costs are lower ($\tilde{c}_i$) does not necessarily imply that weighted average prices will be higher and, hence, competition tougher. This demand-side explanation can be added to the supply-side motivations provided by Konings and Vandenbussche (2008) in explaining why EU anti-dumping protection may have actually hurt the most productive domestic firms, which were likely to produce higher-quality varieties than the imported ones in their narrowly defined sector. This consideration highlights the relation between market indices and firm performance and introduces the more careful analysis of their interactions presented in the next section.

3.7.2 Propositions on trade and firm performance

In the framework proposed, the best way to study firm performance is to look at the profit-maximizing price charged for the varieties it produces. As the firm-level variation in operating profits has been shown to depend only on markups and taste, with the latter just shifting quantities, attention can be drawn on how market indices affect prices. Even assuming negligible trade costs, the same variety s with marginal cost of production $c(s)$ can be associated with different profit maximizing prices in different markets, i , because of differences in competitive environment. The price and quality of each variety in the market is compared by consumers to their experience of alternative varieties in the same market and this constrains the pricing strategy of the firm. This can be clearly seen by rewriting the equilibrium price equation (3.52) in terms of markups and rearranging:

$$p_{s,i}^* - c_{s,i} = \frac{\alpha_s - c_{s,i}}{2 + \gamma_i N_i} + \frac{\gamma_i N_i \left[\frac{\alpha_s - \tilde{\alpha}_i}{2} - \frac{c_{s,i} - \tilde{c}_i}{2} \right]}{2 + \gamma_i N_i}. \quad (3.101)$$

Rewriting the social value associated with variety s in market i as $\phi_{s,i} = \alpha_s - c_{s,i}$, it can be expressed more compactly as

$$p_{s,i}^* - c_{s,i} = \frac{\phi_{s,i} + \gamma_i N_i \left[\frac{\phi_{s,i} - \tilde{\phi}_i}{2} \right]}{2 + \gamma_i N_i} \quad (3.102)$$

Note that, when taste and quality parameters are equal across varieties, all the terms of comparison between individual varieties and market weighted averages cancel out and the equilibrium price function collapses to the baseline Melitz and Ottaviano (2008) model of cost heterogeneity reported in equation (3.14). If also marginal costs are assumed constant across varieties, it collapses to a Ottaviano et al. (2002).

When $N_i \rightarrow 0$ or $\gamma_i \rightarrow 0$, firms behave like pure monopolists and choose prices only as a function of their quality and marginal costs, the effect of their distance from the

average costs and quality being irrelevant for them. The opposite is true when $N_i \rightarrow \infty$ or $\gamma_i \rightarrow \infty$, as in this case the absolute values of idiosyncratic cost and quality parameters cease to have any relevance and all that matters becomes the distance from the weighted average. As noted in the discussion following equation (3.55), at the limit this leads to the distribution of productivity indices collapsing to the highest value, as all the varieties below average would generate negative operating profits. This confirms the claim that tougher competition, whether in the form of higher substitutability between varieties or larger mass of competitors, strengthens the process of selection of the most productive firms, in terms of consumers' willingness to pay for their products or technical efficiency.

Proposition 4. As competition becomes more intense, because of a larger mass of firms or a greater degree of substitutability between varieties, firms' pricing behavior depends more on aggregate behavior, as captured by market indices. Looking at the two extremes, when competition is negligible ($\gamma \rightarrow 0$ or $N \rightarrow 0$), firms only according to the absolute value of their idiosyncratic characteristics; when competition is intense ($\gamma \rightarrow \infty$ or $N \rightarrow \infty$), firms' markups depend only on their characteristics relative to the market weighted averages.

Finally, it can be noted that, even for given levels of substitutability and effective mass of firms, markets are likely to differ in their cost and quality indices, implying different markups in different markets for the same variety. Firms operating in tougher markets may expect to sell profitably their varieties in market with weaker competition, higher marginal costs or lower quality. Given the multi-dimensional nature of heterogeneity in firms characteristics, then, high-quality, high-cost markets can generate the same operating profits as low-quality, low-cost ones. This may explain why some markets are extremely difficult to enter, as Yamawaki (2004) notes in the case of Japanese domestic manufacturing market, notwithstanding high prices of domestically produced varieties.

This view seems to empirically confirmed by Fontagné et al. (2008), who note that "*international specialization in terms of quality within industries and product categories plays an important role in the dynamics of North-South competition*". And also Schott (2004, 2008) observes that the relevant difference in trade composition across countries seems to lie in quality levels within sectors rather than in specialization in specific sectors.

Proposition 5. Besides the competitive pressure exerted by the effective number of firms and substitutability, toughness of competition in a market depends on the costs and quality of the varieties serving it. High quality of domestic varieties may be a barrier to entry as important as low costs.

No relation is imposed between costs and quality, even if it would be reasonable to imagine a positive relation between the two. Verhoogen (2012), for example, looking at input and output prices of Colombian manufacturing plants, shows that higher cost inputs are systematically associated with higher quality outputs. To this end an "elasticity of quality to cost" is proposed by Baldwin and Harrigan (2011) in a CES utility model and adapted by Kneller and Yu (2008) to the context of quadratic utility. Alternatively, Antoniades (2008) introduces a more general structure of fixed and marginal costs of producing quality, treating physical production and quality production as independent processes.

Note also that tastes may play a role in determining profitability, but in this framework they enter the picture only in determining the actual quantities supplied to the market, not directly affecting prices and markups. Therefore, the relevance of their role in regulating entry and exit depends on the specific characteristics of the model: if fixed costs are paid only once to enter a particular market and then never again, tastes are irrelevant as negative operating profits would be the only reason to exit; if fixed costs are to be paid regularly by firms to stay in a market, then not only operating profits but also total profits matter, this making taste-mismatch-driven differences in quantities an additional concern for firms.

Proposition 6. Taste mismatch doesn't affect the sign of operating profits, but influence their magnitude, thus determining their capacity to cover fixed costs of entry and stay in a market.

Thus, differences in tastes across markets, besides helping explain the lack of empirical robustness in the relation between firm size and export status (Hallak and Sivadasan, 2009), may be used to make sense of the "temporary trade" patterns identified by Békés and Murakozy (2012) using detailed country-product transaction level data on Hungarian exports and gradual export behavior discovered by Eaton et al. (2007) through transactions-level customs data from Colombia and Albornoz et al. (2012) using census firm-level data on Argentinean manufacturing export.

Indeed, looking at it through the lens of the model presented in the previous section, firms may be assumed to know the quality of their products and their costs of production and they can also be expected to know market indices in all the other potential export markets, for example by looking at the prices of competing varieties present in their own market and in the other ones. This means that firms have no uncertainty over the profit maximizing price to charge in a different market and they do know if this is going to cover marginal costs of production and delivery. What they do not probably know, though, even when they realize that they can obtain positive markups and generate positive operating profits, is the magnitude of these profits and whether they will cover the fixed costs of entry and stay in the market. These depend, in fact, on the actual quantities sold, which are a function of local tastes and can be discovered only by actually entering the market.

Temporary trade can then be explained by firms discovering the $\beta_{s,i}$ of their variety s in market i , as this affects operating profits in equation (3.59), even as it leaves equilibrium prices in equation (3.52) unaffected. A graphical intuition of the problem can be obtained by looking at figure 3.3, noting that $\beta_{s,i}$ determines the slope of the demand function in such a way that the same equilibrium price can be associated with different quantities sold, hence different operating profits.

3.7.3 Profit functions and consumer surplus

Common to the vertical model and the other the models based on quadratic preferences, there is an interesting property linking firms' operating profits and consumer surplus which can be proofed both geometrically and algebraically: consumer surplus derived from the consumption of variety s is just half of the operating profits accruing

to firms. In other words, since profits can be written as

$$\pi_{s,i} = \frac{1}{\beta_{s,i}} (p_{s,i}^* - c_{s,i})^2,$$

consumer surplus can be easily measured just as

$$W_{s,i} = \frac{1}{2\beta_{s,i}} (p_{s,i}^* - c_{s,i})^2.$$

This relation between profits and consumer surplus also contributes to explain why the first derivative of consumer surplus with respect to price is equal to the additive inverse of quantities, as shown in (1.14).

Graphically, the intuition is provided in Figure 3.17. Notice that it has been shown in (3.12) that equilibrium prices p^* are equal to the average between the marginal costs of production and delivery $c_{s,i}$ and the intercept of the inverse demand function $\alpha_s - \gamma Q_i$. This means that the height of the rectangle describing profits is equal to the height of the triangle capturing the consumer surplus obtained from the consumption of variety s , i.e. $p_{s,i}^* - c_{s,i} = \alpha_s - \gamma Q_i - p_{s,i}^*$. At the same time, also the bases of the rectangle and the triangle coincide. Therefore, $(p_{s,i}^* - c_{s,i})q_{s,i}^* = \frac{(\alpha_s - \gamma Q_i - p_{s,i}^*)q_{s,i}^*}{2}$, or also $W_{s,i} = \frac{\pi_{s,i}}{2}$.

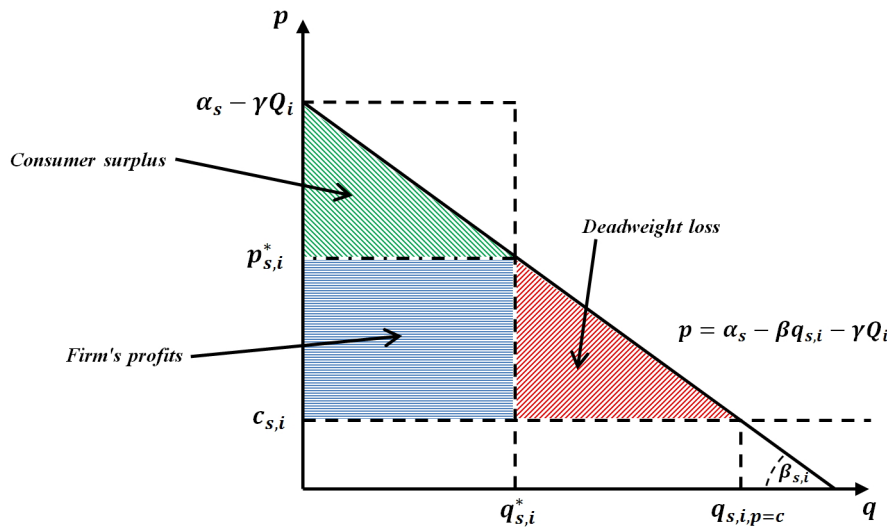


Figure 3.17: Visual representation of firm's profits, consumers' surplus and deadweight loss associated with the sales of variety s in market i .

A more formal proof, based on the geometric properties of the linear demand function associated with the quadratic utility, can be obtained noticing that the area between the inverse demand function and the equilibrium prices in 3.17 can be written as

$$W_s = \int_0^{q_{s,i}^*} p_{s,i} - p_{s,i}^* dq.$$

However, given the linearity of demand, W_s can be measured simply as the area of the triangle whose base and height are respectively $q_{s,i}^*$ and $\alpha_s - \gamma Q_i - p_{s,i}^*$. Noticing that

$$p_{s,i}^* = \frac{\alpha_s - \gamma Q_i}{2} + \frac{c}{2}$$

and

$$q_{s,i}^* = \frac{\alpha_s - \gamma Q_i}{2\beta_{s,i}} + \frac{c_{s,i}}{2\beta_{s,i}},$$

consumer surplus can be calculated as

$$\begin{aligned} W_s &= \frac{1}{2} \left(\frac{\alpha_s - \gamma Q_i}{2\beta_{s,i}} + \frac{c_{s,i}}{2\beta_{s,i}} \right) \left(\alpha_s - \gamma Q_i - \frac{\alpha_s - \gamma Q_i}{2} + \frac{c_{s,i}}{2} \right) = \\ &= \frac{1}{2\beta_{s,i}} \left(\frac{\alpha_s - \gamma Q_i - c_{s,i}}{2} \right)^2 = \frac{1}{2\beta} (p_{s,i}^* - c_{s,i})^2, \end{aligned}$$

which again proves that

$$W_{s,i} = \frac{\pi_{s,i}}{2}.$$

Notice that this correspondence between profits and consumer surplus can also be used to avoid the cumbersome calculations needed to derive the indirect utility function as in equation (1.13), which otherwise would have to be calculated analytically from the utility function (1.1), plugging in quantities as in 1.3 and following these steps:

$$\begin{aligned} W_i &= \alpha \int_{s \in S_i} \left(\frac{\alpha\beta + \gamma P_i}{\beta(\beta + \gamma N_i)} - \frac{p_s}{\beta} \right) ds - \frac{\beta}{2} \int_{s \in S_i} \left(\frac{\alpha\beta + \gamma P_i}{\beta(\beta + \gamma N_i)} - \frac{p_s}{\beta} \right)^2 ds + \\ &- \frac{\gamma}{2} \left[\int_{s \in S_i} \left(\frac{\alpha\beta + \gamma P_i}{\beta(\beta + \gamma N_i)} - \frac{p_s}{\beta} \right) ds \right]^2 - \int_{s \in S_i} \left[p_s \left(\frac{\alpha\beta + \gamma P_i}{\beta(\beta + \gamma N_i)} - \frac{p_s}{\beta} \right) \right] ds + \bar{q}_0 + Y_i \\ \Rightarrow W_i &= \alpha \left(\frac{\alpha N_i}{\beta + \gamma N_i} + \frac{\gamma N_i P_i}{\beta(\beta + \gamma N_i)} - \frac{P_i}{\beta} \right) ds + \\ &- \frac{\beta}{2} \int_{s \in S_i} \left[\left(\frac{\alpha}{\beta + \gamma N_i} \right)^2 + \left(\frac{p_s}{\beta} \right)^2 \right] ds + \\ &- \frac{\beta}{2} \int_{s \in S_i} \left[\left(\frac{\gamma P_i}{\beta(\beta + \gamma N_i)} \right)^2 - \frac{2\alpha p_s}{\beta(\beta + \gamma N_i)} + \frac{2\alpha \gamma P_i}{\beta(\beta + \gamma N_i)^2} - \frac{2\gamma P_i p_s}{\beta^2(\beta + \gamma N_i)} \right] ds + \\ &- \frac{\gamma}{2} \left[\int_{s \in S_i} \left(\frac{\alpha}{\beta + \gamma N_i} - \frac{p_s}{\beta} + \frac{\gamma P_i}{\beta(\beta + \gamma N_i)} \right) ds \right]^2 + \end{aligned}$$

$$\begin{aligned}
& - \int_{s \in S_i} \left[\left(\frac{\alpha p_s}{\beta + \gamma N} - \frac{p_s^2}{\beta} + \frac{\gamma p_s P_i}{\beta(\beta + \gamma N_i)} \right) \right] ds + \bar{q}_0 + Y_i \\
\Rightarrow W_i &= \frac{\alpha^2 N_i}{\beta + \gamma N_i} + \frac{\alpha \gamma N_i P_i}{\beta(\beta + \gamma N_i)} - \frac{\alpha P_i}{\beta} - \frac{\alpha^2 \beta N_i}{2(\beta + \gamma N_i)^2} - \frac{\int_{s \in S_i} p_s^2 ds}{2\beta} - \frac{N_i \gamma^2 P_i^2}{2\beta(\beta + \gamma N_i)^2} + \\
& + \frac{\alpha \beta P_i}{\beta(\beta + \gamma N_i)} - \frac{\alpha \beta \gamma N P_i}{\beta(\beta + \gamma N_i)^2} + \frac{\gamma P_i^2}{\beta(\beta + \gamma N_i)} - \frac{\alpha^2 \gamma N_i^2}{2(\beta + \gamma N_i)^2} - \frac{\gamma P_i^2}{2\beta^2} - \frac{\gamma^3 N_i^2 P_i^2}{2\beta^2(\beta + \gamma N_i)^2} \\
& + \frac{\alpha \gamma N_i P_i}{\beta(\beta + \gamma N_i)} + \frac{N_i \gamma^2 P_i^2}{\beta^2(\beta + \gamma N_i)} - \frac{\alpha \gamma^2 N_i^2 P_i}{\beta(\beta + \gamma N_i)^2} - \frac{\alpha \beta P_i}{\beta(\beta + \gamma N_i)} + \frac{\int_{s \in S_i} p_s^2 ds}{\beta} - \frac{\gamma P_i^2}{\beta(\beta + \gamma N_i)} + \bar{q}_0 + Y_i \\
\Rightarrow W_i &= \frac{2\alpha^2 \beta N_i + 2\alpha^2 \gamma N_i^2 - \alpha^2 \beta N_i - \alpha^2 \gamma N_i^2}{2(\beta + \gamma N_i)^2} + \frac{\int_{s \in S_i} p_s^2 ds}{2\beta} + \\
& + P_i \left(\frac{2\alpha \beta \gamma N_i + 2\alpha \gamma^2 N_i^2 - \alpha \beta^2 - \alpha \gamma^2 N_i^2 - 2\alpha \beta \gamma N_i - \alpha \beta \gamma N_i - \alpha \gamma^2 N_i^2}{\beta(\beta + \gamma N_i)^2} \right) + \\
& + P_i^2 \left(\frac{-\beta \gamma^2 N_i - \beta^2 \gamma - \gamma^3 N_i^2 - 2\beta \gamma^2 N_i - \gamma^3 N_i^2 + 2\beta \gamma^2 N_i + 2\gamma^3 N_i^2}{2\beta^2(\beta + \gamma N_i)^2} \right) + \bar{q}_0 + Y_i \\
W_i^* &= \frac{\alpha^2 N_i}{2(\beta + \gamma N_i)} + \frac{\int_{s \in N_i} p_{s,i}^2 ds}{2\beta} - \frac{\alpha}{\beta + \gamma N_i} P_i - \frac{\gamma}{2\beta(\beta + \gamma N_i)} P_i^2 + Y_i + \bar{q}_0.
\end{aligned}$$

Notice that the indirect utility function, expressed in this way, is still dependent on parameters not directly observable. Hence, besides the computational advantage, the use of profits for the measurement of welfare also allows economists to deal with directly observable variables. Of course, this relation between profits and welfare should be understood with caution because it stems directly from the monopolistic competition assumptions and cannot be extended to other market structures. To make an example, if profits in a market increase because of an oligopoly becoming a duopoly or a pure monopoly, in that case profits and consumer welfare would move in opposite directions, as well known in the field of Industrial Organization.

Finally, one last remark is due, concerning Figure 3.17 on the dead-weight loss. First of all, it may be easily proved that it is of the same magnitude as consumer surplus. Indeed, plugging $p = c$ in the demand function (3.11), it can be seen that

$$q_{s,i,p=c} = \frac{\alpha_s - \gamma Q_i}{\beta_{s,i}} + \frac{c_{s,i}}{\beta_{s,i}} = \frac{q_{s,i}^*}{2}$$

and therefore $q_{s,i}^* = q_{s,i,p=c} - q_{s,i}^*$, but since also $\alpha_s - \gamma Q_i - p_{s,i}^* = p_{s,i}^* - c$, it turns out that the consumer surplus triangle and the dead-weight loss triangle have the same base and height and hence the same area.

This means that an outward shift of the demand function (say because of an increase in quality α_s) or an increase in efficiency (i.e., a reduction in $c_{s,i}$) is also going to increase the dead-weight loss, together with firm's profits and consumers' welfare. In other

words, as long as varieties are differentiated, the market power associated with each variety implies that half of the entire total potential gains obtained from any productive advancement is reaped by firms, one quarter is translated into higher consumer surplus and one quarter is lost. Taking it with a grain of salt, quadratic utilities may provide an easy way to perform some sort of welfare accounting.

3.7.4 How income matters

Finally, before turning to the empirical part of the Thesis, it is worth discussing another feature of the vertical model which is common to the other quadratic utility models presented. It may have been noted that consumer income has never been mentioned, as it is known not to have an impact on the demand for the differentiated good in models based on quadratic preferences. In other words, it is as if income does not matter. Yet, it is reasonable to expect that it matters, i.e. consumers with different incomes may have a different willingness to pay for the same variety (Markusen, 2013). When the product under consideration accounts for a small share of their total consumption and the numéraire is interpreted as a Hicksian composite good representing a bundle of all the other products, this effect may be captured by slightly altering consumer i 's utility function. Specifically, in (2.6) q_0 can be replaced by $q_{0,i} = \delta_i q_0$, where $\delta_i > 0$ measures consumer i 's marginal utility of income. Because this typically decreases with the consumer's income, consumers can be ranked in decreasing order of income, and thus $\delta_1 < \delta_2 < \dots < \delta_n$ where $\delta_1 = 1$ and $q_{0,1} = q_0$ by normalization.

Consumer i 's inverse demand for variety s becomes

$$p_i(s) = \max \left\{ \frac{\alpha(s) - \beta_i(s)q(s) - \gamma Q_i/2}{\delta_i}, 0 \right\}$$

where $p_i(s)$ is expressed in terms of the numéraire of the richest consumer: the lower δ_i , the more the inverse demand is shifted upward. Thus, the impact of income on demand can be indirectly captured. In addition, though it is convenient not to assume any a priori relation between the quality of variety s , $\alpha(s)$, and its taste mismatch with a particular destination market, $\beta_i(s)$, the relation between these parameters may be correlated with income or other related variables, as discussed by Gabszewicz and Thisse (1979) and recently investigated empirically by Martin and Mayneris (2013). Hence it can be shown that quasi-linear models can deal with income differences across countries, even though it is more difficult to deal with income inequality within countries, even if Latzer and Mayneris (2012) show that it may be a promising field of research. Still, to work with a representative consumer model seems a reasonable assumption in view of the current data availability. Most available trade data, however, only have one observation per firm-product-country which does not allow analysis of consumer differences within countries.

3.8 Concluding remarks

This Chapter has investigated all the possible variations of a standard quadratic utility framework on the demand side. Out of the eight models resulting from the introduction of heterogeneity in the three terms composing it, one preferred functional form, called verti-zontal to stress the combined presence of vertical and horizontal elements of differentiation, is identified and is carried over to the next empirical Chapters to see if it is rejected by the data.

Part II

Taking verti-zontal linearity to the data

Chapter 4

Micro-level evidence of verti-zontality

After the verti-zontal has been identified in Chapter 3 as being the most promising variation, also based on the stylized facts in the literature reported in Chapter 2, it is now in this Chapter that the tests and empirical exercises are concentrated. First, the empirical implications of the model will be explained in terms of what should be observed in price and quantity patterns taking the model at face value.

Then, a second look is given at the European car market data used in Chapter 2 to exploit the information it provides on the European destination markets covered and on individual product characteristics through an exploratory factor analysis.

Finally, the focus is shifted to a much more comprehensive firm-level dataset covering almost the entire universe of the Belgian exporters to the rest of the world for formal tests of the theory following two different methodologies, the first one subdividing the entire sample into homogeneous groups to study the systematic presence of patterns in the different groups; the second one using the entire sample and then testing the predictions of the verti-zontal model against the expected results under alternative models of monopolistic competition. The first methodology aims at confirming the robustness of the empirical regularities that motivated the structure of the model in the previous Chapters; the second methodology tests explicitly the verti-zontal model and explains why existing trade models would not be consistent with the results.

4.1 Distinguishing variety and market-variety effects

One of the key features of the verti-zontal model (Model V in the previous Chapter) is that it is possible to separate variety- and market-specific effects in the equilibrium pricing equation, as can be seen for example from Table 3.1. As shown in the previous chapter, competition effects in a market effects shift the demand for all the varieties downwards by the same amount, so that price rankings are kept constant across markets even if the absolute level of prices can be different. The same is not true of quantities,

as variety-specific horizontal characteristics of a certain variety are perceived differently in the different markets, resulting in a market-variety-specific quantity shifter.

To give some intuition on the empirical implications of these features, in Figure 4.1 five markets are shown where three varieties of the same product are met with different competition effects in each market. For the sake of illustration, the horizontal and vertical axes are shifted upwards or downwards depending on the level of market competition. So that the third market (the one in the middle) displays the lowest level of competition (the three varieties have the highest absolute price level) and the second market from the right the highest (in the sense that it is associated with the lowest absolute price level). Notice also from Figure 4.1 that no clear trend in the quantity rankings across market can be expected, consistently with the analysis in Chapter 3. In other words, the three varieties in the five markets stylized in Figure 4.1 display a constant ranking across markets (due to variety-specific "quality" and marginal costs of production, assuming equal transport costs for the same products exported from the same country), but not necessarily the same ranking in quantities because of market-variety-specific taste differences.

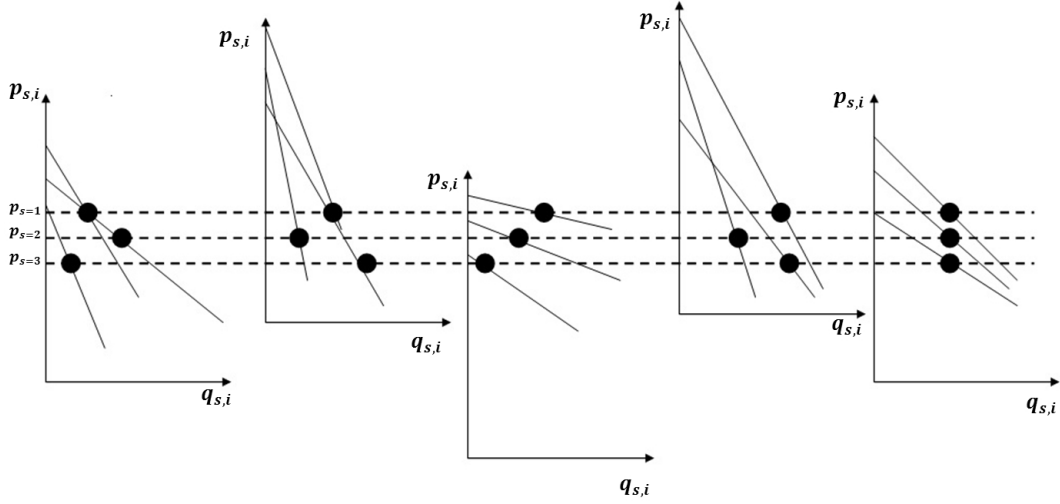


Figure 4.1: Illustration of the empirical implications of the verti-zonal model.

A further implication of the verti-zonal feature of having a parallel demand shift for all the varieties in a market is that knowing the marginal costs of production and delivery $c_{s,i}$ and the prices $p_{s,i}$ it is possible to draw the distribution of the quality-minus-market-effects variable $\alpha_s - \gamma Q_i$. Assuming equal transport costs across markets, since quality α_s and marginal costs of production c_s are variety specific, the only driver of price differences across markets is the competition level γQ_i . However, since γQ_i affects all the varieties in the same way, the price distribution for the same set of varieties is expected to have the same shape, the only difference being that the absolute levels may differ in different markets. Figure 4.2 provides some intuition on this point.

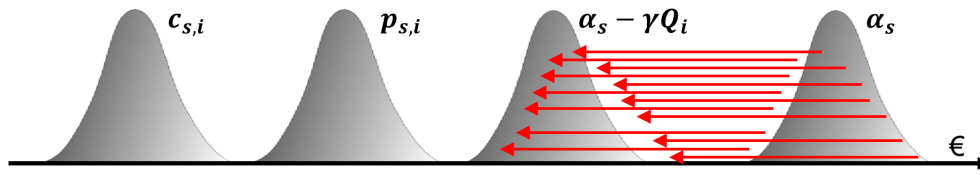


Figure 4.2: Boxplot of differences between car prices and market average in each market.

4.1.1 A second look at the car market data: the price distribution

How different are actual price data from the vertical predictions outlined in Figures 4.1 and 4.2? A preliminary answer can be provided by looking again at the EU car market data used in Chapter 2. Figure 4.3, for example, shows a box plot of the simple price distribution of the 72 varieties of cars sold in the 5 markets in 1999.

Already in Figure 4.3 it is possible to spot some regularity in prices, with medians very close to each other and comparable ranges of values. However, to make the point on the shape of the distribution even clearer, in Figure 4.4 is presented a box plot is provided where is shown the difference between each variety's price and the market average price. The great similarity between the series' median value, the 25th percentiles, the 75th percentiles and even the outliers indicate that, net of a parallel shift, prices' distribution for the same varieties appear to be very similar across countries, leaving little room for market-variety-specific variation in prices.

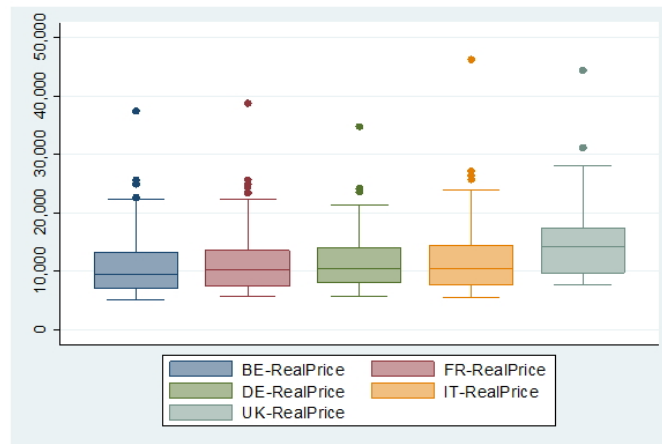


Figure 4.3: Boxplot of car prices in Belgium, France, Germany, Italy and UK.

However, the presence (or absence) of market-variety-specific elements in price setting can also be indirectly inferred by looking at the difference between a variety's price in one market and its average price in the different markets (or, equivalently, its price in a reference market). In the absence of any market-variety-specific effect, all the varieties in one market should have exactly the same distance from the average, positive or negative depending on the levels of competition. In the case of the car market, in Figure 4.5 are

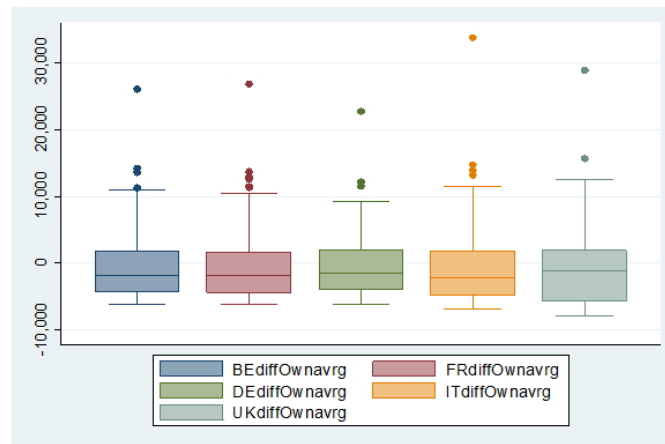


Figure 4.4: Boxplot of differences between car prices and market average in each market.

shown box plots of this statistics. It can be noted that not all the varieties have the same value, as a pure "verti-zontal world" would have displayed, but it should be remembered that in the datasets there are some cars which are produced and sold in the same market and others that are shipped abroad, which are likely not to respect the assumption of equal transport costs across markets. This and others issues are addressed in the next Section of the Chapter by using a different dataset where the exporting country is held fixed. For the moment, it is enough to notice that the differences across varieties in Figure 4.5 are quite small (less than 1/3 of the median price in each market), so even if the data is not perfectly reproducing the expected patterns it does not imply a *prima facie* rejection of the model.

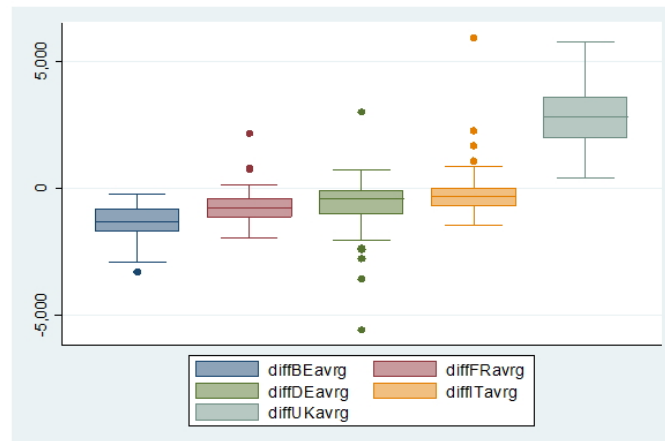


Figure 4.5: Boxplot of differences between car prices in each market and the average of the same variety across markets.

4.1.2 Giving a face to the parameters: an exploratory factor analysis

Before turning to the Belgian exporters' dataset, though, there is some additional information that can be extracted from the EU car market data, exploiting the presence in the dataset of variety characteristics such as engine attributes (horsepower), dimensions (e.g., weight; length; width; height) and performance variables.

The theoretical discussion on the quadratic utilities and the vertical model in particular did not enter into the details of what exactly is a vertical and what a horizontal attribute. Consistently with the patterns identified in the literature reviewed in Chapter 2, it separates market-variety-specific attributes affecting quantities and variety-specific attributes affecting prices, but it does not speculate further on the nature of these attributes.

To fill this gap, an exploratory factor analysis on the EU car market data can help in providing a preliminary indication on whether such distinction between attributes exists and whether prices and quantities are influenced by different sets of product characteristics. In the car market dataset, for each variety, information is available on engine attributes (cylinders, horsepower), dimensions (weight, length, width, height), performance variables (liters/km, speed) and some additional features such as the number of doors and places in the car and, finally, whether the car model is produced in the same country where it is sold.

In Tables 4.2 to 4.9 a factor analysis is presented on all these variables, including the price (normalized to SDRs, the supplementary foreign exchange reserve assets defined and maintained by the International Monetary Fund, which is a convenient reference currency especially in the earlier years of the sample) and quantities sold in per capita terms in the 5 markets. Remember that summary statistics on the sample are in Table 4.1.

For robustness, factor analysis includes first (Table 4.2 to Table 4.5) the sample used in Chapter 2, which considers only year 1999, shown in 2.1 to be the year with the highest overlap in sales to different markets. Then (Table 4.6 to Table 4.9) it covers the 30 years of the entire sample with qualitatively similar results.

First of all, some summary statistics on the sample are shown in Table 4.1.

Table 4.1: Summary statistics on the European car market dataset.

European car market summary statistics								
	Entire sample				Year=1999; varieties in 5 markets			
Observations	11,543				360			
Variable	Mean	St. Dev.	Min.	Max	Mean	St. Dev.	Min.	Max
Real Price	8354.0	5541.5	830.7	49380.6	12725.5	6328.1	5123.8	46259.7
Q per capita	4.1E-04	6.5E-04	4.4E-06	7.6E-03	4.4E-04	5.5E-04	9.3E-06	3.8E-03
Cylinders	1462.07	479.88	425	4520	1494.44	370.74	796	2771
Horsepower	57.14	23.89	13	169.5	66.41	23.16	33	142
Weight	978.94	225.41	520	1910	1109.13	215.42	725	1650
Length	415.84	44.39	250	506	421.54	40.33	349.5	503.5
Width	164.38	9.62	122	188	169.99	6.91	149.5	188
Liters/km	8.18	1.72	4	18.6	8.60	1.44	6.17	12.83
Speed	159.91	23.80	95	247	177.39	21.02	142	236
Domestic prod.	0.19	0.39	0	1	0.14	0.34	0	1
Height	140.44	4.62	117.5	173.5	142.52	4.31	133	161
Doors	3.65	0.90	2	5	3.82	0.79	2	5
Places	4.87	0.38	2	7	4.93	0.29	2	5

Turning to the factor analysis, in the two samples considered, the four sets of Tables are organized in the same way. First, in Table 4.2 and Table 4.6, is shown the residual variability explained by each additional factor in a preliminary principal-component factor analysis with unrotated factors. In these Tables, column (1) just lists the factors in decreasing order of importance (so that the first factor account for as much of the variation as possible and each following one for less than the previous); the column (2) captures the total variance accounted by each factor; column (3) shows the difference between each eigenvalue and the next; column (4) indicates the relative weight of each factor in the overall variance and column (5) just computes the cumulative amount of variance explained by adding the corresponding additional factor.

Then Tables 4.3 and 4.7 show the correlations (or factor loadings, as they can be seen as the "weight" of each variable in the corresponding factor) between the variables and the factors retained from the previous step in columns (1) and (2) and the amount of unique variance (in the sense that it is not share with the other variables) of each variable in column (3).¹

Factors are then rotated in Tables 4.4 and 4.8 to get orthogonal factors (uncorrelated with each other), which reduces the possibility that the same variable appear associated with the same factor (phenomenon known as "multiple loadings"). this is a common procedure in standard principal-components analyses, even if in case analyzed here (the verti-zontal model) the assumption of orthogonality of the factors associated with prices and quantities is less necessary since the variety-specific characteristics (vertical attributes and costs of production) are assumed to affect not only prices but also quantities sold. Columns (1) to (5) in these tables have to be read exactly like those in Tables 4.2 and 4.6.

Finally, Tables 4.5 and 4.9 are the equivalent of Tables 4.3 and 4.7 for rotated factors and their Columns have a similar interpretation, the only difference being that results now are based on orthogonal factors.

As for the interpretation of the results, notice first of all that in both in Table 4.2 and Table 4.6 the first factor has a very high proportion of variance explained (more than 50%) and a high eigenvalue (above 7). Notice that since the sum of all eigenvalues coincides with the total number of variables, roughly speaking it can be claimed that Factor 1 captures the variance of 7 of the variables analyzed.

Turning to Tables 4.3 and 4.7 the reason for the high eigenvalue becomes clear. The first factor is indeed highly associated with prices and with a series of variables which can be seen as vertical attribute (cylinders; horsepower; weight; length; width; liters/km; speed). Admittedly, this factor is also associated with negative quantities sold, which from the perspective of the verti-zontal model would mean that the cost of producing this "quality attributes" appear to be higher than the monetary benefit in terms of consumers' willingness to pay, even if it should be noted that in (3.52) and (3.56) there is an evident negative externality for the competitors from a group of firms investing in quality, as they

¹In this analysis the number of factor is constrained to a maximum of 2, but robustness checks on the outcomes adding additional factors have been run and the results are qualitatively unchanged, i.e. the new factors just correlate with some individual variables and do not affect much the previous ones.

will increase the markets' aggregate and average quality index, respectively $\mathbb{A}_i$ and $\tilde{a}_i$. As for the second factor, it appears to be defined mainly by the domestic production of the variety, consistently with the common empirical observation of a sizeable domestic market effect (Brooks, 2003; Chung and Song, 2008; Ferreira and Waldfogel, 2013; Goldberg and Verboven, 2005). Looking at the results with rotated factors on both the entire sample and on the 1999 data, there is little change in results. Again, one factor is associated with prices and reasonable quality indicators and the other only with quantities, having no correlation with prices.

A possible interpretation of this factor analysis is that the first factor would indeed capture the impact of the variety specific factors in the verti-zontal model, i.e. α_s and c_s , whereas the second factor captures the taste mismatch parameter $\beta_{s,i}$, affecting quantities sold but not prices. Clearly there are some caveats on these results, the most important being that it is impossible to observe costs directly in this dataset and even if c_s is constant across markets, the costs of production and delivery $c_{s,i}$ are very likely to be different. Similarly, it can be noted that domestically produced cars may also be shipped at a lower cost, so that the lack of effect on prices may mean that domestic consumers are also willing to pay a higher markup on locally produced cars in such a way that a lower $c_{s,i}$ and a higher $\alpha_{s,i}$ result in no price effect. This alternative explanation would indeed contradict the verti-zontal hypothesis of no market-variety specific effects of quality valuation. Therefore the results should be seen as a strict test of the model and should be interpreted with a pinch of salt and just be seen as a way to look at the data. Future works, possibly on more complete datasets displaying more information on both the producer of the varieties (similarly to the Belgian exporters' dataset showed in the next section) and the destination markets (as in the car market dataset).

However, the main contribution of this analysis is to give a preliminary idea of a methodology that can be used to map the verti-zontal model parameters into observed characteristics. The verti-zontal α_s and $\beta_{s,i}$ could indeed be seen as underlying factors capturing different attributes of a variety. This would then further contribute to bridge the distance between IO and Trade models of product differentiation.

Table 4.2: Residual variability explained by each additional factor in a principal-component factor analysis on the balanced cross-section of European car market, year=1999

Factor analysis/correlation			Number of obs = 360	
Method: principal-component factors			Retained factors = 2	
Rotation: (unrotated)			Number of params = 25	
Factor (1)	Eigenvalue (2)	Difference (3)	Proportion (4)	Cumulative (5)
Factor 1	7.19592	5.57468	0.5535	0.5535
Factor 2	1.62124	0.38386	0.1247	0.6782
Factor 3	1.23738	0.23002	0.0952	0.7734
Factor 4	1.00736	0.34947	0.0775	0.8509
Factor 5	0.65789	0.28144	0.0506	0.9015
Factor 6	0.37646	0.1166	0.029	0.9305
Factor 7	0.25985	0.05136	0.02	0.9505
Factor 8	0.20849	0.08133	0.016	0.9665
Factor 9	0.12716	0.02165	0.0098	0.9763
Factor 10	0.10551	0.00727	0.0081	0.9844
Factor 11	0.09824	0.01307	0.0076	0.992
Factor 12	0.08517	0.06584	0.0066	0.9985
Factor 13	0.01933	.	0.0015	1
LR test: independent vs. saturated: $\chi^2(78) = 5207.20$ Prob> $\chi^2 = 0.0000$				

Table 4.3: Factor analysis on car characteristics in the European car market with unrotated factor loadings, year=1999.

Unrotated factor loadings (pattern matrix) and unique variances			
Variable (1)	Factor 1 (2)	Factor 2 (3)	Uniqueness (4)
Real Price	0.896	0.0457	0.195
<i>Q per capita</i>	-0.2441	<i>0.8357</i>	0.242
Cylinders	0.9491	0.0142	0.0991
Horsepower	0.9659	-0.019	0.0667
Weight	0.9135	0.0664	0.161
Length	0.9418	0.049	0.1106
Width	0.9071	0.1448	0.1561
Liters/km	0.9075	-0.0263	0.1757
Speed	0.9729	0.0324	0.0524
<i>Domestic prod.</i>	0.0007	<i>0.8208</i>	0.3263
Height	-0.0244	-0.2661	0.9286
Doors	0.3199	-0.3657	0.7639
Places	0.2866	0.1116	0.9054

Table 4.4: Residual variability explained by each additional factor in a principal-component factor analysis on the balanced cross-section of European car market rotating the factor loads for uncorrelated factors, year=1999.

Factor analysis/correlation		Number of obs = 350		
Method: principal-component factors		Retained factors = 2		
Rotation: orthogonal varimax (Kaiser off)		Number of params = 27		
Factor (1)	Variance (2)	Difference (3)	Proportion (4)	Cumulative (5)
Factor 1	7.15529	5.49343	0.5504	0.5504
Factor 2	1.66186	.	0.1278	0.6782
LR test: independent vs. saturated: $\chi^2(78) = 5207.20$ Prob> $\chi^2 = 0.0000$				

Table 4.5: Factor analysis on car characteristics in the European car market with rotated factor loadings, year=1999.

Rotated factor loadings (pattern matrix) and unique variances			
Variable (1)	Factor 1 (2)	Factor 2 (3)	Uniqueness (4)
Real Price	0.8967	-0.031	0.195
<i>Q per capita</i>	-0.1719	<i>0.8535</i>	0.242
Cylinders	0.9468	-0.0669	0.0991
Horsepower	0.9608	-0.1014	0.0667
Weight	0.9159	-0.0118	0.161
Length	0.9426	-0.0315	0.1106
Width	0.9162	0.0668	0.1561
Liters/km	0.9019	-0.1037	0.1757
Speed	0.9721	-0.0508	0.0524
<i>Domestic prod.</i>	0.0708	<i>0.8177</i>	0.3263
Height	-0.0471	-0.263	0.9286
Doors	0.2876	-0.3917	0.7639
Places	0.2951	0.0867	0.9054

Table 4.6: Residual variability explained by each additional factor in a principal-component factor analysis on the balanced cross-section of European car market. Entire sample.

Factor analysis/correlation			Number of obs = 11,543	
Method: principal-component factors			Retained factors = 2	
Rotation: (unrotated)			Number of params = 25	
Factor (1)	Eigenvalue (2)	Difference (3)	Proportion (4)	Cumulative (5)
Factor 1	6.61287	5.08943	0.5087	0.5087
Factor 2	1.52344	0.27445	0.1172	0.6259
Factor 3	1.24899	0.30536	0.0961	0.7219
Factor 4	0.94363	0.0772	0.0726	0.7945
Factor 5	0.86643	0.26299	0.0666	0.8612
Factor 6	0.60343	0.18272	0.0464	0.9076
Factor 7	0.42072	0.12902	0.0324	0.94
Factor 8	0.2917	0.12843	0.0224	0.9624
Factor 9	0.16327	0.04193	0.0126	0.975
Factor 10	0.12134	0.02422	0.0093	0.9843
Factor 11	0.09713	0.0278	0.0075	0.9918
Factor 12	0.06932	0.0316	0.0053	0.9971
Factor 13	0.03772	.	0.0029	1
LR test: independent vs. saturated: $\chi^2(78) = 1.4e+05$ Prob> $\chi^2 = 0.000$				

Table 4.7: Factor analysis on car characteristics in the European car market with unrotated factor loadings. Entire sample.

Unrotated factor loadings (pattern matrix) and unique variances			
Variable (1)	Factor 1 (2)	Factor 2 (3)	Uniqueness (4)
Real Price	0.7585	-0.0229	0.4242
<i>Q per capita</i>	-0.2277	<i>0.8497</i>	0.2262
Cylinders	0.9217	-0.0023	0.1505
Horsepower	0.9408	-0.0552	0.1118
Weight	0.9622	0.0484	0.0717
Length	0.9136	0.0723	0.16
Width	0.8957	0.1243	0.1823
Liters/km	0.6785	0.0083	0.5396
Speed	0.8999	-0.032	0.1891
<i>Domestic prod.</i>	-0.0414	<i>0.8502</i>	0.2755
Height	0.1516	0.0699	0.9721
Doors	0.4346	-0.0188	0.8108
Places	0.4522	0.2139	0.7498

Table 4.8: Residual variability explained by each additional factor in a principal-component factor analysis on the balanced cross-section of European car market rotating the factor loads for uncorrelated factors. Entire sample.

Factor analysis/correlation		Number of obs = 11,543		
Method: principal-component factors		Retained factors = 2		
Rotation: orthogonal varimax (Kaiser off)		Number of params = 25		
Factor (1)	Variance (2)	Difference (3)	Proportion (4)	Cumulative (5)
Factor 1	6.58486	5.03341	0.5065	0.5065
Factor 2	1.55146	.	0.1193	0.6259
LR test: independent vs. saturated: $\chi^2(78) = 5207.20$ Prob> $\chi^2 = 0.0000$				

Table 4.9: Factor analysis on car characteristics in the European car market with rotated factor loadings. Entire sample.

Rotated factor loadings (pattern matrix) and unique variances			
Variable (1)	Factor 1 (2)	Factor 2 (3)	Uniqueness (4)
Real Price	0.7547	-0.0791	0.4242
<i>Q per capita</i>	-0.1641	<i>0.8642</i>	0.2262
Cylinders	0.919	-0.0706	0.1505
Horsepower	0.9341	-0.1248	0.1118
Weight	0.9632	-0.0231	0.0717
Length	0.9165	0.0044	0.16
Width	0.9024	0.0575	0.1823
Liters/km	0.6772	-0.042	0.5396
Speed	0.8951	-0.0986	0.1891
<i>Domestic prod.</i>	0.0218	<i>0.8509</i>	0.2755
Height	0.1564	0.0584	0.9721
Doors	0.432	-0.051	0.8108
Places	0.4668	0.1798	0.7498

4.2 Empirical analysis: the NBB data

The aim of this Section is to confront the verti-zontal model with more comprehensive micro-level dataset than the one on the European car market. To this end, a unique dataset on Belgian exporters is used, similar to the one in Bernard et al. (2012), to undertake two different kinds of analysis. The first one, more general in nature, consists in splitting the overall sample into a high number of homogeneous, balanced subsamples to document the systematically higher variability of quantities across markets than prices. It is not a direct test of the verti-zontal model, but it is a preliminary test on the properties of trade patterns observed in the data (prices and quantities), to see if they are consistent with the implications of the model, as summarized in Table 4.10, based on the equilibrium prices and quantities obtained in expressions (3.54) and (3.57). The second analysis goes one step further and aims at testing the empirical relevance of the verti-zontal model against competing theories using dummy regressions based on the entire sample.

Table 4.10: Observables and structural variables, for a variety s in destination market i .

Observables	Sources of Heterogeneity	Relevant parameters
Prices_{s,i}	Quality_s ; Cost_s	$p_{i,s}(\alpha_s; \mathbf{c}_s; MarketEffects_i)$
Quantities_{s,i}	Quality_s ; Cost_s ; Taste_{i,s}	$q_{i,s}(\alpha_s; c_s; MarketEffects_i; \beta_{i,s})$

The data is composed of fob (free on board) export prices and quantities by destination country. Prices (unit values) and quantities of the same varieties are thus comparable across and within destination markets. The Belgian export data are obtained from the National Bank of Belgium's Trade Database and are a cross-section of the entire population of recorded annualized trade flows at the firm level by product and destination. Exactly which trade flows are recorded (i.e. whether firms are required to report their trade transactions) depends on their value and destination. For extra-EU trade (trade partner outside the EU borders), all transactions with a minimum value of 1,000 euros or weight of more than 1,000 kg have to be reported. For intra-EU trade (trade partner inside the EU borders), firms are only required to report their export flows if their total annual intra-EU export value is higher than 250,000 euros. The products are recorded at 8-digit Combined Nomenclature (CN8) level.² In most cases, CN8 output is measured in weight (kilograms), but, for a smaller set of products, quantities are also expressed in units (liters, bottles, pairs etc.).³

Due to its hierarchical nature, CN8 products can also be classified as products at

²The CN classification is equal to the HS classification at the 6 digit levels.

³Measurement error that can plague quantity measurement should be lower when output is measured in units be it that the number of observations is much lower. For this purpose results are reported for both units and weights.

more aggregate levels. For firms with primary activity in manufacturing, the data includes more than 5,000 exporters and over 7,000 different CN8 products, exported to 220 countries, for a total of more than 200,000 observations. It covers cross-sectional manufacturing export data for the year 2005 for which both values and quantities exported are reported. No information on other firm-characteristics is provided.

With the data at hand it is possible to combine a product category at 8-digit level (CN8) with a firm identifier such that beers can be distinguished from one another by the firm they are exported by. These firm-product combinations are allowed to enter consumer preferences differently. Even with this very detailed product classifications, one limitation is that it cannot be excluded that there may still be heterogeneity within the 8-digit product category that cannot be observed (e.g., specific brands, distribution channels, and so on). While most 8-digit products have a precise description, for some products this is less the case. But what is important to keep in mind is that, by linking the product to a firm, consumer preferences are now allowed to differ between the various firm-product combinations available in the country. In what follows, a *variety* as a *firm-product* combination is defined. Each product is now defined at the CN8 level and is considered as a separate product market within which it is possible to analyze the determinants of export prices and quantities across destinations for varieties shipped from Belgium.

To deal with outliers, the raw data on unit values and quantities has been dropped at the 1% extremes of the distribution. The only data restrictions imposed are that, first, each firm faces some competition in their own CN8 product in a particular destination country and, second, that a variety is exported to more than one country. In practice, it is imposed that a minimum of two firm-CN8 products be present in the same destination and a minimum of two export markets for each variety. In this way, the variety- and market-variety-specific effects can be identified in the regressions. While results are not very sensitive to an increase in the number of competing varieties per destination country, with each additional variety required to be present in a market, the number of observations for the regression falls substantially. Table 4.11 shows how the restricted sample compares to the full sample for both weights and units.

4.3 Analyzing variability in market-product subsamples

In the first analysis, based on the full sample of the Belgian exporters' data, the main aim is to identify general trade patterns independently of a theoretical rationalization. In particular, the focus is on price and quantity variability across markets. To this end, the empirical strategy consists first in identifying "balanced cross sections", i.e. product-market combinations in which all the varieties are present in all the markets considered and, within each market, the exact same set of varieties is present. In this way, different markets become comparable in term of rankings of prices and quantities and it will be possible to see if price ranking are found to be more stable across markets than quantity rankings.

The definition of the subsamples is explained in the next subsection and then the

Table 4.11: The full and restricted data sample of Belgian firm-product-country exports.

	WEIGHT		UNITS	
	(1) Full sample	(2) Restricted sample	(3) Full sample	(4) Restricted sample
Observations	239,127	111,876	52,227	20,929
Firms	5,386	3,528	2,521	1,067
CN2 Products	95	89	56	46
CN4 Products	1,159	755	315	182
CN6 Products	4,122	1,999	1,161	494
CN8 Products	7,051	2,691	1,922	604
Firm-CN2 Combinations	20,358	8,835	4,844	1,748
Firm-CN4 Combinations	36,709	13,333	7,000	2,320
Firm-CN6 Combinations	50,234	17,759	10,243	3,454
Firm-CN8 Combinations	62,355	19,612	12,842	3,703
Destinations	220	139	206	108
CN2-Destination Combinations	8,283	3,646	3,236	1,214
CN4-Destination Combinations	38,924	13,089	9,404	2,544
CN6-Destination Combinations	78,997	23,738	19,500	4,908
CN8-Destination Combinations	107,681	28,343	26,538	5,548
Trade volume (bill. euros)	88.10	27.02	23.91	8.78
Destinations per firm-CN8:				
Mean	3.84	5.71	4.07	5.65
Median	1	3	1	4
Min	1	1	1	1
Max	160	67	118	60
Firms per CN8-destination:				
Mean	2.22	3.95	1.97	3.77
Median	1	3	1	3
Min	1	2	1	2
Max	235	192	113	76

Notes: "Raw data on unit values and quantities is used dropping outliers at the 1% of the distribution. To be able to identify a variety-specific and a market-specific effect in the regressions, in the restricted sample a minimum number of two markets for each firm-CN8 product and a minimum of two firms for each country-CN8 market is imposed."

results of rank correlations are illustrated, followed by an example using Belgian chocolate exports. Afterwards, actual correlations are tested to check whether rank correlation results are confirmed. The analysis is further developed in the next section, where the verti-zontal model is tested with dummy regressions of price and quantities on variety, product and market dummies.

4.3.1 Definition of the subsamples

In what follows, a *variety* s is defined as a firm-CN8 combination, where CN8 is the most detailed product-level classification available. When the CN8 is used as product definition, the product-market is narrowly defined and each firm is associated with a different variety. While the definition of a variety does not change throughout the analysis, the definition of a product and the size of the product-market S_i is allowed to change.

When selecting a product-market, the level of product aggregation must be traded off against the number of varieties, which falls dramatically as the product-market narrows. For this reason, the analysis is repeated for the four levels of aggregation, the CN8, CN6, CN4 and CN2. In a more aggregated product classification, a *product* will then be defined as a collection of varieties (firm-CN8) sharing the same CN code. More broadly defined product-markets will have a higher number of varieties, but the varieties included will be poorer substitutes and, therefore, the assumption of symmetry in substitutability becomes more stringent.⁴

Product and market selections are performed separately. Their combination then determines the product-market samples on which price and quantity comparisons will be conducted in the ensuing analysis.

Product selection. For each level of product aggregation, only products which are sold in a sufficiently large number of varieties and markets can be considered in order to ensure that there are enough varieties in enough markets to be compared. To this end, only the five products supplied in the highest number of varieties are considered, for each level of aggregation. The products yielding the highest number of varieties are listed in Table 4.12 with corresponding CN codes and descriptions.

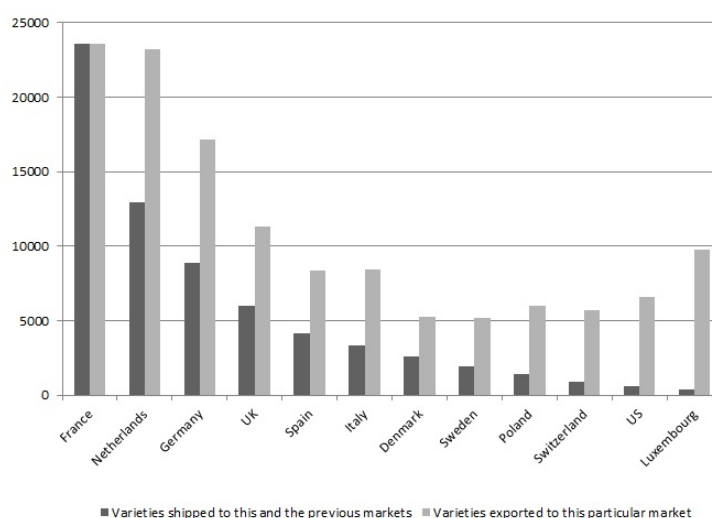
Market selection. Since the analysis focuses on price and quantity variations across destination markets, another trade-off involves the number of countries to consider. Since the focus is on price and quantity differences across markets, a sufficient number of markets has to be selected. However, a sufficient number of varieties should be simultaneously sold in all the markets for the ranking comparison to be meaningful. The trade-off arises because the number of varieties simultaneously present in all markets drops significantly with each additional destination market. Since there is no clear-cut rule to settle this issue, a data driven approach is followed. First, the sample of possible destinations is restricted to the countries importing the highest number of Belgian varieties (firm-products), resulting in a threshold to at least 5,000 varieties. This results in 12

⁴The verti-zontal model assumes that product-markets are characterized by the same pattern of substitutability, γ . Note that constant patterns of substitutability between varieties within a product category, or even the entire economy, is the standard assumption virtually all empirical trade models, be they based on CES or linear quadratic utility functions.

destination markets, which are listed in Table 4.13. Next, all the possible market combinations are considered in order to find how many varieties are exported simultaneously to $N = 2, 3, \dots, 12$ countries and, for each value of N the *best N-market combination* is identified in terms of the number of varieties observed. In the first column of Table 4.13, the number of varieties shipped to each of these 12 markets is reported. The second column gives the total number of varieties sold simultaneously in each best N-market combination, which is obtained by adding the corresponding country to all the countries listed in the previous rows.⁵ Thus, for example, at the bottom of the second column can be seen the number of varieties present in all markets, which is close to 400.

Product-market samples. The intersection of all the best N-market combinations with the 20 products (i.e., five products for each of the four levels of aggregation) leads to 220 potential data samples. Since some samples are very small, having just 2 or 3 varieties, a further restriction is imposed: in order to permit a meaningful rank correlation analysis between markets, only samples with more than 10 varieties are considered. This results in 171 samples. Across these samples, Table 4.14 provides the effective number of varieties used in the analysis for each level of aggregation (rows) and each best N-country combination (columns).

Figure 4.6: Graphic illustration of Table 4.13.



Note: Light gray bars represent varieties shipped from Belgium to the destination market on the horizontal axis. The dark gray bars represent the number of varieties shipped simultaneously to the specific destination market on the horizontal and to all the destination markets to its left, which correspond always with the best N-country combination.

⁵As it turns out, the best N-market combinations happen to be always a sub-group of the (N+1)-market combinations, so that they can be displayed in this order.

Table 4.12: Product codes considered for each level of product disaggregation.

“Top 5” Combined Nomenclature product codes							
<i>CN2</i>	Short description	<i>CN4</i>	Short description	<i>CN6</i>	Short description	<i>CN8</i>	Short description
84	Machinery and mechanical appliances	1806	Chocolate and food preparations with cocoa	180690	Chocolate products	39269099	Other articles of plastics
39	Plastics and articles thereof	3926	Other articles of plastics not containing cocoa	170490	Sugar confectionery	18069019	Chocolate palines not containing alcohol
85	Electrical machinery and equipment	0710	Frozen vegetables	220300	Beer (malt)	21069098	Food preparations
73	Articles of iron or steel	9403	Furniture and parts thereof	210690	Food preparations	57033019	Polypropylene carpets and floor coverings
90	Optical, measuring, precision, medical, surgical instruments	4911	Printed matter, including printed pictures and photographs	071080	Frozen vegetables	22030001	Bottled beer made from malt

Table 4.13: Varieties by destination markets and destination-market combinations.

Markets	Varieties exported to this particular destination market	Varieties shipped to this market and all the previous
France	24,612	24,612
Netherlands	24,183	13,608
Germany	17,911	9,347
UK	11,956	6,367
Spain	8,799	4,419
Italy	8,869	3,572
Denmark	5,540	2,519
Sweden	5,530	2,047
Poland	6,227	1,498
Switzerland	5,732	966
U.S.	6,592	649
Luxembourg	10,317	393

Note: In the first column is reported the number of varieties exported to each destination market. In the second column only varieties that are present simultaneously also in all the destination markets listed in the previous rows are counted.

Table 4.14: Varieties considered in each intersection of best N-market combination and level of product disaggregation.

Number of varieties considered	Best N-country combinations										
	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9	N=10	N=11	N=12
<i>top 5</i> CN8	275	221	174	139	117	93	66	24	15	12	11
<i>top 5</i> CN6	333	263	215	174	130	100	72	10	0	0	0
<i>top 5</i> CN4	818	604	464	339	250	174	134	83	41	24	22
<i>top 5</i> CN2	3674	2591	1835	1352	1123	811	698	535	358	259	135
Entire Manufacturing (weight)	12981	8908	6040	4166	3361	2362	1908	1407	893	599	355
Entire Manufacturing (units)	2831	1913	1306	879	701	502	412	311	212	146	81

Note: Each intersection is composed of 5 samples at most, but there could be less, as samples are considered valid for the analysis when they are composed of at least 10 varieties. On the last two rows, all the varieties are reported for which quantities are reported shipped in Kilograms (weight) or other units of measure (units).

4.3.2 Looking at prices and quantities in subsamples: rank correlations

First of all, rank correlations of prices and quantities within and across markets are analyzed. The use of rank correlations allows for the identification of general features of the data, even in the context of non-linear or non-additive demand functions. Put differently, by considering rank correlations a less strict interpretation of the theory is imposed, valid for a wider set of functional forms.

Price-quantity ranking correlations within markets. Similarly to what has been shown on the European car dataset, it is first verified whether rankings of prices and quantities within the same market are significantly correlated. In a model where only quality or only cost efficiency matters, they should be. If at least both elements are at play, then the relationship should be generally weak or insignificant, with the exception of sectors in which there is not much scope for quality or productive differences. Spearman and a Kendall rank correlations are calculated on the samples resulting from the market and product selection.⁶ Results are given in Table 4.15, reported by product-market aggregation and number of countries included in the analysis. In particular it is shown how many times the price-quantity correlation within markets is not significantly different from 0 at a 5% level of confidence.

Interestingly, results vary a lot depending on the level of aggregation and N-market combination selected. Overall, for the entire sample, the data reject a significant correlation of prices and quantities within markets in about 1/3 of the times. Evaluated in the narrowest product definition, the CN8 level, the rejection rate of a significant correlation is much higher and lies between 76% and 78% of the cases, depending on the statistic used. These results seem to confirm the notion that any theory should at least involve two sources of heterogeneity to explain the pattern of prices and quantities observed in the data. This is most evident in narrowly defined product-markets.

Turning to statistics for quantity rank correlations and price rank correlations across markets, results are reported in Table 4.16 in a similar format as in table 4.15. It can be noted that quantity rank correlations between markets are quite often not significantly different from 0, at a 5% level. At the narrowest product-level which is the CN8, the quantity correlations are not significantly different from zero in about 60% of the cases. In table 4.17, the corresponding results are shown for price rankings between markets. It is striking how lower the rejection rates are for prices as compared to quantities. The Spearman rank statistic, considers prices to be significantly correlated in 98% of cases, while the corresponding value for the Kendall Tau statistic is about 97%. Put differently, both measures of rank correlations estimate price correlations not to be correlated in only 2 to 3% of the cases.

⁶The difference between these two approaches to rank correlation is that, whereas the Spearman rank correlation transforms actual values into their relative rank and then compute a standard correlation, the Kendall tau rank correlation measures the frequency of concordant pairs, i.e. observations whose rank coincides.

Table 4.15: Rejection rates for within-market rank correlations.

Spearman and Kendall Tau rank correlation: Rejection of significance for price-quantity correlations within markets													
All samples	Spearman	35.3%											
	Kendall	37.6%											
	Samples	(171)											
By level of product aggregation:	Spearman	CN8		CN6		CN4		CN2					
		76.3%		25.7%		48.9%		1.8%					
		78.9%		34.3%		48.9%		1.8%					
	Samples	(38)		(35)		(45)		(53)					
By best N-market combinations:	Spearman	12 Mkts	11 Mkts	10 Mkts	9 Mkts	8 Mkts	7 Mkts	6 Mkts	5 Mkts	4 Mkts	3 Mkts	2 Mkts	
		50.0%	37.5%	44.4%	54.5%	47.1%	55.0%	40.0%	35.0%	25.0%	15.0%	15.0%	
	Kendall	50.0%	37.5%	44.4%	54.5%	52.9%	60.0%	40.0%	35.0%	30.0%	20.0%	15.0%	
	Samples	(6)	(8)	(9)	(11)	(17)	(20)	(20)	(20)	(20)	(20)	(20)	

Note: Percentages of samples not significantly correlated at a 5% level are reported by product aggregation and market combination. The number of samples considered is reported in brackets. For example, looking at Spearman rank correlations at a CN8 level of product aggregation, 76.3% of the 38 samples considered are not significantly different from 0.

Table 4.16: Rejection rates for between-market quantity rank correlations.

NAZING VARIABILITY IN MARKET												
<i>Spearman</i> and <i>Kendall Tau</i> rank correlation: Rejection of significance for <i>quantity correlations between markets</i>												
All samples	Spearman	19.1%										
	Kendall	19.7%										
	Samples	(171)										
By level of product aggregation:	Spearman Kendall	CN8		CN6		CN4		CN2				
		60.5%		8.6%		15.6%		0.0%				
		60.5%		11.4%		15.6%		0.0%				
	Samples	(38)		(35)		(45)		(53)				
By best N-market combinations:	Spearman Kendall	12 Mkts	11 Mkts	10 Mkts	9 Mkts	8 Mkts	7 Mkts	6 Mkts	5 Mkts	4 Mkts	3 Mkts	2 Mkts
		50.0%	37.5%	22.2%	18.2%	29.4%	25.0%	20.0%	15.0%	15.0%	10.0%	5.0%
	Samples	50.0%	37.5%	22.2%	18.2%	29.4%	30.0%	20.0%	15.0%	15.0%	10.0%	5.0%
	Samples	(6)	(8)	(9)	(11)	(17)	(20)	(20)	(20)	(20)	(20)	(20)

Note: Percentages of samples not significantly correlated at a 5% level are reported by product aggregation and market combination. The number of samples considered is reported in brackets. For example, looking at both Spearman and Kendall rank correlations at a CN8 level of product aggregation, 60.5% of the 38 samples considered are not significantly different from 0.

Table 4.17: Rejection rates for between-market price rank correlations.

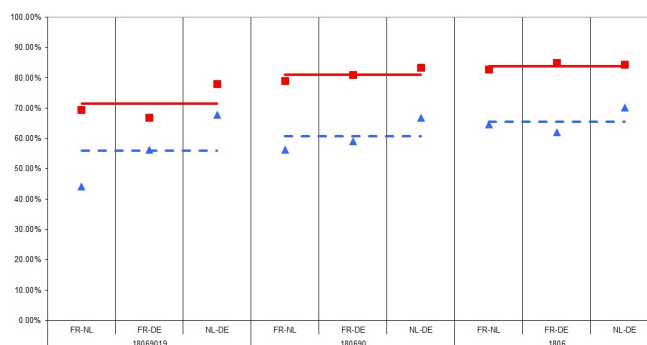
Spearman and Kendall Tau rank correlation: Rejection of significance for <i>price correlations between markets</i>												
All samples	Spearman	2.9%										
	Kendall	3.5%										
	Samples	(171)										
By level of product aggregation:	Spearman	CN8		CN6		CN4		CN2				
		5.3%		2.9%		4.4%		0.0%				
		10.5%		2.9%		2.2%		0.0%				
	Samples	(38)		(35)		(45)		(53)				
By best N-market combinations:	Spearman	12 Mkts	11 Mkts	10 Mkts	9 Mkts	8 Mkts	7 Mkts	6 Mkts	5 Mkts	4 Mkts	3 Mkts	2 Mkts
		0.0%	0.0%	11.1%	18.2%	11.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Kendall	0.0%	0.0%	0.0%	18.2%	11.8%	5.0%	0.0%	0.0%	0.0%	5.0%	0.0%
	Samples	(6)	(8)	(9)	(11)	(17)	(20)	(20)	(20)	(20)	(20)	(20)

Note: Percentages of samples not significantly correlated at a 5% level are reported by product aggregation and market combination. The number of samples considered is reported in brackets. For example, looking at Spearman rank correlations at a CN8 level of product aggregation, 5.3% of the 38 samples considered are not significantly different from 0.

Price and quantity rank correlations across markets. The results on rank correlations across markets can be used to judge whether models with only two sources of heterogeneity (normally cost and quality) can perform as well as the vertical model in describing the data. In fact, if rank correlations are systematically lower for quantities than for prices, then cost and quality variability alone are not sufficient to explain the data patterns. The introduction of a third source of variability affecting quantities but not prices would be necessary in that case.

An illustrative example: chocolate products. To illustrate how ranks are compared across markets, an example follows on a product frequently exported from Belgium and included in the data: chocolates. At the CN8 level, Belgian chocolates fall under the category "Chocolate products not containing alcohol". For the sake of illustration, results are shown based on the combination of 3 markets yielding the highest overlap of exported varieties: Germany, France and the Netherlands, resulting in 34 different varieties exported. The values of the pairwise ranking correlations are provided in the top panel of Table 4.18 and visualized in Figure 4.7. It can be noted that price rank correlations ($corr(pp)$) are systematically higher than quantity rank correlations ($corr(qq)$) which suggests that the relative price ranking across the three destination markets is more regular than the quantity ranking. This is true not only for the average correlations across country pairs, but for any country pair correlation, even when CN6 and CN4 definitions of chocolate products are used, which are reported in the middle and bottom panel of Table 4.18 respectively. The visual representation of ranks provided for the car market in Figures 2.2 and 2.3 can be repeated for the chocolates markets. In Figure 4.8 is shown the scatterplot of price against quantity rankings within the three destination markets and in Figure 4.9 the scatterplot of price rankings between markets to the left and quantity rankings to the right. These scatterplots recall what has already been seen for the European car market in Chapter 2.

Figure 4.7: Visual representation of the results reported in Table 4.18.



Note: Square dots indicate bilateral price rank correlations, triangle dots indicate quantity correlations for chocolate products at CN8, CN6 and CN4 level of product aggregation. The horizontal line segments refer to average rank correlations across the three country pairs: the solid one refers to prices, the dashed one to quantities.

Table 4.18: Spearman rank correlations for chocolate products.

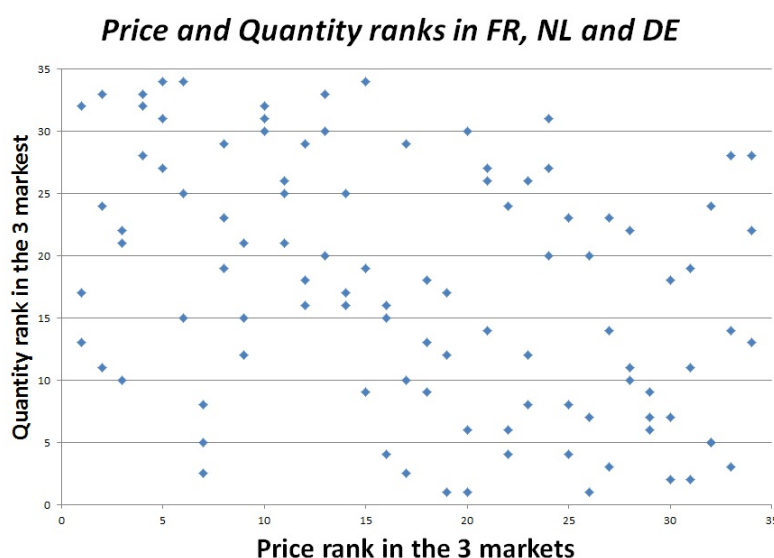
CN8 - 18069019 (Best 3 markets)	Chocolate products not containing alcohol			
	(1)	(2)	(3)	(4)
Market pairs	Average	FR-NL	FR-DE	NL-DE
Rank Corr(pp)	71.35%	69.38%	66.81%	77.85%
Rank Corr(qq)	56.01%	44.17%	56.17%	67.70%
Varieties	34	34	34	34

CN6 - 180690 (Best 3 markets)	Chocolate products			
	(1)	(2)	(3)	(4)
Market pairs	Average	FR-NL	FR-DE	NL-DE
Rank Corr(pp)	80.99%	78.79%	80.85%	83.32%
Rank Corr(qq)	60.67%	56.25%	59.09%	66.67%
Varieties	94	94	94	94

CN4 - 1806 (Best 3 markets)	Chocolate and other food preparations containing cocoa			
	(1)	(2)	(3)	(4)
Market pairs	Average	FR-NL	FR-DE	NL-DE
Rank Corr(pp)	83.84%	82.56%	84.77%	84.18%
Rank Corr(qq)	65.52%	64.47%	61.95%	70.15%
Varieties	150	150	150	150

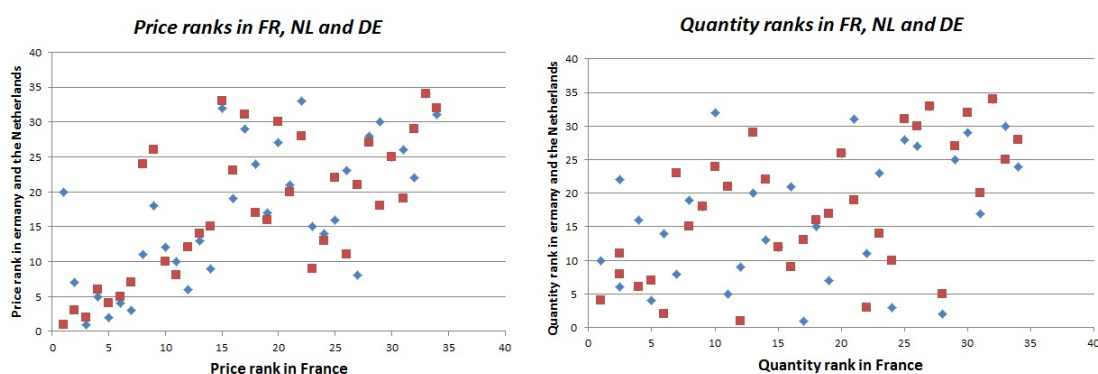
Note: Spearman rank correlations for prices and quantities between markets are reported for the product codes involving chocolate present in the “top 5” product list, considering the “best 3 destination markets” .

Figure 4.8: Price-quantity rankings within markets, Belgian chocolates markets



Note: Scatterplot of price against quantity rankings for varieties of the product "Chocolates not containing alcohol" (CN8 18069019) within each of the three main destination markets: France, Netherlands and Germany.

Figure 4.9: Price rankings across markets, Belgian chocolates markets



Note: To the left, a scatterplot of price rankings in the Netherlands and Germany against price rankings in France for varieties of the product "Chocolates not containing alcohol" (CN8 18069019) is shown. To the right, the same scatterplot is drawn for quantity rankings.

The general case. While the chocolate example reported the correlation coefficients for 3 chocolate-related samples, the same analysis can be repeated for the remaining 168 samples in the data and, for robustness, for the whole manufacturing. In order to give the reader a sense of the pattern that emerges from all the pairwise correlations considered, averages are reported.⁷ So for reporting purposes the pairwise coefficients arising from comparing rankings in any two destination markets are averaged at the sample level and then these sample coefficients are further averaged by the level of product-aggregation and market-combination. When turning to the whole manufacturing, on the other hand, all the varieties are considered together and, thus, there is only one correlation coefficient.

Tables 4.19 and 4.20 report average Spearman and Kendall correlation coefficients and show that *average price rank correlations between markets are systematically higher than average quantity rank correlations*. This holds irrespective of the number of varieties included (column dimension) and the number of markets considered (row dimension). The difference is of about 15 percentage points and relatively similar across the samples.

As a robustness check, the same rank correlation analysis can be repeated considering the entire manufacturing sector in the different country combinations. Table 4.21 shows that when doing so previous results are even stronger, i.e. high price correlation but low quantity correlation between markets.

As noted before, these results do not appear consistent with a combination of two most commonly adopted sources of heterogeneity, be they both variety- or market-variety specific. Price correlations between markets are high, suggesting that quality and/or productive efficiency are intrinsic and not market-specific. Yet, quantity correlations are lower, indicating that an additional source of heterogeneity must be envisaged at a market-variety level.

The coefficients reported in Table 4.19 are averaged by best N-market combinations and level of disaggregation and plotted in Figure 4.10. The simple average by product is instead shown in Figure 4.11. The square dots show average price rank correlations for the considered samples, while triangle dots show quantity rank correlations. In the two graphs, these averages are additionally averaged by level of product disaggregation (CN2, CN4, CN6 and CN8), which is represented through the solid line for prices and the dashed line for quantities. It can be observed that price correlations consistently lie well above quantity correlations, especially at narrowest levels of product definitions.

These results support the idea that a third source of heterogeneity needs to be taken into account when dealing with micro-level trade data. Ideally, this third source should affect only quantities sold in different markets, or at least should affect quantities to a larger extent than prices. A nice feature of the verti-zontal model of monopolistic competition is that it manages to reconcile all these needs at once, through the interaction of standard weak interactions, typical of this kind of model, with vertical and horizontal dimensions of differentiation.

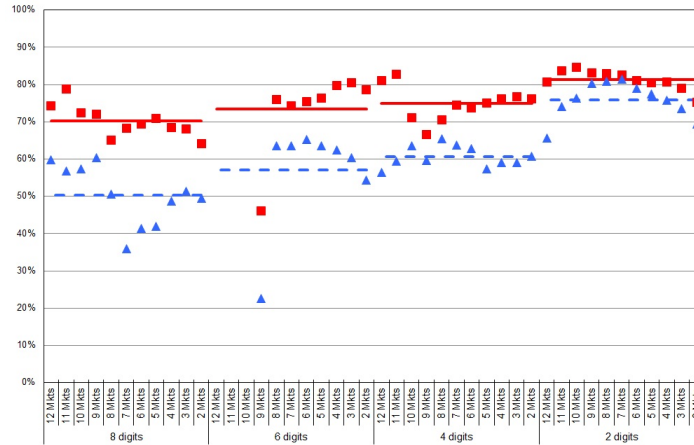
⁷When 3 markets are considered, for example, 3 pairwise market correlations for prices and 3 for quantities are obtained; when 4 markets are considered, the coefficients are 6, and so on up to 12 markets, at which point 66 bilateral correlations are obtained.

Table 4.19: Between-market Spearman price and quantity rank correlations.

Spearman Rank correlations		Average of averages	CN8	CN6	CN4	CN2
			(Average of Top 5)	(Average of Top 5)	(Average of Top 5)	(Average of Top 5)
		(1)	(2)	(3)	(4)	(5)
Average of Averages	p	75.29%	70.17%	73.36%	74.90%	81.25%
	q	61.38%	50.36%	56.99%	60.66%	75.79%
2-market combination	p	73.55%	64.16%	78.67%	76.14%	75.24%
	q	58.51%	49.38%	54.43%	60.83%	69.42%
3-market combination	p	76.05%	68.00%	80.48%	76.69%	79.00%
	q	61.13%	51.43%	60.37%	59.13%	73.59%
4-market combination	p	76.25%	68.52%	79.68%	76.10%	80.70%
	q	61.49%	48.71%	62.40%	59.09%	75.77%
5-market combination	p	75.71%	70.96%	76.41%	75.09%	80.40%
	q	60.09%	41.99%	63.64%	57.32%	77.41%
6-market combination	p	74.93%	69.45%	75.50%	73.71%	81.05%
	q	62.12%	41.45%	65.28%	62.72%	79.02%
7-market combination	p	74.85%	68.25%	74.22%	74.46%	82.46%
	q	61.19%	36.00%	63.62%	63.83%	81.33%
8-market combination	p	73.56%	65.02%	75.91%	70.46%	82.86%
	q	65.13%	50.61%	63.64%	65.43%	80.83%
9-market combination	p	66.92%	72.10%	45.99%	66.50%	83.09%
	q	55.69%	60.42%	22.53%	59.58%	80.22%
10-market combination	p	76.01%	72.36%		71.03%	84.64%
	q	65.76%	57.43%		63.56%	76.28%
11-market combination	p	81.71%	78.73%		82.76%	83.63%
	q	63.45%	56.81%		59.38%	74.17%
12-market combination	p	78.68%	74.37%		80.96%	80.69%
	q	60.59%	59.72%		56.43%	65.61%

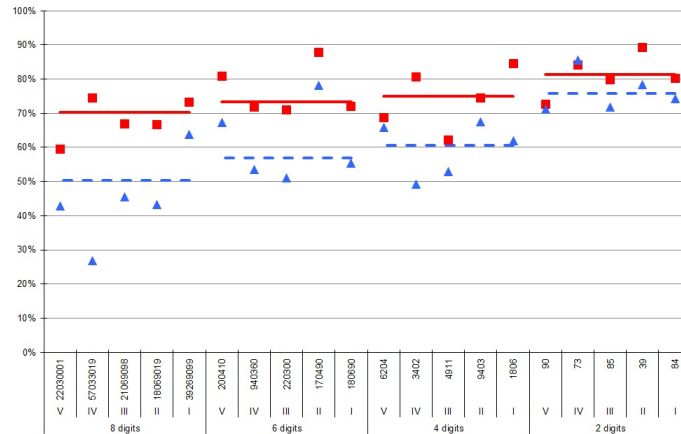
Note: Between-market Spearman price and quantity rank correlations are reported for the varieties present in Table 4.14. Coefficients are averaged across the number of samples present per intersection of best N-market combination and product disaggregation.

Figure 4.10: Visual representation of the results reported in Table 4.19, by number of markets.



Note: Square dots indicate average price rank correlations by best N-market combination across product codes, triangle dots indicate the same for quantity rank correlations. The horizontal line segments refer to average rank correlations across best N-market combinations by level of product disaggregation: the solid one refers to prices, the dashed one to quantities.

Figure 4.11: Visual representation of the results reported in Table 4.19, by product codes.



Note: Square dots indicate average price rank correlations by product code across best N-market combinations, triangle dots indicate the same for quantity rank correlations. The horizontal line segments refer to average rank correlations across product codes by level of product disaggregation: the solid one refers to prices, the dashed one to quantities.

Table 4.20: Between-market Kendall price and quantity rank correlations.

Kendall Rank correlations		Average of averages	CN8	CN6	CN4	CN2
			(Average of Top 5)	(Average of Top 5)	(Average of Top 5)	(Average of Top 5)
		(1)	(2)	(3)	(4)	(5)
Average of Averages	p	59.38%	54.51%	58.09%	59.30%	65.60%
	q	46.05%	37.92%	42.40%	45.45%	58.44%
2-market combination	p	57.27%	49.65%	61.65%	59.09%	58.68%
	q	42.51%	35.39%	39.25%	43.68%	51.72%
3-market combination	p	59.48%	51.83%	63.42%	60.04%	62.61%
	q	44.91%	36.80%	44.22%	43.07%	55.56%
4-market combination	p	59.97%	52.57%	63.30%	59.58%	64.42%
	q	45.57%	35.45%	46.17%	42.80%	57.85%
5-market combination	p	59.74%	55.15%	60.45%	59.01%	64.37%
	q	44.85%	30.93%	47.20%	41.96%	59.32%
6-market combination	p	59.23%	54.01%	59.88%	58.10%	64.92%
	q	46.92%	31.16%	49.19%	46.38%	60.96%
7-market combination	p	59.40%	53.03%	59.15%	59.05%	66.38%
	q	46.86%	27.32%	48.14%	48.24%	63.74%
8-market combination	p	58.51%	50.86%	60.82%	55.15%	67.20%
	q	50.09%	38.85%	48.75%	49.35%	63.40%
9-market combination	p	52.88%	55.35%	36.05%	52.25%	67.85%
	q	42.33%	45.27%	16.30%	44.88%	62.88%
10-market combination	p	60.60%	55.64%		56.14%	70.01%
	q	51.30%	44.44%		49.80%	59.66%
11-market combination	p	66.40%	62.31%		67.48%	69.40%
	q	49.50%	44.46%		46.00%	58.04%
12-market combination	p	63.80%	59.17%		66.45%	65.78%
	q	46.87%	47.05%		43.83%	49.72%

Note: Between-market Kendall price and quantity rank correlations are reported for the varieties present in Table 4.14. Coefficients are averaged across the number of samples present per intersection of best N-market combination and product disaggregation.

Table 4.21: Between-market price and quantity correlations, whole manufacturing.

Rank correlations		Volumes expressed in Units		Volumes expressed in Weight	
		<i>Spearman</i>	<i>Kendall</i>	<i>Spearman</i>	<i>Kendall</i>
		(1)	(2)	(3)	(4)
Average of Averages	Price	95.65%	84.85%	92.93%	79.56%
	Quantity	77.66%	59.29%	79.50%	60.91%
2-market combination	Price	95.10%	83.98%	91.46%	77.43%
	Quantity	75.64%	56.71%	74.62%	55.73%
3-market combination	Price	95.49%	84.83%	92.40%	78.93%
	Quantity	76.78%	58.09%	77.29%	58.53%
4-market combination	Price	95.64%	85.19%	93.17%	79.81%
	Quantity	78.11%	59.46%	78.38%	59.68%
5-market combination	Price	95.86%	85.66%	93.45%	80.26%
	Quantity	79.41%	60.75%	80.05%	61.37%
6-market combination	Price	96.14%	85.89%	93.46%	80.43%
	Quantity	78.86%	60.58%	81.39%	62.86%
7-market combination	Price	96.12%	85.85%	93.32%	80.21%
	Quantity	78.62%	60.33%	82.07%	63.63%
8-market combination	Price	95.91%	85.22%	93.16%	80.03%
	Quantity	77.91%	59.59%	82.41%	63.95%
9-market combination	Price	95.87%	84.97%	93.21%	80.04%
	Quantity	76.38%	58.05%	82.33%	63.73%
10-market combination	Price	95.67%	84.73%	93.95%	81.13%
	Quantity	76.80%	58.85%	80.65%	62.01%
11-market combination	Price	95.60%	84.17%	92.34%	78.71%
	Quantity	77.42%	59.28%	77.97%	59.51%
12-market combination	Price	94.71%	82.91%	92.32%	78.17%
	Quantity	78.32%	60.50%	77.38%	58.97%

Note: Between-market Kendall and Spearman price and quantity rank correlations are reported for the whole manufacturing in each best N-market combination. Correlations are computed separately for varieties whose quantities are reported in weigh and varieties whose quantities are reported in units.

4.3.3 Simple correlations on subsamples

A general feature of quadratic utility functions is that they generate extremely tractable demand functions. Whereas this represents a clear advantage in terms of theoretical developments, it may pose some problems when confronted with real data, as it imposes a linear demand on the data. A legitimate concern may then arise on how restrictive this assumption is.

This issue is explored more in detail in the following Section with dummy regressions, but a preliminary answer can be obtained by repeating the rank correlation analysis looking at simple correlations instead of rankings. If simple correlations on prices and quantities are found to be similar to rank correlations, this suggests that the assumption of linear demand is not very restrictive. To see this, consider the case where demand is non-linear. If the rankings of prices show a strong positive correlation, this may just imply that prices are monotonic (not necessary linear) in quality, marginal costs of production and local market characteristics. But when the absolute value of prices shows a similar positive correlation, it must be the case that a linear structure is a good approximation and that local market effects are shifting the demand for all the varieties in a parallel way.

In Table 4.22 correlation coefficients are shown for actual prices and quantities across markets, which can be usefully compared to the results in Table 4.19 where Spearman rank correlations have been displayed.

The average difference between price and quantity correlations across destination markets when using actual values (column 1) is surprisingly similar to the rank correlations, ranging from 15% to more than 25% depending on the sample considered. Correlations lose however, some of their strength due to the possible presence of outliers, different transport costs across markets and any other possible measurement error whose importance was reduced through the use of rankings. This is shown in Figure 4.12 and 4.13, which have mirror Figures 4.10 and 4.11, when actual values are considered instead of rankings. Again it can be noted that average price correlations (square dots) are much higher than average quantity correlations (triangle dots) independent of the product aggregation and independent of the number of destination markets that are included in the sample.

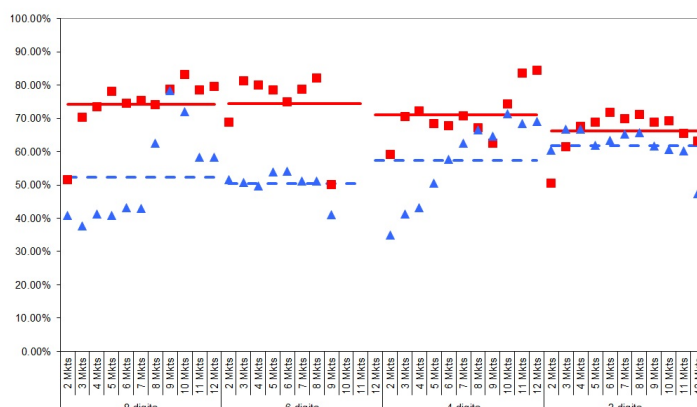
These results suggest that prices across markets depend on some variety-specific characteristics which have a similar impact across markets, while quantities sold appear to be affected by *something else*. In the vertical model, this *something else* is captured by market-variety specific differences in the liking by consumers of a set of product characteristics. It is also worth noting that if destination market-specific factors, such as institutions or market size, affected Belgian exports in a similar fashion, this would not affect correlation coefficients within a product category. This point is further developed in the next step of the exploratory analysis, where it is shown that variety- and market-dummies capture the variability of prices across markets much better than for quantities.

Table 4.22: Between-market price and quantity correlations.

Between-market correlations		Average of averages	CN8	CN6	CN4	CN2
			(Average of Top 5)	(Average of Top 5)	(Average of Top 5)	(Average of Top 5)
		(1)	(2)	(3)	(4)	(5)
Average of Averages	p	71.55%	74.31%	74.36%	70.98%	66.20%
	q	56.35%	52.39%	50.43%	57.32%	61.87%
2-market combination	p	57.56%	51.58%	68.90%	59.22%	50.55%
	q	46.94%	40.78%	51.49%	34.97%	60.51%
3-market combination	p	70.88%	70.31%	81.28%	70.48%	61.47%
	q	49.19%	37.76%	50.82%	41.36%	66.83%
4-market combination	p	73.34%	73.49%	80.13%	72.15%	67.59%
	q	50.22%	41.21%	49.78%	43.06%	66.81%
5-market combination	p	73.51%	78.03%	78.59%	68.53%	68.89%
	q	51.80%	40.85%	53.94%	50.52%	61.91%
6-market combination	p	72.26%	74.60%	74.88%	67.80%	71.75%
	q	54.61%	43.06%	54.19%	57.77%	63.40%
7-market combination	p	73.72%	75.32%	78.78%	70.81%	69.97%
	q	55.52%	42.97%	51.12%	62.62%	65.36%
8-market combination	p	73.63%	74.15%	82.19%	67.09%	71.09%
	q	61.52%	62.62%	51.13%	66.64%	65.68%
9-market combination	p	65.06%	78.74%	50.15%	62.47%	68.89%
	q	61.42%	78.32%	41.01%	64.56%	61.78%
10-market combination	p	75.52%	83.09%		74.30%	69.18%
	q	68.08%	72.10%		71.45%	60.70%
11-market combination	p	75.90%	78.52%		83.61%	65.57%
	q	62.34%	58.32%		68.40%	60.30%
12-market combination	p	75.71%	79.57%		84.38%	63.20%
	q	58.26%	58.34%		69.12%	47.33%

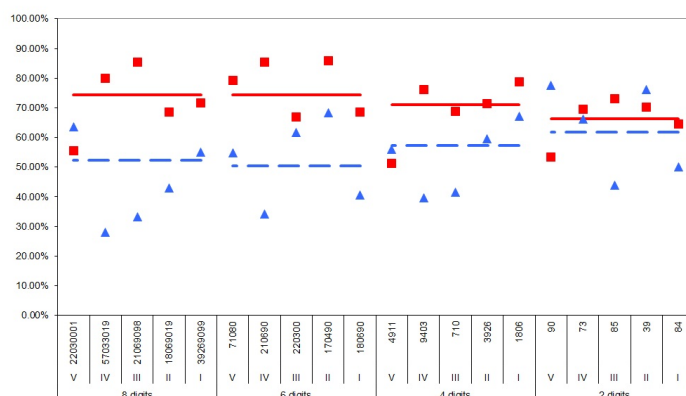
Note: Between-market price and quantity correlations are reported for the varieties present in Table 4.14. Coefficients are averaged across the number of samples present per intersection of best N-market combination and product disaggregation.

Figure 4.12: Visual representation of the results reported in Table 4.22, by number of markets.



Note: Square dots indicate average actual price correlations by best N-market combination across product codes, triangle dots indicate the same for quantity correlations. The horizontal line segments refer to average correlations across best N-market combinations by level of product disaggregation: the solid one refers to prices, the dashed one to quantities.

Figure 4.13: Visual representation of the results reported in Table 4.22, by product codes.



Note: Square dots indicate average actual price correlations by product code across best N-market combinations, triangle dots indicate the same for quantity correlations. The horizontal line segments refer to average correlations across product codes by level of product disaggregation: the solid one refers to prices, the dashed one to quantities.

4.4 Testing the verti-zontal model on Belgian export data

After having shown some systematic patterns in the different subsamples, the focus is now shifted towards a more formal test of the verti-zontal model against alternative models. To this end, the regression analysis performed on the subsamples is further refined and applied to the entire sample of Belgian exporters. However, since it is still necessary to have some variability across markets and varieties, the analysis is based on the restricted sample shown in Table 4.11, even if results are robust to the inclusion of the entire sample (the only difference is that the results on the variability captured by the dummy regressions are biased upwards by the presence of many dummies being associated with single data points).

In this Section, the following two propositions stemming from the verti-zontal model as presented in the previous chapter are directly tested:

Proposition I: Equilibrium export prices depend on variety-specific cost and quality and on the market-specific degree of competitiveness. Market effects, which can be captured by taste-weighted price, quality and cost indices as well as by the effective mass of competitors, vary with the destination country, but are common to all varieties exported there. Thus, export prices of the same variety across countries only vary through market-specific effects. This can be seen from equation (3.54):

$$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \mathcal{T}_i \left(\frac{\tilde{a}_i - \tilde{c}_i}{2} \right);$$

Proposition II: Equilibrium export quantities (sales) depend on market-specific and variety-specific tastes. Thus, export quantities of the same variety across countries shows additional variability, as compared to prices, because of idiosyncratic tastes. Based on the these propositions, one would expect the combination of variety characteristics and country characteristics to be important and to give a high goodness-of-fit for prices, but a much lower goodness-of-fit for quantities (sales). This is what is explored in the next section. This can be seen from equation (3.57).

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} \left[\frac{\alpha_s - c_{s,i}}{2} - \mathcal{T}_i \frac{\bar{\alpha}_i - \bar{c}_i}{2} \right].$$

It should be remarked that the analysis is based on exports from one country, Belgium, to other countries, so if transport costs vary by country or by country-product, identifying the destination market (country or country-product) by i , it can be written that $t_{s,i} = t_i$, and thus in the analysis are simply captured by destination dummies. this can be seen by rewriting equation (3.54) including transport costs,

$$p_{s,i}^* = \frac{\alpha_s + c_{s,i}}{2} - \left(\mathcal{T}_i \frac{\tilde{a}_i - \tilde{c}_i}{2} - \frac{t_i}{2} \right). \quad (4.1)$$

Similary, equation (3.57) turns into

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} \left[\frac{\alpha_s - c_s}{2} - \left(\mathcal{T}_i \frac{\bar{\alpha}_i - \bar{c}_i}{2} + \frac{t_i}{2} \right) \right]. \quad (4.2)$$

4.4.1 Goodness-of-fit test

Equations (3.54) and (3.57) show that equilibrium prices and quantities consist of a first term, which is determined by firm-product level cost (c) and quality (α), and a second term, which depends on destination country specific variables (indexed by i). Thus, variety-specific variation (cost and quality) can be captured empirically by firm-product fixed effects, and local competition effects in the destination can be captured by country-product fixed effects.

The following empirical specification where individual firm-product prices ($y_{s,i} = p_{s,i}$) and quantities ($y_{s,i} = q_{s,i}$) are regressed on on variety and destination dummies allows for an easy way to discriminate between the verti-zontal and the other models:

$$y_{s,i} = \delta_0 + \delta_1 Firm_Product_s + \delta_2 Country_Product_i + \epsilon_{s,i} \quad (4.3)$$

In the regressions alternatively price ($p_{s,i}$) and quantity ($q_{s,i}$) level data are used as dependent variables.

The equilibrium price equation (3.54) implies that firm-product quality and cost affect prices in a similar and linear way. So, even without identifying quality and without disentangling quality and cost, a simple OLS regression of export prices on firm-product dummies is expected to capture this variation and to explain an important part of the price data. Since cost and quality are variety-specific, firm-product dummies should account for that.

According to the verti-zontal model, the other determinants of export prices are all country effects indexed by i in (3.54). These country effects affect all varieties (firm-CN8) competing in the same country-product in the same way and also enter the price equation in a linear way. Since trade data holds information on destinations, country effects can be approximated through country-product dummies. Based on the theory, the joint inclusion of firm-product and country-product dummies is expected to yield a good fit in a regression on individual firm-product prices.

In the verti-zontal model, the same set of variables is expected to perform less well in explaining variation of quantities across countries. In addition to quality, taste differences between consumers also matter. This is expected to result in a very different fit between price and quantity regressions where quantities are expected to have a consistently lower R^2 .

The reason is that quantities are not just a function of firm-product cost and quality and country-level competition effects, but are also determined by idiosyncratic taste $\beta_{s,i}$ that makes the quantity equation (3.57) a non-linear one.

Prices and quantities are not log-linearized in (4.3), as for example Bastos and Silva (2010) or Hallak and Sivadasan (2013) do. That is because, by using the raw data for unit values and output, a stricter test is imposed to the model because the linearity of demand is one of the specific implications of the verti-zontal model and it is what distinguishes the price from the quantity regressions in (4.3). Furthermore, taking logs would have been useful if the focus had been on interpreting the specific regression coefficients, but

this is not the aim here. Instead the focus is on the value of the R^2 as a measure of the goodness-of-fit in the regressions

As shown in the regressions, the systematically lower R^2 for quantities than for prices in almost every product, industry and destination considered, is suggestive that quantities do not depend on the same fundamentals as prices. Based on the theory, taste heterogeneity can be considered to be the underlying reason.

Unfortunately, a formal test on the significance of differences in R^2 does not exist. Therefore, complementary to a goodness-of-fit test, also a correlation test is presented. Propositions I and II can also be formulated in terms of price and quantity correlations across countries. The advantage of using correlations is that a formal test statistic exist to test the prediction of weaker quantity the price correlations across countries. While the evidence is overwhelmingly in favor of the verti-zontal model, this should not be seen as conclusive evidence that "taste" is the only missing source of variation.

4.4.2 Predictions from the verti-zontal and other models

What is expected to be the goodness-of-fit of an empirical approximation of both the price and quantity equation in (4.3) estimated on cross-sectional data? And how do the predictions under verti-zontal preferences differ from other models?

First of all, consider the case of a standard CES model where productivity is the only source of heterogeneity, as in Melitz (2003). In such a model, prices are expected to differ between varieties but not for the same variety across countries. Under a standard CES, fob export prices are the same independently of the destination to which the products are shipped. Therefore, one would expect a variety-fixed effect, which accounts for cost heterogeneity across firms, to capture all the variation in prices.

This also applies to a CES model with consumer taste draws, as in Bernard et al. (2011). A CES model with taste draws by variety-country and a discrete choice model with a different taste distribution per destination country are closest to the verti-zontal model in rationalizing the stronger quantity variability that is found in empirical observations. However, they cannot explain the patterns of price and quantity variation described below. A CES model with taste draws would predict that export prices do not vary by destination country, while the data clearly shows they do. In a discrete choice model, a stronger taste for a product would also result in a higher price for that product, which would result in strong price volatility and would render the goodness-of-fit of (4.3) for prices as low as for quantities, which is not what is observed in the data.

Thus, based on a standard CES model (with or without taste draws), one would not expect additional variability in fob prices to come from country-fixed effects or, alternatively, from more narrowly defined country-product fixed effects.

For quantities, a standard CES model assigns a role to country effects, driven by income differences across countries. Country fixed effects would also explain some of the variation in quantities. Thus, in a CES model we would expect country dummies to raise the goodness-of-fit in the quantity regressions, but not in the price regression. In other words, a CES model would predict a higher goodness-of-fit for quantities, but this is not what is observed in the data.

In a CES model augmented with quality, as in Baldwin and Harrigan (2011), the variety-fixed effect would now account for both productivity and quality differences between firm-products. While with variety-FE it is not possible to separate cost from quality heterogeneity, it is possible to distinguish the type of quality differentiation that firms are making. If firms ship the same quality to all destination countries, then the variety-fixed effect would take up all the variation in prices. In such a world, adding country-fixed effects to the regression would yield no additional explanatory power for prices, while it would for quantities, as in the standard CES. But should firms ship a different quality of the same variety to different countries, this would correspond to a parallel demand shifter that varies by country. In such a model, one would expect this quality variation to be absorbed by country-fixed effects both for prices and quantities. Country-fixed effects in the quantity regression would additionally also absorb income differences between countries.

Thus, based on a CES model, irrespective of whether quality is intrinsic to a variety or depends on the destination country, one would not expect a lower goodness-of-fit of (4.3) in the quantity regression compared to the price regression. Thus, the prediction from a CES model is quite different from Proposition I derived from the verti-zontal model. The only exception would be represented by a quality-augmented CES with linear transport costs as discussed in Crozet et al. (2012) where, as shown by Martin (2010), profit-maximizing fob export prices do change with the level of transport costs (as opposed to iceberg transport costs, which do not affect prices). This means that the variety dummy would capture the part of variability induced by intrinsic product quality differences and the destination dummy would capture the market-specific variability induced by linear transport costs. On top of that, market characteristics in the importing country would increase variability in quantities, thus producing a pattern similar to the verti-zontal. In order to rule out this alternative explanation, at the end of the Chapter the role of distance is explicitly taken into account, showing that distance does have an impact on prices (as predicted also by the verti-zontal model), but its contribution in explaining overall price and quantity variability is insignificant, which would not be consistent with a model in which transport costs represent the only source of fob price variability across markets.

What about a standard quadratic utility, as in Melitz and Ottaviano (2008)? In such a model, both the equilibrium prices and quantities are a linear combination of a variety-specific effect and a country-effect. The variety effect captures heterogeneity in costs across firm-products, while a country-effect captures competition effects that vary by destination country. Based on a standard quadratic utility, price and quantity variation should both be equally well explained by a combination of variety-(firm-product) fixed effects and country-fixed effects. Thus, in contrast to the verti-zontal model, a standard quadratic utility would predict both price and quantity dummy regressions on variety and country fixed effects to give *an equally high* goodness-of-fit measured by the R^2 .

A quadratic utility model augmented with quality would give a similar prediction as a standard quadratic utility model. Quality acts as a parallel demand shifter between varieties and possibly even within varieties across countries. But this should not alter the

equality in goodness-of-fit between a price and a quantity dummy regression.⁸ Therefore, even in a quadratic utility model with quality differentiation, the expectation would continue to be of *an equally good fit* for price and quantity dummy regressions on variety and country fixed effects.

Thus, the verti-zonal model is the only model that predicts a systematically lower R^2 in quantity regressions than in price regressions when variety and destination effects are accounted for.

Under verti-zonal preferences, equilibrium quantities are determined by a non-linear combination of variety- and country-variety-specific variables. This non-linearity in output is driven by the presence of variety-country specific taste, which can be seen from (3.57). However, the equilibrium price equation is linear, with the taste parameter not entering directly, thus leaving all the variability to be explained by variety characteristics and country characteristics. Therefore, to capture the variation in firm-product-country prices (unit values) with a linear combination of variety-and country fixed effects is expected to yield a high goodness-of-fit in the price equation. In contrast, trying to fit a linear model on a combination of variables that are expected to behave in a non-linear way, as in the case of firm-product-country quantities, is expected to yield a much lower goodness-of-fit. This result is not affected by selection issues because variety characteristics are intrinsic to each variety in every destination market while country characteristics affect all the varieties present in a particular country in a symmetric way.⁹ A simple test where we approximate firm-product variation and country-product variation through a set of dummies for each provides an easy and direct way of discriminating between all the models discussed above.

Before discussing the results of the specification (4.3), first is considered the within data variation explained by firm, product and country-level effects alone. The highly disaggregate nature of the trade data at the 8-digit CN level allows for the examination of the heterogeneity of within-firm, within firm-product and within country-product unit values and output across countries and to compare results to earlier findings in the literature.

4.4.3 Results

Heterogeneity across firms, products and countries

In the dataset quantities are expressed in weight (kilograms) or alternatively in units (pairs, liters, and so on). The results for quantities expressed in units are less likely to be plagued by measurement error and as such they can be regarded as a robustness check. But first the results are discussed for products whose quantities are given in weights for

⁸In a standard quadratic utility, quantities are given by $(p - c)/\beta$, but since β is now a constant it should not affect the R^2 , so we would expect an equally good fit in the quantity regression as in the price regression.

⁹A selection model cannot be run, like a Heckman two-stage model, because the second stage does not allow for a meaningful measure of the goodness-of-fit which is the measure needed to compare the variability explained in the price and quantity regressions. But in the theory it is shown that the results do not depend on selection issues.

which many more observations are available. The results on the two samples are shown in Table 4.23.

In column 1 firm-fixed effects (FE) are included to see how much data variation in prices and quantities is explained by firm heterogeneity. Including firm-FE is equivalent to assuming that there is only one source of heterogeneity in the data and it works at the firm level, for example when cost and quality differences are small between products of the same firm but are significant between products of different firms. The results in column (1) do not confirm this assumption. The inclusion of firm-FE alone explains about a third (38%) of the variation in prices. This finding is comparable to Munch and Nguyen (2014) and others.¹⁰ But while previous studies looked at sales variation, we separate price from quantity variation. For quantities, firm-specific effects explain much less of the variation. Only 16% to 19% are explained depending on whether output is measured as "quantity per capita of the destination country" or "quantity per dollar of GDP of the destination country." The variation that firm-FE explain of simple quantities is 17% and lies between the other two output measures.

What about product-FE? In other words, how much of the variation in firm-product-country prices is driven by the type of product. Product-FE (columns 2 to 5) in the weight regressions, explain about 30% of price variability, but this varies substantially with the level of detail at which a product is defined. At the most disaggregate level (CN2-FE) of a product definition products explain 18% of price variation and about 4% of quantity variation. At the most detailed product definition (CN8-FE), products explain 40% of price variation and about 12 – 15% of quantity variation, depending on how quantities are reported.

Clearly, for a given product, export unit values exhibit substantial variation. But the remaining variability is large and either comes from different firm-level costs and quality or from different destination countries served by the firms selling the same product.

With country-product FE, the explained variability for quantities is substantially higher (columns 6 to 9). For weights (Table 2), at the most detailed product-level (country-CN8), 55% of export price variability and 32% to 48% of quantity variability are explained. The R^2 for price and quantities in general are closer together when country-product fixed effects are considered. This is not a surprise and is consistent with both the verti-zontal and CES models. In the verti-zontal model country-product dummies which capture destination country-effects affect both prices and quantities. But country-product effects, at least in part, also capture taste heterogeneity since taste varies across countries. Taste is inherently non-linear, therefore it is reasonable to expect the country-dummies, which are parallel shifters, to capture quantity variation only in part. This is especially true when "quantities per dollar of GDP of the destination country" are considered, where the dependent variable output is divided by a country-specific variable.

With firm-product FE as the sole regressors (columns 10 to 13), the variability ex-

¹⁰Munch and Nguyen (2014) find that firm-specific effects explain 31% of unconditional export sales variation of Danish firms. Eaton et al. (2011) France finds that variation of sales conditional upon entry explains 39% of variation. Lawless and Whelan (2008) for Irish firms find firm-specific effects to account for 41% of firm destination sales variation.

plained is also high compared to firm-level FE. This supports the assumptions that most variation in quality and unit cost was at firm-product level. This assumption allows making predictions independent of the single- or multi-product nature of firms. Empirically, however, that assumption needs to be verified. At the most detailed level (firm-CN8), the explained price variability of observations in weight is now about 67%, while for quantities, the explained variability with the inclusion of firm-product FE explains about 33%, depending on how quantities are measured. Thus, the inclusion of a firm-product FE explains much more variability in both the price and quantity regressions than either firm- FE or product-FE. This justifies a theoretical approach that allows demand to vary by firm-product rather than by firm or by product only.¹¹

Turning to products whose quantities are expressed in units, in the bottom of Table 4.23 it can be noticed that all FE explain more of the variation in the data, but it should be kept in mind that the number of observations and varieties in units are much lower, as shown in Table 1. For prices, all types of FE give a higher fit in the regressions with units than with weights. But more importantly, the difference in R^2 between the price and the quantity regression is consistently present with a lower R^2 in the quantity regressions. For observations in units, which are arguably less subject to measurement error than weights, the difference of goodness-of-fit between prices and quantity regressions is even larger.

Single-attribute models, like the one in Table 4.23, leave a substantial amount of variability unexplained, as also pointed out by Hallak and Sivadasan (2013). However, unreported F-tests turn out to be significant for all the single-attribute models in Table 4.23. This suggests that firm-product and country-product are both important regressors to include since each of them explains a significant part of the variation in the firm-product-country data. The F-tests for the price regressions are always substantially higher than those for quantities, which is suggestive that the linear functional form that imposed by including the dummies is more suited to explain prices than quantities.¹²

¹¹Munch and Nguyen (2014) using Danish export data also point out that the firm-product dimension is important to explain data variation.

¹²For brevity, the F-tests are not reported but are available upon request.

Table 4.23: Single-attribute Models and Goodness-of-fit for Pooled Observations in Weight and Units.

	(1) $y = p$; $y = q$	(2) $y = p$; $y = q$	(3) $y = p$; $y = q$	(4) $y = p$; $y = q$	(5) $y = p$; $y = q$	(6) $y = p$; $y = q$	(7) $y = p$; $y = q$	(8) $y = p$; $y = q$	(9) $y = p$; $y = q$	(10) $y = p$; $y = q$	(11) $y = p$; $y = q$	(12) $y = p$; $y = q$	(13) $y = p$; $y = q$
Firm FE	YES												
Product(CN2) FE		YES											
Product(CN4) FE			YES										
Product(CN6) FE				YES									
Product(CN8) FE					YES								
Country-CN2 FE						YES							
Country-CN4 FE							YES						
Country-CN6 FE								YES					
Country-CN8 FE									YES				
Firm-CN2 FE										YES			
Firm-CN4 FE											YES		
Firm-CN6 FE												YES	
Firm-CN8 FE													YES
Weight													
Price reg. R^2	38.3%	18.5%	33.4%	37.9%	40.0%	23.6%	45.7%	52.7%	55.6%	53.2%	62.9%	66.5%	67.9%
Quantity reg. R^2	17.4%	4.2%	8.8%	11.2%	12.6%	9.1%	19.6%	28.1%	32.6%	22.0%	26.2%	30.1%	32.5%
Q.perCapita reg. R^2	16.6%	4.2%	8.8%	10.9%	12.5%	14.2%	26.5%	34.9%	39.3%	21.7%	25.6%	29.1%	31.8%
Q.perGDP reg. R^2	18.9%	4.4%	11.3%	13.5%	15.6%	25.1%	38.6%	46.0%	48.9%	24.9%	28.8%	31.9%	34.3%
Units													
Price reg. R^2	70.3%	37.1%	70.9%	76.5%	81.3%	43.5%	79.7%	84.8%	86.7%	81.1%	86.1%	89.9%	91.8%
Quantity reg. R^2	18.1%	5.1%	7.7%	10.2%	11.3%	12.9%	20.0%	28.0%	32.8%	20.8%	23.5%	26.3%	28.7%
Q.perCapita reg. R^2	20.3%	6.6%	9.6%	11.7%	12.6%	20.2%	30.4%	37.1%	40.4%	23.5%	25.9%	28.7%	30.1%
Q.perGDP reg. R^2	20.1%	6.8%	10.9%	13.9%	14.8%	34.8%	42.3%	50.3%	52.1%	23.1%	25.8%	30.1%	30.7%

Notes: The results in this table are based on the restricted sample as described in Table 1. Quantities expressed in weight (kilograms) or units (liters, bottles, pairs etc).

However, from the single-attribute models in Table 4.23, it is impossible to know how important firm-product FE versus country-product FE are in explaining data variability since a comparison of R^2 across different models is not meaningful.¹³ Firm-product and country-product FE models both result in a high R^2 , especially with observations in units. The relative role of firm-product FE and country-product FE, when included jointly in the regression, can be determined through a variance decomposition analysis. At the same time, it can also be used to discriminate quadratic utility models from CES models. Quadratic utility models predict that country effects are an important determinant of prices, while CES type of models see no role for country-effects to explain prices.

In the ANOVA Table 4.24, a combined attribute model of firm-CN8 and country-CN8 is considered. The ANOVA decomposition verifies whether a combined model is justified. Since the inclusion of firm-CN8 FE involves a larger number of dummies (degrees of freedom) than in the case of country-CN8 dummies, one may wrongly conclude that firm-product FE explain more of the data variation. The ANOVA analysis takes this different number of dummies into account such that it is possible to get a better idea about the relative importance of each regressor.

The results in the top panel of Table 4.24 show the results for the price regressions and the bottom panel for the quantity regressions. The Mean Sum of Squares (MS) is reported, which is the outcome of dividing the Partial Sum of Squares of each regressor (not shown for brevity) by its degrees of freedom from the regressions. As such the MS gives the explanatory power of each regressor per degree of freedom. Measured this way, firm-CN8 FE and country-CN8 FE account for a relatively even part of the variation explained, be it that the relative importance of the regressors alternates between specifications. In the quantity regressions, the importance of variety- versus country-FE is about even, while in the price regressions, the country-FE appear to be more important per degree of freedom. This issue is not explored further because the relative importance of variety- versus country-specific effects is beyond this thesis' objectives. More importantly, the ANOVA analysis confirms that the inclusion of both variety-effects and country-effects seem warranted explaining price and quantity variation.¹⁴

¹³Only when the regressors are orthogonal and completely uncorrelated the increase in the R^2 indicates what the contribution of each regressor is, but this is unlikely here.

¹⁴Munch and Nguyen (2012) argue that an ANOVA analysis in an unbalanced dataset may bias results, which means one cannot draw too strong conclusions on the relative importance of variety-versus country-effects, other than that both seem needed.

Table 4.24: Analysis of Variance (ANOVA) in dummy regressions.

	(1) Price Regression $y = p$	
	Mean Sum of Squares	
	weight	units
Firm-CN8 FE	14,510	3,285,966
Country-CN8 FE	7,401	923,217
	Quantity Regression $y = q$	
	Mean Sum of Squares	
Firm-CN8 FE	4.1216e+11	1.1867e+11
Country-CN8 FE	3.0467e+11	1.0277e+11

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight and units. The results refer to the dummy regressions including firm-CN8 and country-CN8 FE.

Combining variety and country dummies

The results associated with the single-attribute models in Table 4.23 suggest that firm-product and country-product dummies in isolation are relevant regressors. The variance decomposition in Table 4.24 suggests that the combination of the two is necessary to explain the data variability.

The results of combining variety and country dummies to explain price and quantity variation are shown more systematically and for different product-level definitions in Table 4.25. In this Table the results are shown of regressions where data is pooled over all product categories, essentially assuming a single market in which all goods compete and insert firm-product and country-product dummies. The definition of a product-market is progressively narrowed from firm-CN2 to firm-CN8.

Independently of the product-market definition, it can be seen that the variability explained in the price regression is always higher than in the quantity regressions. In the weights regressions, the difference between price and quantity regressions' R^2 is about 20% to 40%, while for the units' regressions in the bottom panel the difference is closer to around 40%. In the units' regressions, the variation in the quantity regression explained is typically less than half of what is explained by the same two sets of dummies in the price equation. It is worth noting that the finer the firm-product and country-product definition, the better the goodness-of-fit for both the price and quantity regressions. But this can be attributed to the fact that more dummies also imply less residual degrees of freedom in the regression which tends to raise the R^2 .

Table 4.25: Goodness-of-fit of the verti-zontal model for Weight and Units.

	(1) $y = p, q$		(2) $y = p, q$		(3) $y = p, q$		(4) $y = p, q$	
Firm-CN2 FE	YES		YES		YES		YES	
Firm-CN4 FE								
Firm-CN6 FE								
Firm-CN8 FE								
Country-CN2 FE	YES		YES		YES		YES	
Country-CN4 FE								
Country-CN6 FE								
Country-CN8 FE								
	weight	units	weight	units	weight	units	weight	units
Price regression R^2	55.7%	83.1%	70.9%	91.2%	76.9%	95.1%	79.1%	96.0%
Quantity regression R^2	28.6%	31.3%	40.3%	39.7%	50.7%	48.9%	56.7%	54.8%
Q per capita regression R^2	31.6%	36.7%	43.5%	46.6%	53.4%	54.6%	59.1%	58.5%
Q per GDP regression R^2	39.6%	44.5%	51.7%	52.5%	60.0%	62.9%	63.7%	64.7%
Number of observations	111876	20929	111876	20929	111876	20929	111876	20929
Number of dummies	12482	2963	26423	4865	41498	8363	47956	9252

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight (kilograms) and units (liters, bottles, pairs etc).

Two important insights emerge from the combined-attribute models in Table 4.25. First, while price variability is pretty much pinned down by a combination of variety and country dummies, quantity variability is less so. This is in sharp contrast to models that predict that prices and quantities should be perfectly correlated as they are supposedly determined by the same sources of variability, as in the standard quadratic utility setting. In addition it is in contrast with models predicting that destination-specific characteristics are the only additional source of variability when moving from prices to quantity equations, such as the CES. But the data seem to suggest that different sources of variability are at work, being destination-variety specific and affecting quantities rather than prices. Second, the empirical results show that the linear functional form that we imposed in (4.3) gives a good fit for prices but a consistently lower fit for quantities. This is in line with what one would expect since the verti-zontal theory suggests that a linear form applies to prices but not to quantities which are inherently non-linear.

Regressions by products and industries

Pooling all the data amounts to considering the product market as one integrated market which may hide heterogeneity between industries. For this reason in Table 4.26 results on the specification (4.3) are reported for product-level regressions.

Based on the results thus far one can say that including both variety- and country-FE at the most detailed product (CN8) level is the specification that works most against the verti-zontal model's results since the price and quantity regressions for this most detailed definition of a product market lie closest to each other. Therefore this specification is used to give the data most chance to reject the theory.

Table 4.26: Product-level Regressions and Goodness-of-fit for Weight and Units.

	(1)		(2)		(3)	
	Weighted averages		How often price R^2 > quantity R^2		Number of products	
	weight	units	weight	units	weight	units
by CN2						
Price R^2	65.3%	74.0%	.	.	89	46
Quantity R^2	36.3%	36.9%	93.3%	82.6%	89	46
Q per capita R^2	37.5%	40.6%	87.6%	84.8%	89	46
Q per GDP R^2	42.4%	44.7%	84.3%	80.4%	89	46
by CN4						
Price R^2	65.4%	69.5%	.	.	740	178
Quantity R^2	39.4%	41.4%	83.2%	79.8%	740	178
Q per capita R^2	42.5%	45.8%	81.8%	78.7%	740	178
Q per GDP R^2	46.2%	49.6%	78.5%	78.7%	740	178
by CN6						
Price R^2	65.7%	71.4%	.	.	1,930	482
Quantity R^2	44.3%	47.7%	77.5%	78.6%	1,930	482
Q per capita R^2	48.7%	51.3%	75.2%	75.9%	1,930	482
Q per GDP R^2	51.5%	55.2%	73.4%	74.1%	1,930	482
by CN8						
Price R^2	66.4%	71.4%	.	.	2,541	589
Quantity R^2	46.5%	49.9%	77.2%	78.6%	2,541	589
Q per capita R^2	50.6%	53.2%	74.9%	76.2%	2,541	589
Q per GDP R^2	53.1%	56.5%	72.6%	74.4%	2,541	589

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight (kilograms) and units (liters, bottles, pairs etc). The only additional restriction, per CN product, is that the number of regressors for each type of dummy is lower than the number of observations to ensure some variability in the sample. The regressors included are firm-CN8 and country-CN FE, for the different CN product categories. For each CN product category, averages of all the CN products are weighted by their number of observations.

In Table 4.26, first re considered all firm-CN8 varieties belonging to the same CN2 and exported to the same country to be in competition with each other in every country they are exported to. Put differently, CN2 is considered at the beginning as the relevant product market where all goods are substitute products. This results in about 90 different CN2 product markets for weights and about 45 different CN2 industries for units. For each of these industries separate regressions are run of price and output on variety- and country-product FE.¹⁵

Column 1 of Table 4.26 reports the weighted average R^2 across all CN2 industries which is 65% for prices and about 36% for simple quantities. The corresponding numbers for the units' regressions is an average R^2 of 74% for prices and around 37% for simple quantities regressions.¹⁶ Column 2 shows the percentage of times that the goodness-of-fit in the price regressions exceeds that of the quantity regressions, which is around 93% for weight and 82% for units' regressions when considering simple quantities. The definition of a relevant product market is then narrowed from CN4, CN6 to CN8. Even in the most narrow product market definition, where 1,701 separate regressions are considered for each of the CN8 industries (weights), the weighted average R^2 for prices is 66% and for simple quantities is 46%. Column (3) shows that in 77% of the 1,701 regressions run, the goodness-of-fit in the price regression is strictly higher than that of the simple quantity regressions. Results are qualitatively the same when considering varieties in units. Results do not differ much when we measure output in a different way, although R^2 tend to go up slightly when considering quantity per capita or quantity per dollar of GDP.

Regressions at product-level thus confirm that prediction that a linear model like the one in (4.3) appears to have less predictive power in quantity regressions. While this holds for the large majority of products considered, from column (3) in Table 4.26 it is clear that there are instances where there is not always a positive difference between price and quantity R^2 . The theory does not rule out the existence of products where taste differences are not very important or where business-to-business sales are more relevant than business-to-consumer.¹⁷ Put differently, in the case of intermediate products the cost-minimizing combination of inputs in production functions may differ from the utility-maximizing consumption bundle of consumers. The model is more likely to explain price and quantity variation of final consumption goods than of intermediate goods.

To have a first indication for which industries taste differences seem to matter less, in Table 4.27 industry-level regressions are reported, where CN2 products are grouped by the sections to which they belong in the RAMON Eurostat classification.

¹⁵In the product-level regressions the country-product is defined at country-CN2 in the CN2 regressions, at country-CN4 in the CN regressions and so forth.

¹⁶For each CN product category averages are weighted by the number of observations, but results are very similar for weighted and simple averages.

¹⁷Similar R^2 in prices and quantities could point at the absence of taste heterogeneity.

Table 4.27: Industry-level Regressions and Goodness-of-fit for Weight and Units.

INDUSTRIES (CN2 product codes)	Exports in weight			Exports in units		
	(1) R^2 of price regr.	(2) R^2 of quantity regr.	(3) Obs. # (model degrees of freedom)	(4) R^2 of price regr.	(5) R^2 of quantity regr.	(6) Obs. # (model degrees of freedom)
Agriculture <i>CN2 codes 1 to 15</i>	81.5%	35.5%	6,821 (1,420)	.	.	.
Food, beverages <i>CN2 codes 16 to 24</i>	78.9%	33.6%	11,625 (2,047)	62.0%	44.4%	1,204 (271)
Minerals, chemicals <i>CN2 codes 25 to 38</i>	76.8%	37.1%	16,277 (2,649)	36.2%	55.5%	344 (129)
Plastics and rubber <i>CN2 codes 39 and 40</i>	56.7%	34.3%	16,641 (2,760)	65.1%	36.2%	583 (183)
Leather, skins, wood <i>CN2 codes 41 to 46</i>	78.5%	42.3%	2,353 (562)	91.6%	34.3%	1,220 (299)
Articles of paper <i>CN2 codes 47 to 49</i>	50.4%	37.5%	5,843 (1,257)	83.3%	59.8%	16 (12)
Textile articles <i>CN2 codes 50 to 63</i>	86.9%	35.8%	13,544 (2,679)	89.0%	26.8%	12,276 (2,165)
Footwear, accessories <i>CN2 codes 64 to 67</i>	73.3%	48.1%	322 (97)	71.1%	35.5%	356 (106)
Construction materials <i>CN2 codes 68 to 70</i>	75.5%	45.9%	2,757 (612)	76.8%	42.8%	1,114 (245)
Base metals, jewelry <i>CN2 codes 71 to 83</i>	75.5%	40.6%	10,859 (2,395)	77.3%	32.5%	274 (88)
Mechanical appliances <i>CN2 codes 84 and 85</i>	59.4%	29.0%	17,672 (3,369)	85.4%	38.1%	2,884 (731)
Transport equipment <i>CN2 codes 86 to 89</i>	75.8%	40.2%	2,160 (492)	95.3%	52.8%	330 (129)
Precision instruments <i>CN2 codes 90 to 93</i>	62.7%	30.9%	2,128 (498)	86.8%	36.9%	550 (169)
Furniture and toys <i>CN2 codes 94 to 96</i>	68.6%	27.1%	5,162 (980)	69.1%	27.0%	299 (85)

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight (kilograms) and units (liters, bottles, pairs etc). As regressors firm-CN8 and country-industry FE are included. The industry "Agriculture" has been dropped from the sample because it had only 4 observations and the same number of dummies.

For the fourteen so-obtained industries, the regressions for weights do not reject the verti-zontal model. The R^2 for prices is typically 20% to 30% higher than for quantities. Only for exports in units for "Minerals and Chemicals" the quantity regression shows a stronger goodness-of-fit. This may suggest that taste effects are not important in this industry or that "Minerals and Chemicals" is more of a business-to-business industry for which the model may not apply.

More detailed industry studies will likely reveal where taste heterogeneity is strong and where it is not or where other factors are at play. In any case, all the evidence presented above seems to suggest that in the large majority of products and industries, taste heterogeneity matters since that is today the only model which can explain consistently lower R^2 of specification (4.3) in quantity regressions than in price regressions.

4.4.4 Robustness check I: dummy regressions on subsamples

A dummy regression as specified in (4.3) can also be performed on the 171 subsamples presented in the previous Section. Noting that the unit of observation is always an individual variety, defined by the combination of a firm and a CN8 product code in a particular destination market, the results are summarized in Table 4.28.

The price regressions have all an R^2 of between 60 to 70%, which is systematically higher than the one associated with quantity regressions. Looking at the top row, column (1), it can be seen that the average of the averages across all samples displays a difference of 20% in the captured variability between price and quantity regressions. Browsing Table 4.28, it can be noted that this difference is always present, no matter which product-market definition or market combination is used. This consistently higher goodness-of-fit for price as opposed to quantity regressions can be interpreted as the effect on quantities of different tastes in different markets.

The differences in goodness-of-fit are also displayed in Figure 4.15 and 4.16, where the square dots should now be read as average R^2 resulting from the price regressions and the triangle dots are the R^2 from the quantity regressions. The horizontal line segments indicate the average R^2 by level of product aggregation, while the individual dots show the averages by number of markets considered for each level of product aggregation. The solid line shows average prices while the dashed line shows average quantities in different samples. It can be noted that the OLS fit is systematically better in the price regressions than in the quantity regressions.

On the same regressions, the functional form assumed in the theory is tested using a RAMSEY test (Ramsey, 1969), which also indicate the presence of an omitted variable bias. The RESET test is performed for each of the actual samples on which regressions are run. Table 4.29 shows how many times the RESET test is passed. The results are strikingly different for price and quantity regressions. The top row shows that the price regression passes the Ramsey test in 63.7% of the samples, while the comparable number of the quantity regression is 21.1%. The way to interpret this is that the high R^2 for the price regression suggests it has a reasonable functional form and no important variables seem to be omitted. The opposite is true of quantity regressions, which again supports the idea that a market-specific taste parameter is missing in the regression and/or structural

parameters affecting equilibrium quantities do so in a non-linear way.

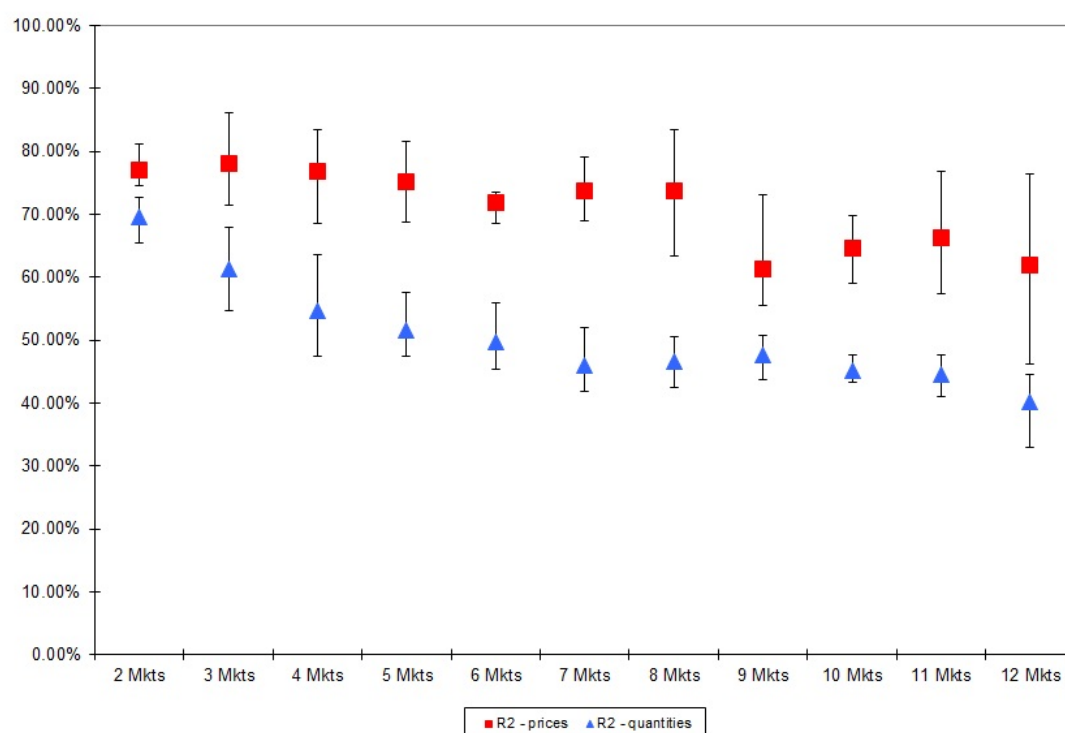
The rest of Table 4.29 disaggregates this result by levels of product aggregation and best-N market combinations. The difference between price regressions and quantity regressions is again striking, especially at the narrowest levels of product aggregation and for an intermediate number of destination markets. For example, when 7 markets are considered, only 1 quantity regression out of 20 passes the RESET test, whereas 18 out of 20 do so for the price regressions on dummies.

Table 4.28: R^2 associated with prices and quantities regressed on dummies.

R-squared in regressions on dummies		Average of averages	CN8	CN6	CN4	CN2
			(Average of Top 5)	(Average of Top 5)	(Average of Top 5)	(Average of Top 5)
		(1)	(2)	(3)	(4)	(5)
Average of Averages	Price	70.96%	73.42%	77.86%	70.80%	65.46%
	Quantity	50.69%	48.65%	53.91%	49.97%	53.12%
2-market combination	Price	77.05%	75.46%	81.12%	77.15%	74.48%
	Quantity	69.51%	68.66%	72.71%	65.45%	71.23%
3-market combination	Price	78.15%	77.26%	86.03%	77.95%	71.37%
	Quantity	61.41%	54.61%	64.31%	58.77%	67.93%
4-market combination	Price	76.74%	78.20%	83.34%	76.90%	68.51%
	Quantity	54.79%	47.50%	55.26%	52.78%	63.61%
5-market combination	Price	75.11%	80.84%	81.58%	69.17%	68.85%
	Quantity	51.65%	47.82%	53.73%	47.52%	57.51%
6-market combination	Price	71.92%	72.77%	72.76%	68.58%	73.59%
	Quantity	49.77%	45.45%	50.31%	47.34%	55.96%
7-market combination	Price	73.81%	76.40%	79.14%	68.87%	70.85%
	Quantity	46.08%	41.91%	46.84%	43.66%	51.92%
8-market combination	Price	73.65%	76.23%	83.37%	63.45%	71.55%
	Quantity	46.66%	42.48%	44.45%	49.09%	50.64%
9-market combination	Price	61.29%	73.11%	55.52%	58.28%	58.25%
	Quantity	47.74%	50.66%	43.66%	49.45%	47.21%
10-market combination	Price	64.65%	69.86%		65.17%	58.93%
	Quantity	45.08%	47.66%		43.32%	44.28%
11-market combination	Price	66.27%	64.55%		76.84%	57.43%
	Quantity	44.60%	45.15%		47.70%	40.96%
12-market combination	Price	61.88%	62.99%		76.41%	46.24%
	Quantity	40.30%	43.26%		44.60%	33.05%

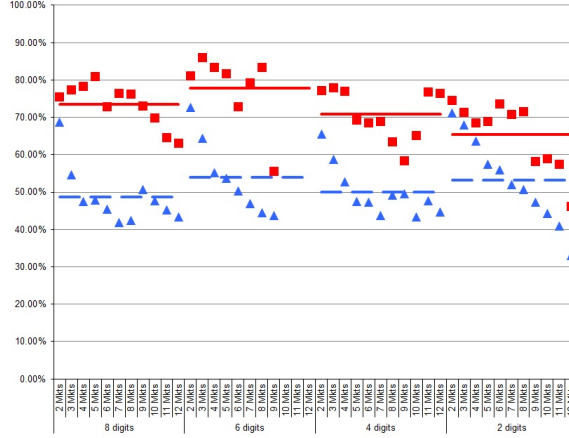
Note: This table reports R^2 associated with OLS regressions of prices and quantities on dummies for the varieties present in Table 4.14. Coefficients are averaged across the number of samples present per intersection of best N-market combination and product disaggregation.

Figure 4.14: Visual representation of the results reported in Table 4.28, by number of markets aggregating all the levels of product classification.



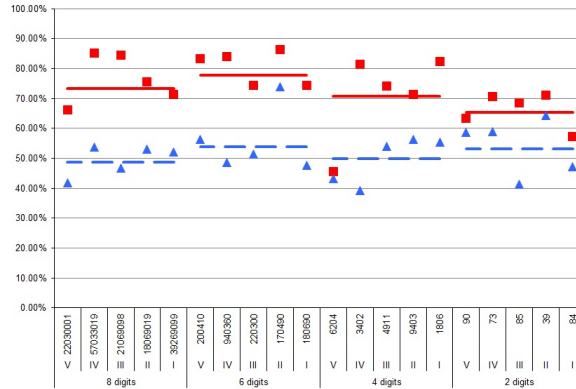
Note: Square dots indicate averages of the average R^2 for regressions of prices on dummies by level of product disaggregation, triangle dots indicate the same for regressions of quantities on dummies. The segment around square and triangle dots indicate the minimum and the maximum average R^2 by level of product disaggregation.

Figure 4.15: Visual representation of the results reported in Table 4.28, by number of markets.



Note: Square dots indicate average R^2 for regressions of prices on dummies by best N-market combination across product codes, triangle dots indicate the same for regressions of quantities on dummies. The horizontal line segments refer to average R^2 across best N-market combinations by level of product disaggregation: the solid one refers to prices, the dashed one to quantities.

Figure 4.16: Visual representation of the results reported in Table 4.28, by product codes.



Note: Square dots indicate average R^2 for regressions of prices on dummies by product code across best N-market combinations, triangle dots indicate the same for regressions of quantities on dummies. The horizontal line segments refer to average R^2 across product codes by level of product disaggregation: the solid one refers to prices, the dashed one to quantities.

Table 4.29: Success rates in tests for omitted variables in the regressions on dummies run for Table 4.28.

Share of samples passing the regression specification error test (<i>RESET</i>) for omitted variables.												
All samples	Price	63.7%										
	Quantity	21.1%										
	Samples	(171)										
By level of product disaggregation:	Price	CN8		CN6		CN4		CN2				
		67.5%		74.2%		64.4%		62.5%				
		28.8%		30.4%		17.6%		11.3%				
	Samples	(38)		(35)		(45)		(53)				
By best N-market combinations:	Price	12 Mkts	11 Mkts	10 Mkts	9 Mkts	8 Mkts	7 Mkts	6 Mkts	5 Mkts	4 Mkts	3 Mkts	2 Mkts
		16.7%	37.5%	55.6%	54.5%	76.5%	90.0%	75.0%	65.0%	80.0%	90.0%	80.0%
		0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	15.0%	15.0%	20.0%	45.0%	60.0%
	Samples	(6)	(8)	(9)	(11)	(17)	(20)	(20)	(20)	(20)	(20)	(20)

Note: Percentages of samples passing the RESET test for omitted variables are reported by product disaggregation and market combination. The number of samples considered is reported in brackets. For example, at a CN8 level product disaggregation, 63.7% of the 38 samples considered passed the test when prices were regressed on dummies, but only 21.1% passed the test when quantities regressions were considered.

4.4.5 Robustness check II: correlations and remote destinations

A legitimate concern is whether the results are driven by the fact that the most important trading partners for Belgium are European, which may have a dampening effect on price differences. If the high goodness-of-fit in the price regressions is the result of arbitrage or lack of border controls, this could drive the results. Therefore, as a consistency check, we investigate whether this trade orientation towards European destinations may have affected the results.

It can be done so by looking at a set of heterogeneous and remote countries (Australia, Brazil, Canada, China, India, Japan, South Africa, Turkey, and US)¹⁸ together with the three main trading partners of Belgium (France, Netherlands and Germany). For these countries, pairwise bilateral correlations are considered for each country-pair of Belgian export prices and quantities shipped. An advantage of using correlations is that differences can be statistically tested for. But for pairwise correlations to be meaningful, we exclude zero trade flows here and only consider those varieties that are present in all countries. This results in a balanced panel of 87 varieties and 1,044 observations.¹⁹

These pairwise correlations all lie around 90%, which is the average of all the bilateral price rank correlations considered and is indicated by the solid line at the top of Figure 4.17. Proposition I, which predicts that the price rankings of varieties within destination countries will not be affected by country effects, is confirmed by the high price correlation found. Therefore, one would expect stable price rankings amongst a set of varieties exported even when the destination countries are remote and heterogeneous compared to the country of origin.

In contrast, the bilateral quantity ranking correlations given by the triangle dots in Figure 4.17, can be as low as 50% as indicated by the dashed horizontal line segment. The four most correlated country pairs in terms of quantity ranks correspond to the three EU member states considered (France, Netherlands and Germany) and Turkey, a candidate EU member country. Of all the countries included, the ones with the highest pairwise quantity rank correlations are the three European countries. This can clearly be seen from Figure 4.17 where EU countries are circled. Figure 4.17 thus suggests that taste differences are smallest in the three EU countries included, which seems quite plausible given their proximity. All the quantity correlations are lower than price correlations in a statistically significant way at a 1% confidence level.

The evidence in Figure 4.17 casts further doubt on measurement error in quantities as an alternative explanation for the findings. Measurement error would result in random variability in quantities, but Figure 4.17 clearly shows that quantity variation is lower in nearby countries. This makes an explanation like *taste* more plausible as a source of quantity variation than measurement error, although one cannot exclude the possibility

¹⁸The criteria for choosing these countries included a maximum distance from Belgium, including as many different continents as possible and conditioning on the fact that countries received the same set of varieties exported from Belgium.

¹⁹The lower quantity correlations, which is found in this balanced sample, are in line with the goodness-of-fit results obtained on the unbalanced sample in the previous section. This confirms that selection issues are not driving the results.

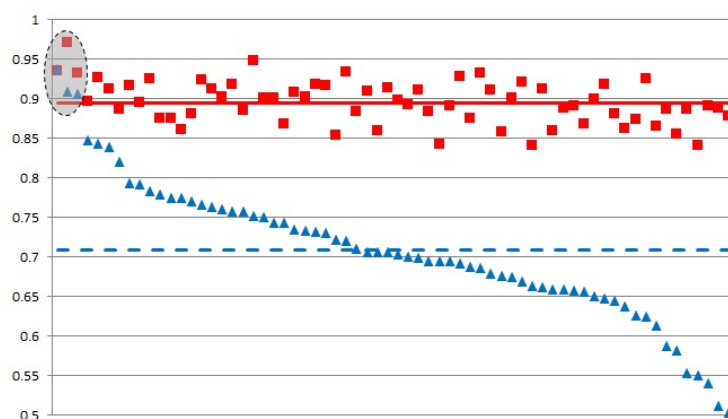


Figure 4.17: Farmarkets

that measurement error would increase with distance from Belgium which would raise the variance of quantities for far away countries. Provided measurement error is not driving results, Figure 4.17 also suggests that taste and distance to destination may be highly correlated, which raises some doubts on the correct specification of many gravity models where distance typically features as the prominent explanation explaining bilateral trade flows but which may in part capture taste effects that run along similar dimensions. This is another reason why future research should be focusing on separating taste effects in trade from other potential explanations at work.

4.4.6 Robustness check III: what is the role of distance?

As discussed earlier in this Section, there is only one class of models which would be as consistent with the evidence presented as the verti-zontal: a quality-augmented CES à la Crozet et al. (2012) with linear transport costs. As noted by Martin (2010), in such model the variety-specific component of price variability would be combined with the variability induced by the linear transport costs.

This mechanism can be directly tested by adding a proxy for trade costs in the dummy regressions summarized in Table 4.23. Since there is no dataset available with precise and comparable information on trade costs, the proxy typically used in the literature is distance, as reported for example in the CEPII' GeoDist database (Mayer and Zignago, 2011). There are different ways in which distance can be measured, considering the distance between the capitals or the biggest cities, or with more sophisticated techniques, as the one used to produce the variable *distw* in the GeoDist database, which calculates the distance between two countries based on bilateral distances between the biggest cities of those two countries, weighting them by the relative population of the cities in the corresponding countries. This is the variable used for this exercise, but since all the distance measures are very correlated, the results are robust to alternative indicators.

In order to account for the impact of distance, the dummy regression in (4.3) is slightly adapted as

$$y_{s,i} = \delta_0 + \delta_1 Firm_Product_s + \delta_2 Country_Product_i + \delta_3 Distance + \epsilon_{s,i}. \quad (4.4)$$

The results of (4.4) are reported in Tables 4.30 (for weight) and 4.31 (for units), where columns are numbered in accordance to Table 4.23. Of course, since the data used is cross-sectional, in the regressions with country-fixed effects the distance regressor has to be dropped for multicollinearity, so columns (6) to (9) have to be dropped. The variability captured by the specification in (4.4) is so similar to the specification in (4.3) that in order to highlight the few differences, in Tables 4.30 and 4.31 results are reported in bold when they are 0.2% points higher than in Table 4.23 and, even so, they are never higher than 0.9% points from the corresponding regression without distance. It can be noted that changes in the variability capture in prices are never perceptible, i.e. they are smaller than the 0.1% level of precision at which results are reported. This is striking, because the country-product dummies in Table 4.23 captured between 23.6% and 55.6% of the price variation and in Table 4.25, when country-product dummies are added to variety dummies, the additional explanatory power increases by more than 10% of the total variability for CN6 and CN8 products. This seems to suggest that the part of destination-market specific variability explained by transport costs (as approximated by distance, which can be admittedly an imprecise proxy) is negligible and surely cannot be the only source of price variation across markets as implied by Crozet et al. (2012).

In line with the prediction of the verti-zontal model and with the empirical observation of Martin (2012), though, the coefficient for the impact of distance on prices is positive and significant in almost all cases, with a loss of statistical significance only when units are considered, in particular in the presence of firm-product dummies. The statistical significance of distance can be reconciled with the economic insignificance in terms of variability explained by looking at the magnitude of the coefficient. Noting that distance is expressed in kilometers and prices are unit values of shipments, the coefficients in Table 4.30 say that every 1000 kilometers prices per 100 kilograms increase by 1 euro. Considering that the average distance from Belgium in the sample is 2500 kilometers (the maximum is 18,525 for New Zealand) and the average price per 100 kilograms is 286 euros, the impact would on average be very small, in fact below 1%. When considering units, the numbers are even more impressive, considering that the average price per unit is 5,223 euros and the coefficients for distance, when significant, are around 0.015 euros/kilometer.

Table 4.30: Single-attribute Models and Goodness-of-fit for Pooled Observations in Weight as shown in Table 4.23, with the introduction of distance as a regressor.

	(1) $y = p$; $y = q$	(2) $y = p$; $y = q$	(3) $y = p$; $y = q$	(4) $y = p$; $y = q$	(5) $y = p$; $y = q$	(10) $y = p$; $y = q$	(11) $y = p$; $y = q$	(12) $y = p$; $y = q$	(13) $y = p$; $y = q$
Firm FE	YES								
Product(CN2) FE		YES							
Product(CN4) FE			YES						
Product(CN6) FE				YES					
Product(CN8) FE					YES				
Firm-CN2 FE						YES			
Firm-CN4 FE							YES		
Firm-CN6 FE								YES	
Firm-CN8 FE									YES
Price reg. R^2	38.3%	18.8%	33.5%	38.0%	40.0%	53.3%	62.9%	66.5%	67.9%
Quantity reg. R^2	17.6%	4.2%	8.9%	11.4%	12.8%	22.3%	26.5%	30.5%	32.9%
Q.perCapita reg. R^2	16.8%	4.4%	9.0%	11.1%	12.7%	22.1%	26.1%	29.7%	32.4%
Q.perGDP reg. R^2	18.9%	4.6%	11.3%	13.5%	15.6%	24.9%	28.9%	32.0%	34.5%
Distance coeff., price reg.	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
T-statistic	(16.40)	(21.59)	(16.89)	(15.18)	(14.58)	(15.05)	(12.49)	(11.76)	(11.20)
Distance coeff., quantity reg.	-5.779	-2.977	-4.329	-4.776	-5.191	-7.498	-8.578	-9.131	-9.720
T-statistic	(-15.96)	(-8.30)	(-11.96)	(-13.04)	(-14.11)	(-20.00)	(-22.32)	(-23.36)	(-24.83)

Notes: This Table reproduces Table 4.23 with the only addition of distance from Belgium as a regressor. The results in this table are based on the restricted sample as described in Table 1. Quantities expressed in weight (kilograms). All coefficients for the distance regressor are significant at the 1% confidence level.

Table 4.31: Single-attribute Models and Goodness-of-fit for Pooled Observations in Units as shown n Table 4.23, with the introduction of distance as a regressor.

	(1) $y = p, q$	(2) $y = p, q$	(3) $y = p, q$	(4) $y = p, q$	(5) $y = p, q$	(10) $y = p, q$	(11) $y = p, q$	(12) $y = p, q$	(13) $y = p, q$
Firm FE	YES								
Product(CN2) FE		YES							
Product(CN4) FE			YES						
Product(CN6) FE				YES					
Product(CN8) FE					YES				
Firm-CN2 FE						YES			
Firm-CN4 FE							YES		
Firm-CN6 FE								YES	
Firm-CN8 FE									YES
Price reg. R^2	70.3%	37.1%	70.9%	76.5%	81.3%	81.1%	86.1%	89.9%	91.8%
Quantity reg. R^2	18.6%	5.2%	7.9%	10.5%	11.6%	21.3%	24.2%	25.0%	29.4%
Q.perCapita reg. R^2	20.8%	6.7%	9.9%	12.1%	13.0%	24.2%	26.6%	29.6%	31.0%
Q.perGDP reg. R^2	20.2%	6.8%	10.9%	13.9%	14.9%	23.2%	26.1%	30.5%	31.1%
Dist. coeff., price reg.	0.018	0.000	0.015	0.010	0.011	0.004	0.003	0.003	0.002
T-statistic	(2.48)**	(0.00)	(2.25)**	(1.56)	(2.01)**	(0.63)	(0.59)	(0.63)	(0.52)
Dist. coeff., quantity reg.	-4.399	-2.162	-2.967	-3.685	-3.639	-4.983	-5.487	-5.914	-5.828
T-statistic	(-10.47)***	(-5.22)***	(-7.06)***	(-8.66)***	(-8.52)***	(-11.66)***	(-12.74)***	(-12.27)***	(-13.13)***

Notes: This Table reproduces Table 4.23 with the only addition of distance from Belgium as a regressor. The results in this table are based on the restricted sample as described in Table 1. Quantities expressed in units (liters, bottles, pairs etc). Significance of the distance coefficients is reported at 10% (*), 10% (**) and 1% (***) level.

The role of distance in explaining variability is stronger for quantities, which could capture an additional taste effect due, for example, to the positive correlation between the taste-mismatch parameter β and the remoteness of the producer from the consumer of a certain variety. In other words, the physical distance may be related to the distance in the characteristics space.

This observation leads to the definition of another possible channel to explain the positive relation between prices and distance, which can reinforce the standard channel linked to part of the higher marginal costs of production (and delivery) passed-through to the final consumers typical of quadratic utilities (where half of the transport costs are charged to consumers) and of models based on CES functions with linear transport costs (Martin, 2010). In addition to this effect, the verti-zontal model allows also for the inclusion of a price effect due to the competitive interaction with substitutable varieties. Indeed, the strength of the destination-market component of the linear demand resulting from the quadratic utility is proportional to the level of competition between varieties of the same good, shifting both prices and markups in the same direction (as opposed to the pass-through effect in a quadratic utility framework, where prices and markups are pushed in opposite directions by trade costs).

In the verti-zontal model, and more generally in models based on quadratic utilities, the substitutability between one variety and all the other varieties in market i is captured by γQ_i , with $Q_i = \int_{S_i} q_{r,i} dr$, hence, if one particular variety competes with varieties produced in nearby markets (say, European exporters in the case of Belgium or France) and all exporters have to face a similar degree of taste mismatch due to distance, the price premium experienced by each exporter can be explained by the lower Q_i due to a higher $\beta_{r,i}$ of all the competitors. To make a concrete example, if French wines compete with Italian and Spanish wines in Asian markets, then part of the price premium observed by Crozet et al. (2012) can be explained by a lower γQ_i as compared to closer European markets in which the same competing varieties are sold in higher quantities. It should however be kept in mind that this explanation may hold for Belgium and other European countries, because of their geographical location next to producers of competing varieties, but not necessarily for other countries. It would be interesting to test this hypothesis looking at the impact of distance on export prices of non-European countries in markets with strong European competition. For example, it could be analyzed how South African or Australian wines' prices and markups evolve with distance, when datasets comparable to the one used by Crozet et al. (2012) will be available in these countries.

A final remark on the relation between distance and the variability of prices and quantities concerns the level of aggregation at which a market can be considered relevant to measure competition between varieties. Table 4.32 reproduces Tables 4.30 and 4.31 by considering only importer-country dummies, which is the level at which variability in distance can be measured, but which also captures other features as the wealth of the destination country, the strength of its currency, its openness to trade and so on. It is remarkable how small is the impact of the destination country in explaining price variability (a feature that is confirmed also in the next Chapter) and, considering that distance is only one of the characteristics captured by a country dummy, it becomes clear

why the inclusion of distance in the dummy regressions doesn't affect the overall variability explained by the dummy regressions. It also implies that producers of varieties, when setting their prices in the different markets, may not really be influenced by overall country characteristics, but rather by the country-product-specific competitive conditions, since country-product dummies alone ranged between 23.6% and 55.6% in Table 4.25. Notice that country-CN2 dummy does not really add much precision to the definition of a market: the manufacturing sector is divided into 97 products, with precision instruments and mechanical appliances clustered into two or three product categories. Still, moving from a pure market dummy to a market-CN2 increases the variability captured by more than 20% of the overall variability, and so on as the product definition becomes more disaggregate, with gains in variability explained leveling off between CN6 and CN8 levels.

Table 4.32: Goodness-of-fit for Pooled Observations with destination-country dummy alone, in Weight and Units.

	weight	units
	$y = p, q$	$y = p, q$
Country FE	YES	YES
Price reg. R^2	1.2%	1.3%
Quantity reg. R^2	1.6%	1.6%
Q.perCapita reg. R^2	4.0%	4.1%
Q.perGDP reg. R^2	8.8%	19.4%

Notes: The results in this table are based on the restricted sample as described in Table 1. Quantities expressed in weight (kilograms) and in units (liters, bottles, pairs etc).

The main point is thus that distance, as any other country-level variable, doesn't seem fit to explain price variability, which should be rather related to country-product characteristics. The verti-zontal model provides a straightforward and intuitive way of relating country-product characteristics to the pricing strategy of each variety through the competition effects, as captured by γQ_i . Therefore, any alternative explanation of this variability made in terms of linear transport costs in an augmented-CES setting should first show that these costs display significant country-product-pair variability, which may require better data than currently available on transport costs in international shipments.

4.4.7 Robustness check IV: using logarithms instead of raw values

Finally, one last robustness check concerns the use of raw values instead of logarithms in Tables 4.23, 4.24, 4.25, 4.26, 4.27, which is more arguably more common in the literature

but less appropriate in the context of the empirical validation of the verti-zontal model. In fact, the choice of using raw values has been based the need to test not only the general patterns of price and quantity variability in the data, but also whether the imposition of a functional form as rigid as the quadratic utility may have been rejected by the data. In addition, logarithms have the clear advantage to provide researchers with an intuitive interpretation of the coefficients resulting of their regressions, but in the case of the empirical test undertaken in this Chapter there have been no coefficients to estimate or to interpret.

However, as a robustness check and as a way to compare the results with existing research and future studies using different datasets, here follow Tables 4.33, 4.34, 4.35, 4.36, 4.37, with regressions performed on the logarithm of the prices and quantities. It can be noted that the results are qualitatively equivalent to the Tables presented earlier, the only difference being that the levels of captured variability are all shifted upwards. What is more relevant for the analysis of trade patterns, though, is that the difference between the price variability captured by the dummies and the quantity variability is comfortably wide, which is still the case.

The increase in variability across the board may be explained by the presence of outliers (whose importance is reduced after the transformation) since the data cleaning procedure has been very parsimonious not to risk losing information. In fact, only the 1% tails of the price and quantity distributions have been cut in the restricted sample, but in such a large dataset that may have left some outliers in. For example, considering prices (measures as unit values, in euros per 100 kilograms of product shipped), their raw values after the data cleaning range from 0.16 to 1245.3, with average 33.75 and standard deviation 91.14. When prices are taken in logarithms, they range from -1.81 to 7.13, with average 2.13 and standard deviation 1.62, so that dummy regressions may artificially capture higher variability because of a reduced variation of the data. As a matter of fact, it should be noticed that single-attribute dummy regressions in 4.33 capture substantially more variability than Table 4.23, even if there is no theoretical reason for this discrepancy (since each dummy is just capturing a different level of prices or quantities). The comparison between Tables in logarithms and raw values may this suggest that single-attribute models tested only using data in logarithms, when not justified by the underlying theory, may overestimate the explanatory power of the empirical implementation.

Table 4.33: Single-attribute Models and Goodness-of-fit for Pooled Observations in Weight and Units. Prices and quantities in logs.

	(1) $y = p;$ $y = q$	(2) $y = p;$ $y = q$	(3) $y = p;$ $y = q$	(4) $y = p;$ $y = q$	(5) $y = p;$ $y = q$	(6) $y = p;$ $y = q$	(7) $y = p;$ $y = q$	(8) $y = p;$ $y = q$	(9) $y = p;$ $y = q$	(10) $y = p;$ $y = q$	(11) $y = p;$ $y = q$	(12) $y = p;$ $y = q$	(13) $y = p;$ $y = p, q$
Firm FE	YES												
Product(CN2) FE		YES											
Product(CN4) FE			YES										
Product(CN6) FE				YES									
Product(CN8) FE					YES								
Country-CN2 FE						YES							
Country-CN4 FE							YES						
Country-CN6 FE								YES					
Country-CN8 FE									YES				
Firm-CN2 FE										YES			
Firm-CN4 FE											YES		
Firm-CN6 FE												YES	
Firm-CN8 FE													YES
Weight													
Price reg. R^2	65.3%	48.6%	65.5%	70.0%	71.6%	52.4%	70.2%	75.4%	77.2%	81.2%	86.8%	89.1%	89.9%
Quantity reg. R^2	40.8%	16.9%	28.9%	33.7%	35.7%	23.4%	38.5%	46.6%	49.9%	54.8%	62.1%	66.5%	68.4%
Q.perCapita reg. R^2	38.3%	17.0%	27.9%	32.6%	34.7%	29.8%	43.6%	51.0%	54.1%	52.9%	60.3%	64.8%	66.8%
Q.perGDP reg. R^2	40.3%	17.2%	29.5%	34.7%	37.1%	32.2%	45.6%	52.7%	55.7%	55.8%	63.7%	68.5%	70.7%
Units													
Price reg. R^2	78.2%	63.4%	78.1%	82.7%	83.7%	67.6%	81.7%	86.3%	87.2%	89.6%	92.8%	94.3%	95.0%
Quantity reg. R^2	51.2%	28.1%	34.6%	38.9%	40.2%	35.9%	45.0%	53.7%	55.9%	58.1%	61.0%	65.9%	66.8%
Q.perCapita reg. R^2	50.4%	27.0%	33.5%	38.4%	39.8%	42.4%	50.6%	58.3%	60.3%	57.6%	60.6%	65.7%	66.7%
Q.perGDP reg. R^2	53.7%	28.8%	36.4%	41.9%	43.4%	46.3%	53.9%	61.2%	63.0%	61.0%	64.1%	69.4%	70.4%

Notes: The results in this table are based on the restricted sample as described in Table 1. Quantities expressed in weight (kilograms) or units (liters, bottles, pairs etc). Prices and quantities are in logs.

Table 4.34: Analysis of Variance (ANOVA) in dummy regressions. Prices and quantities are in logs.

	(1) Price Regression $y = p$	
	Mean Sum of Squares	
	weight	units
Firm-CN8 FE	5.165	4.396
Country-CN8 FE	1.860	1.434
	Quantity Regression $y = q$	
	Mean Sum of Squares	
	weight	units
Firm-CN8 FE	41.485	27.538
Country-CN8 FE	17.420	16.916

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight and units. The results refer to the dummy regressions including firm-CN8 and country-CN8 FE. Prices and quantities are in logs.

Table 4.35: Goodness-of-fit of the verti-zontal model for Weight and Units. Prices and quantities are in logs.

	(1) $y = p, q$		(2) $y = p, q$		(3) $y = p, q$		(4) $y = p, q$	
Firm-CN2 FE	YES		YES		YES		YES	
Firm-CN4 FE								
Firm-CN6 FE								
Firm-CN8 FE								
Country-CN2 FE	YES		YES		YES		YES	
Country-CN4 FE								
Country-CN6 FE								
Country-CN8 FE								
	weight	units	weight	units	weight	units	weight	units
Price regression R^2	82.1%	90.8%	88.8%	94.3%	91.9%	96.2%	93.0%	96.9%
Quantity regr. R^2	59.8%	65.4%	70.8%	71.2%	78.2%	80.2%	81.5%	82.0%
Q per capita regr. R^2	63.2%	68.9%	73.2%	74.1%	80.1%	82.2%	83.0%	83.8%
Q per GDP regr. R^2	64.5%	71.0%	74.1%	75.8%	80.7%	83.4%	83.6%	84.9%
Number of obs.	111876	20929	111876	20929	111876	20929	111876	20929
Number of dummies	12482	2963	26423	4865	41498	8363	47956	9252

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight (kilograms) and units (liters, bottles, pairs etc). Prices and quantities are in logs.

Table 4.36: Product-level Regressions and Goodness-of-fit for Weight and Units. Prices and quantities are in logs.

	(1)		(2)		(3)	
	Weighted averages		How often price R^2 > quantity R^2		Number of products	
	weight	units	weight	units	weight	units
by CN2					89	46
Price R^2	85.6%	88.5%	.	.		
Quantity R^2	77.1%	74.1%	90.9%	77.8%		
Q per capita R^2	79.1%	77.2%	84.1%	80.0%		
Q per GDP R^2	79.7%	78.3%	84.1%	75.6%		
by CN4					740	178
Price R^2	79.3%	82.7%	.	.		
Quantity R^2	73.2%	71.5%	66.4%	71.3%		
Q per capita R^2	75.9%	75.0%	60.4%	68.5%		
Q per GDP R^2	76.1%	75.7%	60.0%	65.2%		
by CN6					1,930	482
Price R^2	75.3%	78.9%	.	.		
Quantity R^2	70.8%	69.1%	59.4%	67.7%		
Q per capita R^2	73.7%	72.6%	53.8%	61.9%		
Q per GDP R^2	73.7%	72.9%	53.9%	61.9%		
by CN8					2,541	589
Price R^2	73.5%	77.4%	.	.		
Quantity R^2	69.7%	68.4%	58.9%	66.8%		
Q per capita R^2	72.7%	71.9%	53.0%	61.2%		
Q per GDP R^2	72.5%	72.1%	53.4%	62.1%		

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight (kilograms) and units (liters, bottles, pairs etc). The only additional restriction, per CN product, is that the number of regressors for each type of dummy is lower than the number of observations to ensure some variability in the sample. The regressors included are firm-CN8 and country-CN FE, for the different CN product categories. For each CN product category, averages of all the CN products are weighted by their number of observations. Prices and quantities are in logs.

Table 4.37: Industry-level Regressions and Goodness-of-fit for Weight and Units. Prices and quantities are in logs.

INDUSTRIES (CN2 product codes)	Exports in weight			Exports in units		
	(1) R^2 of price regr.	(2) R^2 of quantity regr.	(3) Obs. # (model degrees of freedom)	(4) R^2 of price regr.	(5) R^2 of quantity regr.	(6) Obs. # (model degrees of freedom)
Agriculture <i>CN2 codes 1 to 15</i>	92.1%	63.9%	6821 (1420)	.	.	.
Food, beverages <i>CN2 codes 16 to 24</i>	91.2%	65.5%	11625 (2047)	94.4%	62.6%	1204 (271)
Minerals, chemicals <i>CN2 codes 25 to 38</i>	87.8%	68.9%	16277 (2649)	72.2%	73.3%	344 (129)
Plastics and rubber <i>CN2 codes 39 and 40</i>	82.8%	73.6%	16641 (2760)	94.3%	77.5%	583 (183)
Leather, skins, wood <i>CN2 codes 41 to 46</i>	96.0%	81.9%	2353 (562)	95.0%	68.7%	1220 (299)
Articles of paper <i>CN2 codes 47 to 49</i>	76.5%	70.4%	5843 (1257)	87.9%	76.2%	16 (12)
Textile articles <i>CN2 codes 50 to 63</i>	91.0%	70.1%	13544 (2679)	91.5%	67.3%	12276 (2165)
Footwear, accessories <i>CN2 codes 64 to 67</i>	87.7%	70.3%	322 (97)	86.4%	66.7%	356 (106)
Construction materials <i>CN2 codes 68 to 70</i>	92.7%	79.4%	2757 (612)	94.5%	73.4%	1114 (245)
Base metals, jewelry <i>CN2 codes 71 to 83</i>	88.2%	80.4%	10859 (2395)	92.9%	61.5%	274 (88)
Mechanical appliances <i>CN2 codes 84 and 85</i>	72.5%	68.8%	17672 (3369)	92.8%	73.5%	2884 (731)
Transport equipment <i>CN2 codes 86 to 89</i>	80.4%	69.1%	2160 (492)	97.6%	79.8%	330 (129)
Precision instruments <i>CN2 codes 90 to 93</i>	71.0%	66.2%	2128 (498)	89.0%	75.2%	550 (169)
Furniture and toys <i>CN2 codes 94 to 96</i>	84.4%	68.0%	5162 (980)	90.7%	72.5%	299 (85)

Notes: The results in this table are based on the restricted sample as described in Table 1, for quantities expressed in weight (kilograms) and units (liters, bottles, pairs etc). As regressors firm-CN8 and country-industry FE are included. The industry "Agriculture" has been dropped from the sample because it had only 4 observations and the same number of dummies. Prices and quantities are in logs.

4.5 Concluding remarks

In this Chapter the verti-zontal model presented in Chapter 3 has been shown to be congruent with the empirical observations based on two different datasets, one of which with an exceptional coverage of exporters, destinations and products. The model seems to be robust enough to perform well under quite general market and product definitions. This is reassuring and, while it leaves room for further tests on different contexts and data, it may justify the use of the verti-zontal model to study trade patterns and market competitiveness. To confirm this intuition, in the next Chapter the relevance of the model in a macro context is tested and it is shown how it can be used to undertake analyses at the country-sector level, which of course requires more assumptions in order to compensate the lower amount of detail of the information available.

Chapter 5

From micro to macro: evidence and applications

After having analyzed the theoretical and empirical validity of the verti-zontal model on micro data in the previous Chapters, this Chapter starts by testing whether the micro analysis undertaken so far can be extended to a macro context. In the previous Chapter it has been shown that the linearity of demand implied by the use of quadratic preferences is not rejected by the data at any level of product aggregation when varieties are defined as firm-product combinations, but this does not necessarily imply that the analysis can be extended to country-products, hence the tests. After the tests, the Chapter shows how the verti-zontal model can be applied to aggregate trade data as a way to extract information which may be relevant for policy purposes. Defining varieties as exporter-product combinations, the same methodology used to determine quality and taste mismatch of firm-product combinations can indeed be adopted to derive macroeconomic indicators of competitiveness at the sector-country level.

This Chapter is based on a Chapter of the DG ECFIN's European Economy Occasional Paper "EU Balance-of-Payment assistance for Latvia. Foundations of success" (Di Comite et al., 2012) and Economic Paper "Measuring quality and non-cost competitiveness at the country-sector level" (Comite, 2012), but extends them in two important directions, first, by testing explicitly for the validity of the macro adaptation of the verti-zontal approach and, second, by narrowing substantially the product definition from 97 CN2 products to more than 10.000 CN8 products.

5.1 Verti-zontal evidence in a macro context

Since the analysis of the verti-zontal model presented in the previous Chapter was based on a firm-level data, it may be argued that, a priori, there is no reason to believe that it can be automatically extended to the macro context. For this reason, this Section tests whether the assumptions and the structural form employed in the verti-zontal model are rejected when using aggregate trade data. For robustness, two different approaches are employed: one looking only at Belgian exports (as in the previous Chapter) and

the other using a cross section of EU28 country-product exports. The two datasets are obtained from Eurostat's COMEXT, with export data classified in terms of the Combined Nomenclature system employed also in the previous Chapter. In the first case, only Belgian CN8 exports are considered, in the second case the CN8 exports from the 28 members of the European Union. The key difference between the two methods consists in the definition of product categories. Whereas varieties are always interpreted as country-CN8 product combinations, product categories are defined as higher levels of aggregation in the case of Belgian exports (i.e., product codes in terms of 6 digits, CN6, 4 digits, CN4, and 2 digits, CN2) and simply as CN8 products in the case of EU28 country-product exports. The reason for the different definitions is that the unit of analysis (the variety) in the Belgian exports dataset is a Belgian-CN8 export, so that the smallest category which can be used to aggregate varieties is Belgium-CN6, followed by Belgium-CN4 and Belgium CN2. This is not the case for the EU28 cross-section dataset, where the unit of analysis is a exporter-CN8-importer combination, so that the product category can be defined as the CN8 product, whose varieties are the corresponding exporter-CN8 combinations, resulting in a maximum of 28 varieties per product. Higher levels of product aggregation (CN6, CN4 and CN2) are considered for robustness, keeping the definition of a variety constant (as an exporter-CN8).

To give some concrete examples, consider the CN8 code 90041010, used to identify the product "Sunglasses with optically worked lenses". In the EU28 cross-section, this is also a product category, Belgian 90041010 and French 90041010 being different varieties of it. In the Belgian exports dataset, instead, of the CN code 90041010 alone would be a variety and the product categories would be Belgian "Sunglasses" (CN6 code 900410), "Spectacles, goggles and the like" (CN4 code 9004) and "Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus" (CN2 code 90). It should be remembered from the previous Chapters that the definition of a product is relevant because the substitution effects described in the vertical model involve only varieties of the same product, the rest of the economy being captured by the numéraire. Therefore, the higher the level of aggregation, the looser the relation between the varieties included in it and less acceptable the technical model assumption of equal substitution patterns between varieties of the same product (which is common to virtually all trade models).

On the one hand, the analysis on Belgian exports has the disadvantage of using less narrow product categories but the advantage of fixing the exporter's location, obviating the concerns about institutional differences across exporting countries (think, for example, of strategic transfer pricing for particular products) or varying transport costs across varieties. On the other hand, the EU28 cross-section approach offers the benefit of having varieties differing only by their place of production, keeping the same physical and functional characteristics, but the disadvantage of not being able to account for the differences in transport costs or any other source of country-pair heterogeneity at the product level. Depending on which concern is deemed more compelling, one approach may be preferred over the other. In this Section it is shown that the two approaches yields very similar qualitative results and point in the direction of a confirmation of the

possibility of adopting a quadratic utility framework with variety-specific markup shifter and market-variety-specific quantity shifter.

5.1.1 Data used for macro validation of the verti-zontal model

All the data required for the exercise can be found on the Eurostat COMEXT database, searching for CN8 exports from the 28 European Union member states to any other country of the world. The firm-level analysis in the previous Chapter has been performed on a cross-section of Belgian firms based on 2005 data, therefore the same year has been selected for the macro validation. In addition, the year 2005 has the advantage to be one of the first years in which extensive information on all the EU28 member states is available on COMEXT.¹ Similarly to what has been done in the micro-level analysis, the sample needs some data cleaning before performing the analysis. First of all, because of the sheer size of the dataset (composed of 2,772,102 data points collected from 28 different statistics offices), there may be encoding mistakes that result in abnormal observations. These outliers are dealt with by cutting the top and bottom 1% of the price and quantity distributions. In addition, given that the exercise requires some variability across markets for each variety and across varieties for each market, the sample has to be restricted to varieties present in more than one market and markets being served by more than one variety. A market is here defined as country-product combination, where products are defined slightly differently in the two dataset, as explained above.

The effects of these restrictions on the final sample are shown in Table 5.1, which can be compared to Table 4.11 where the micro-data sample features are displayed. Column 1 of Table 5.1 shows the Belgian CN8 exports dataset; column 2 described the same sample after the restrictions on outliers and number of market and varieties; column 3 shows entire EU28 cross-section dataset; column 4 is its corresponding restricted sample.

¹Most of the countries display accurate CN8 trade statistics starting from 2002, but Poland, Malta and Slovakia start from 2004.

Table 5.1: The full and restricted data sample of Belgian firm-product-country exports.

	Belgian CN8 exports		EU28 cross-section	
	(1)	(2)	(3)	(4)
	Full sample	Restricted	Full sample	Restricted
Observations	177,230	60,401	2,772,102	2,139,445
Exporters	1	1	28	28
CN2 Products	96	89	96	96
CN4 Products	1,221	668	1,244	1,219
CN6 Products	4,932	1,471	5,221	4,957
CN8 Products	8,958	4,619	10,054	9,043
Exporter-CN2 Combinations	96	89	2,664	2,576
Exporter-CN4 Combinations	1,221	668	29,991	25,101
Exporter-CN6 Combinations	4,932	1,471	108,674	84,356
Exporter-CN8 Combinations	8,958	4,619	184,461	134,619
Destinations	185	167	186	185
Importer-CN2 Combinations	10,013	4,590	16,016	12,325
Importer-CN4 Combinations	57,231	14,667	145,713	95,097
Importer-CN6 Combinations	132,589	22,914	461,150	283,516
Importer-CN8 Combinations	177,230	60,401	727,814	425,736
Trade volume (bill. euros)	249	67.5	2,992	1,647
Destinations per variety:				
Mean	19.78	13.08	15.03	15.89
Median	12	8	6	8
Min	1	1	1	1
Max	147	107	179	158
Varieties per CN8-destination:				
Mean			3.81	5.03
Median			2	4
Min			1	2
Max			28	27
Varieties per CN6-destination:				
Mean	1.34	2.64	6.01	7.55
Median	1	2	3	5
Min	1	2	1	2
Max	34	30	352	280
Varieties per CN4-destination:				
Mean	3.10	4.12	19.02	22.50
Median	2	2	6	9
Min	1	2	1	2
Max	75	68	848	763
Varieties per CN2-destination:				
Mean	17.70	13.16	173.08	173.59
Median	6	5	36	37
Min	1	2	1	2
Max	779	468	11,317	10,133

Notes: "In the restricted samples, the bottom and top 1% of the price and quantity distributions are dropped. In addition, a minimum number of two markets per variety and of two varieties per market is imposed. Varieties are defined as exporter-CN8 combinations; markets are defined as importer-CN8 combinations in the EU28 cross-section and as importer-CN6 combinations for Belgian CN8 exports."

5.1.2 Empirical specifications

As for the micro-level exercise of the previous Chapter, equations (3.54) and (3.57) are used to run a goodness-of-fit test. The equations describing market outcomes in the verti-zontal are reported here with a slightly different notation to account for both the country where the variety s is produced, o , and the country where it is sold, i . Keeping trade costs implicit, equilibrium prices can thus be rewritten as

$$p_{s,oi}^* = \frac{\alpha_{s,o} + c_{s,oi}}{2} - \mathcal{T}_i \left(\frac{\tilde{a}_i - \tilde{c}_i}{2} \right)$$

or, writing trade costs explicitly, equilibrium prices become

$$p_{s,oi}^* = \frac{\alpha_{s,o} + c_{s,o}}{2} - \left(\mathcal{T}_i \frac{\tilde{a}_i - \tilde{c}_i}{2} - \frac{t_{oi}}{2} \right). \quad (5.1)$$

The corresponding quantities with implicit trade costs can be thus written as

$$q_{s,oi}^* = \frac{1}{\beta_{s,oi}} \left[\frac{\alpha_{s,o} - c_{s,oi}}{2} - \mathcal{T}_i \frac{\bar{a}_i - \bar{c}_i}{2} \right]$$

or, with explicit trade costs, as

$$q_{s,oi}^* = \frac{1}{\beta_{s,oi}} \left[\frac{\alpha_{s,o} - c_{s,o}}{2} - \left(\mathcal{T}_i \frac{\bar{a}_i - \bar{c}_i}{2} + \frac{t_{oi}}{2} \right) \right]. \quad (5.2)$$

The equations show that equilibrium prices and quantities can be seen as consisting of a first term, which is determined by firm-product level marginal cost ($c_{s,o}$) and quality ($\alpha_{s,o}$) in the country of origin, and a second term which depends on destination market specific variables (indexed by i). Variety-specific variation (cost and quality) can then be captured empirically by firm-product fixed effects, while local competition effects in the destination market can be captured by country-product fixed effects. On top of these two sources of variability, the quantity equation alone is characterized also a variety-country-pair-specific source of variability, which is what distinguishes the verti-zontal model from the existing workhorse trade models and is thus the object of the current analysis.

The empirical specification follows closely the micro-level exercise presented in the previous Chapter, with prices ($y_{s,oi} = p_{s,oi}$) and quantities ($y_{s,oi} = q_{s,oi}$) of varieties being regressed on a variety and a destination set of dummies. Notice that instead of the firm-product dummies used in the firm-level analysis, in a macroeconomic environment the producers are identified by the origin of the trade flow (the exporting country), following the standard Armington (1969) assumption used in macro trade models. As for the destination markets, both in the micro and the macro context, their are represented by the country of destination of the trade flow, taking into account that imported varieties compete with each other within specific product categories defined at different CN levels. Hence, varieties are exporter-CN8 product combinations whereas markets are importer-CN product combinations:

$$y_{s,oi} = \delta_0 + \delta_1 \text{Variety}_{s,o} + \delta_2 \text{Importer_Product}_i + \epsilon_{s,oi} \quad (5.3)$$

In the regressions alternatively price and quantity level data are used as dependent variables, $y_{s,oi} = p_{s,oi}, q_{s,oi}$.

It should be remembered that one of the key results of the verti-zontal model is that the set of dummies in (5.3) should perform better in explaining prices than quantities because exporter-product dummies account for variety-specific cost and quality determinants of prices whereas destination market-specific dummies capture all the characteristics of the importer shifting demand for all the varieties sold in the market. Quantities should instead be explained less well by this specification because variety-market-specific effects are not included out, but according to the model they should play an important role in determining total sales, without affecting prices. This is expected to determine a consistently lower R^2 for quantity dummy regressions also in a macro context.

When one country of origin for the exports is considered, such as in the micro-level analysis of the previous Chapter or the analysis of this Chapter based on the Belgian exports, the specification in (5.3) can implicitly account for trade costs through the destination market dummies, but in the case of multiple exporters (or to test explicitly the role of transport costs in explaining part of the variability), the specification in (5.3) can be adapted as follows, using distance as a proxy for trade costs:

$$y_{s,oi} = \delta_0 + \delta_1 Variety_{s,o} + \delta_2 Importer_Product_i + \delta_3 Distance_{oi} + \epsilon_{s,oi}. \quad (5.4)$$

As in the previous Chapter, distance is included both as a robustness check of the model (where prices are expected to be positively correlated with transport costs) and as a test of the validity of alternative models to the verti-zontal that would explain variability in first-on-board (fob) prices across destination markets only in terms of transport costs, such as the model based on CES preferences with linear transport costs discussed by Crozet et al. (2012) and Martin (2010).

5.1.3 Empirical results based on the aggregate Belgian export data

Following the structure of the previous Chapter's test based on micro-level Belgian exports data, the analysis proceeds as follows. First individual country, product and variety dummies are included alone in the dummy regression. Then the relative importance of variety and market effects is investigated through an ANOVA analysis. Finally, the two set of dummies (with and without distance regressors) are included, first on the entire sample, then product by product and in the end by splitting the sample into industries. The analysis is performed on the Belgian export and then on the EU28 cross section, comparing the results on the two datasets for each table.

Heterogeneity across firms, products and markets

Before discussing the results of the specification (5.3), in Tables 5.2, 5.3 and 5.4 is first reported the variation explained by exporter, product, importer and market (i.e., importer product) effects alone, with and without distance. Quantities are expressed in kilograms and are considered in raw total terms, in per capita terms and in terms of units of GDP.

While Table 5.2 presents results on aggregate Belgian export data, Tables 5.3 and 5.4 are based on the E28 cross section, the first without the effect of distance and the second including distance as a regressor. Of course, exporter effects cannot be included in Table 5.2 where only Belgian exports are considered, and similarly distance cannot be introduced in the dummy regressions on Belgian export data when destination and market dummies are included because of collinearity (columns 9 to 12). Thus distance in Table 5.2 is included only with variety dummies, i.e. in columns 2, 4, 6 and 8.

The simplified empirical specifications for these tests can be written as

$$y_{s,oi} = \delta_0 + \delta_1 \text{IndividualSourceOfVariability} + \epsilon_{s,oi},$$

where *IndividualSourceOfVariability* is without subscript because it can be at the product (*s*), variety (*s, o*) or market level (*i*). When also distance is included, it can instead be written as

$$y_{s,oi} = \delta_0 + \delta_1 \text{IndividualSourceOfVariability} + \delta_3 \text{Distance}_{oi} + \epsilon_{s,oi}.$$

Consistently with Martin (2012), distance is found to affect prices in a positive and significant way in the three Tables, yet its impact on the total price variability explained is so small that cannot be seen at the level of precision reported in Table 5.2 and in Tables 5.3 and 5.4 it is never higher than 0.2% or 0.3% of total variability. This is in line with the results presented in the previous Chapter and would not be consistent with models where the only source of fob price variability across markets is due to differences in linear transport costs. In the case of the verti-zontal model, transport costs are just one of the possible sources of variability (the others being variety-specific cost and quality and destination market-specific competition), so the little amount of variability explained by distance is less of a concern. The quantity variability explained increases slightly more than price variability with the inclusion of distance in the three Tables, which is consistent with the idea of taste mismatch being somehow related to the physical proximity between the place of production and consumption of a certain product.

As for the other results of Table 5.2, it can be noticed that they are in line with the results of the previous Chapter on the firm level and point in the direction of a high amount of price variability explained by both variety specific dummies and market specific dummies, systematically higher than the quantity variability explained (with the exception of the case in which only importer's fixed effects are considered, where price variability is almost completely left unexplained by the regression). Indeed, in columns 1 to 8 product fixed effects are shown to explain between 22.6% and 60.8% of price variability, increasing in the level of disaggregation of the product definition. The quantity variation explained is instead much lower, ranging from 2.8% to 27.7% considering quantities, quantities per capita and quantities per unit of GDP, indicating a much larger dispersion of quantities across varieties within the same product category than prices.

Similarly, importer-product fixed effects are shown in columns 9 to 12, approximating not only the destination market effects in (5.1) but also part of the taste effects, β , for

Belgian exported products (because the exporting country is fixed in Table 5.2). Hence, it can be noted that the explained variability for quantities is substantially higher than in the previous columns, ranging from 4.6% to 56.4% at the most detailed product-level (importer-CN8) considering quantities per unit of GDP. The R^2 for price regressions is still higher than for quantity regressions, but they are closer to each other when importer-product fixed effects are considered as opposed to when only products or varieties are considered.

Turning to the EU28 cross section in Tables 5.3 without distance and 5.4 with distance, it can be noted that the results are qualitatively the same. In columns 1 and 2 exporter-fixed effects and importer-fixed effects alone are included to see how much data variation in prices and quantities is explained by exporting-country characteristics. Including only exporter-FE or importer-FE is equivalent to assuming that there is only one source of heterogeneity in the data and it works at the country level (as, for example, the level of GDP or the exchange rate). The results in columns 1 and 2 show that exporters' or importers' characteristics play almost no role in explaining the variation in prices and quantities, as they explain less than 2% of the total variation in prices and an even lower amount of variation in quantities when transport costs are not included.² This finding suggests that it would not be correct to consider countries as big multi-product firms with a similar level of efficiency (say, because of technology) across the different products, at least as long as EU member states are considered (this finding may not be automatically extended to datasets with developed and developing countries, where there may arguably be at least an exporter effect on prices). This result may also appear counterintuitive in that it is common to think that macroeconomic characteristics of a country such as its institutions, laws, regulations, openness to trade among others may affect its trade performance, but this notion seems to be rejected by the observation of the variability captured by country dummies, both as far as importers and exporters are concerned. One important caveat is that this methodology implicitly looks only at the intensive margin (i.e., how much of a given CN8 product is exported or imported by a country) and hence it does not rule out adjustments on the extensive margin (i.e., that a given country exports or imports a higher number of CN8 products) because of specific country characteristics, which may be an important source of heterogeneity between countries in terms of overall trade performance.³

As for the product fixed effects, at different level of aggregation, in columns 3 to 6 they are shown to explain between 20.9% and 43.4% of price variability in Table 5.3 and between 21.2% and 43.5% in Table 5.4, increasing in the level of disaggregation of the product definition. The quantity variation explained is instead much lower, ranging from 3.1% to 11.6% considering quantities, quantities per capita and quantities per unit of

²Interestingly, when no product or variety dummies are included, the inclusion of transport costs substantially increases the amount of variability captured in terms of quantities, even if not in terms of prices.

³For example, in 2005 Belgium exported 6,574 different CN8 products to the rest of the world. Portugal, with a similar population, exported only 4,195 CN8 products and Sweden, with a similar GDP in 2005 exported 5,430 CN8 products. This suggests that even if country differences in terms of intensive margins are not significant, there is still room for large differences on the extensive margin.

GDP with and without distance, indicating a much larger dispersion of quantities across varieties within the same product category than prices. This result suggests a very low level of fob price equalization in international trade and confirms the need to focus of models of international trade with imperfect competition and imperfect substitutability between varieties of the same product.

Combining the information on exporters and product categories, exporter-product fixed effect are considered in columns 7 to 10, capturing the variety effect at the exporter-CN8 level. The price variation captured is higher than for product dummies alone and ranges from 24.8% to 57.5% in Table 5.3 with almost no increase due to the inclusion of distance regressors, again increasing the disaggregation of product definition. The quantity variation explained ranges instead from 4.1% to 21.2%, with a slightly higher impact of distance. These numbers show that, differently from exporter fixed effects, exporter-product fixed effects have a substantial explanatory power, which is comparable and even more pronounced than firm effects found in the previous Chapter on micro-level export data and in the literature (Eaton et al., 2011; Lawless and Whelan, 2008; Munch and Nguyen, 2014). In fact, in the firm-level analysis, firm-level fixed effects explained 38.3% of the price variation of Belgian exporters and slightly less than 20% of variation for quantities per unit of GDP.

Therefore, at the product level, institutional, technological or other country-product specific features of the exporters do seem to play an important role in determining prices and quantities traded, to an extent similar to firm-level effects in a micro-level dataset. It still captures less variability than the firm-product fixed effects used in the previous Chapter in the micro-level context, but it could be expected that higher levels of aggregation imply a lower capacity to fit the data. It is reassuring to find such a similarity in the behavior of firm-product fixed effects in a firm-level dataset and exporter-product fixed effects in a country-product-level dataset because it suggests that the assumption of variety-specific quality and cost parameters holds at different levels of aggregation.

Finally, importer-product fixed effects are shown in columns 11 to 14, approximating the market effects. The price variability explained is surprisingly similar to the exporter-product fixed effects at the same level of product definition. This is not true of quantity variability, though, which is substantially higher than in the previous columns, ranging from 9.6% to 41.0% at the most detailed product-level (importer-CN8) considering quantities per unit of GDP and the impact of distance. The R^2 for price and quantities in general are closer to each other when importer-product fixed effects are considered. This is not a surprise and is consistent with both the verti-zontal and CES models. Remember indeed that in the verti-zontal model country-product dummies which capture destination country-effects affect both prices and quantities. But country-product effects, at least in part, also capture part of the taste heterogeneity since taste varies across countries. Notice that unreported F-tests turn out to be significant for all the single-attribute models considered also in the macro context, as they were in the previous Chapter, so models not including one of these sources of heterogeneity may be not using all the information contained in the data. To test this intuition explicitly, however, the different sources of heterogeneity have to be introduced together, as shown in what follows.

Table 5.2: Single-attribute Models and Goodness-of-fit for Belgian exports, with and without distance.

	(1) $y = p, q$	(2) $y = p, q$	(3) $y = p, q$	(4) $y = p, q$	(5) $y = p, q$	(6) $y = p, q$	(7) $y = p, q$	(8) $y = p, q$	(9) $y = p, q$	(10) $y = p, q$	(11) $y = p, q$	(12) $y = p, q$
CN2 Product FE	YES	YES										
CN4 Product FE			YES	YES								
CN6 Product FE					YES	YES						
CN8 Product FE							YES	YES				
Importer FE									YES			
Importer-CN2 FE										YES		
Importer-CN4 FE											YES	
Importer-CN6 FE												YES
Goodness of fit												
Price reg. R^2	22.6%	22.6%	39.2%	39.2%	47.8%	47.8%	60.8%	60.8%	1.2%	29.2%	56.6%	68.6%
Quantity reg. R^2	2.8%	3.5%	7.2%	7.9%	10.5%	11.3%	20.4%	21.3%	4.6%	16.4%	37.1%	52.1%
Q.per Capita reg. R^2	3.9%	3.9%	8.7%	8.7%	12.1%	12.1%	21.6%	21.6%	6.5%	18.8%	38.9%	52.0%
Q.per GDP reg. R^2	6.0%	6.0%	13.7%	13.7%	17.9%	17.9%	27.7%	27.7%	10.0%	30.1%	47.8%	56.4%
Distance coefficients												
In price reg. T-statistic		0.016 (2.8) ***		0.007 (1.4)		0.010 (2.0) **		0.012 (2.6) ***				
In quantity reg. T-statistic		-0.680 (20.5) ***		-0.743 (22.1) ***		-0.789 (23.2) ***		-0.858 (25.6) ***				
In Q.per Capita reg. T-statistic		-2.8e-08 (-29.6) ***		-3.2e-08 (-32.7) ***		-3.4Ee-08 (-34.2) ***		-3.7e-08 (-38.3) ***				
In Q.per GDP reg. T-statistic		5.5e-14 (1.1)		-2.24e-13 (4.5) ***		-4.0e-13 (8.0) ***		-6.3e-13 (12.9) ***				

Notes: The results in this table are based on the restricted sample as described in Table 5.1. Quantities are expressed in weight (kilograms). Significance of the distance coefficients is reported at 10% (*), 5% (**) and 1% (***) level.

Table 5.3: Single-attribute Models and Goodness-of-fit for EU28 cross section.

	(1) $y = p;$ $y = q$	(2) $y = p;$ $y = q$	(3) $y = p;$ $y = q$	(4) $y = p;$ $y = q$	(5) $y = p;$ $y = q$	(6) $y = p;$ $y = q$	(7) $y = p;$ $y = q$	(8) $y = p;$ $y = q$	(9) $y = p;$ $y = q$	(10) $y = p;$ $y = q$	(11) $y = p;$ $y = q$	(12) $y = p;$ $y = q$	(13) $y = p;$ $y = q$	(14) $y = p;$ $y = q$
Exporter FE Importer FE	YES	YES												
CN2 Product FE CN4 Product FE CN6 Product FE CN8 Product FE			YES	YES	YES	YES								
Exporter-CN2 FE Exporter-CN4 FE Exporter-CN6 FE Exporter-CN8 FE							YES	YES	YES	YES				
Importer-CN2 FE Importer-CN4 FE Importer-CN6 FE Importer-CN8 FE											YES	YES	YES	YES
Goodness of fit														
Price reg. R^2	1.5%	1.2%	20.9%	34.7%	40.5%	43.4%	24.8%	41.8%	52.0%	57.5%	23.6%	40.4%	50.8%	56.5%
Quantity reg. R^2	0.3%	0.4%	3.2%	5.9%	7.7%	8.9%	4.5%	9.4%	14.1%	17.5%	9.5%	16.3%	24.2%	30.6%
Q.per Capita reg. R^2	0.3%	0.6%	3.1%	5.5%	7.2%	8.5%	4.1%	8.6%	13.0%	16.6%	11.8%	19.7%	28.2%	35.1%
Q.per GDP reg. R^2	0.3%	0.7%	3.1%	6.9%	9.4%	11.3%	4.5%	10.9%	16.7%	21.2%	14.0%	25.1%	34.7%	41.2%

Notes: The results in this table are based on the restricted sample as described in Table 5.1. Quantities are expressed in weight (kilograms).

Table 5.4: Single-attribute Models and Goodness-of-fit for EU28 cross section, accounting for distance.

	(1) $y = p;$ $y = q$	(2) $y = p;$ $y = q$	(3) $y = p;$ $y = q$	(4) $y = p;$ $y = q$	(5) $y = p;$ $y = q$	(6) $y = p;$ $y = q$	(7) $y = p;$ $y = q$	(8) $y = p;$ $y = q$	(9) $y = p;$ $y = q$	(10) $y = p;$ $y = q$	(11) $y = p;$ $y = q$	(12) $y = p;$ $y = q$	(13) $y = p;$ $y = q$	(14) $y = p;$ $y = q$
Exporter FE	YES													
Importer FE		YES												
CN2 Product FE			YES											
CN4 Product FE				YES										
CN6 Product FE					YES									
CN8 Product FE						YES								
Exporter-CN2 FE							YES							
Exporter-CN4 FE								YES						
Exporter-CN6 FE									YES					
Exporter-CN8 FE										YES				
Importer-CN2 FE											YES			
Importer-CN4 FE												YES		
Importer-CN6 FE													YES	
Importer-CN8 FE														YES
Goodness of fit														
Price reg. R^2	1.8%	1.3%	21.2%	34.8%	40.7%	43.5%	24.9%	41.8%	52.1%	57.6%	23.6%	41.4%	50.9%	56.5%
Quantity reg. R^2	0.9%	4.4%	3.7%	6.4%	8.2%	9.5%	5.1%	10.1%	14.9%	18.4%	9.7%	18.6%	24.5%	31.0%
Q.per Capita reg. R^2	1.5%	6.2%	4.1%	6.5%	8.3%	9.7%	5.3%	9.9%	14.5%	18.2%	12.0%	23.0%	28.5%	35.4%
Q.per GDP reg. R^2	0.5%	7.3%	3.3%	7.1%	9.7%	11.6%	4.7%	11.2%	17.1%	21.8%	14.2%	23.3%	34.9%	41.4%
Distance coefficients														
In price reg.	0.07	0.21	0.07	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.16	0.13	0.12	0.12
T-statistic	(68.2)	(30.8)	(74.7)	(69.5)	(66.7)	(68.0)	(54.4)	(51.1)	(50.5)	(53.9)	(26.7)	(22.7)	(21.9)	(22.5)
In quantity reg.	-0.13	-0.51	-0.11	-0.11	-0.11	-0.12	-0.13	-0.14	-0.16	-0.17	-0.50	-0.55	-0.61	-0.68
T-statistic	(99.5)	(61.4)	(89.2)	(89.0)	(92.2)	(96.5)	(101.0)	(108.8)	(120.2)	(130.6)	(60.1)	(64.8)	(70.2)	(76.4)

Notes: The results in this table are based on the restricted sample as described in Table 5.1. Quantities are expressed in weight (kilograms). All coefficients for the distance regressor are significant at the 1% confidence level. Coefficients on the distance regressors for quantities per capita and quantity per GDP are also all negative and significant. They are available under request.

ANOVA analysis

The single-attribute models in Tables 5.2, 5.3 and 5.4 show that variety (or exporter-product) and market fixed effects yield a high R^2 , especially with observations at the CN6 or CN8 level of product aggregation, but it is impossible to know the relative importance of each in explaining data variability by simply comparing R^2 across different models.⁴ The relative importance of each type of fixed effect, when also the other is included, can be determined through a variance decomposition analysis (ANOVA), which can also be useful to discriminate between quadratic utility and CES models since quadratic utility models predict that country effects are an important determinant of prices while CES type of models see no role for country-effects to explain price variability.

The ANOVA analysis on Belgian aggregate export data and on the EU28 cross section are reported, respectively, in Tables 5.5 and 5.6. For Belgian exports, in Table 5.5 a combined attribute model of Belgian-CN8 varieties and different market definitions, ranging from entire countries (column 1) to country-CN6 products (column 4). Again, distance cannot be included in Table 5.5 because of collinearity with the destination dummies. For the cross section of EU28 exports, the ANOVA analysis can be richer, including the impact of distance and of different levels of product definition also in the definition of a variety. Thus, different combined attribute models of exporter-products (as varieties) and importer-product (as destination markets) are considered at different levels of product definition, from exporter and importer fixed effects alone (column 1) to exporter-CN8 and importer-CN8 fixed effects with the inclusion of distance (column 10).

The Tables report then mean sum of squares (MS) associated with each type of regressor (the dummies and the distance) because the number of dummies associated with variety and market fixed effect is very different in the different specifications, so one may wrongly conclude that one type of fixed effects is more important than the other in explaining total variation simply because of a higher number of dummies associated with it. Indeed, the Mean Sum of Squares (MS) is the outcome of dividing the Partial Sum of Squares of each regressor by its degrees of freedom from the regressions, so it can be seen as giving the explanatory power of each regressor per degree of freedom.

The different specifications explored in the columns of the Tables 5.5 and 5.6 tell a consistent story. At any level of product or market aggregation, the ANOVA decomposition suggests that variety and market effects are of similar importance in capturing variability, so that the use of a combined model is justified. As in the previous Chapter's ANOVA analysis, the importance of variety and market fixed effects is about even in the quantity regressions, while variety fixed effect appear more important than market fixed effects in the price regressions, per degree of freedom. The inclusion of distance in Table 5.6 doesn't change substantially the results, but it soaks up some of the variability explained by both variety and market effects in terms of both prices and quantities.

Therefore, the ANOVA analysis confirms that variety and market effects should be included simultaneously to explain price and quantity variation and, in addition, trade

⁴Only when the regressors are orthogonal and completely uncorrelated the increase in the R^2 indicates what the contribution of each regressor is, but this is unlikely here, if only because they capture more than 50% of variability at the CN8 product level.

models should account for the impact of transport costs on fob price variability.

Table 5.5: Analysis of Variance in dummy regressions for Belgian exports.

Mean Sum of Squares in price regressions ($y = p$)				
	(1)	(2)	(3)	(4)
Variety FE	6.12e+07	3.35e+07	3.03e+07	3.04e+07
Importer FE	6.38e+06			
Importer-CN2 FE		6.53e+06		
Importer-CN4 FE			8.48e+06	
Importer-CN6 FE				8.35e+06
Mean Sum of Squares in quantity regressions ($y = q$)				
	(1)	(2)	(3)	(4)
Variety FE	3.47e+09	3.57e+09	2.49e+09	2.50e+09
Importer FE	6.74e+09			
Importer-CN2 FE		2.47e+09		
Importer-CN4 FE			2.82e+09	
Importer-CN6 FE				2.66e+09

Notes: The results in this table are based on the full sample as described in Table 5.1, with the bottom and top 1% of the price and quantity distributions dropped and imposing a minimum number of five markets per variety and of five varieties per market for computational reasons. The results refer to dummy regressions, with and without distance regressors, on unit values and quantities expressed in kilograms.

Table 5.6: Analysis of Variance in dummy regressions on the EU28 cross section, with and without distance regressors.

Mean Sum of Squares in price regressions ($y = p$)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Exporter FE	5.27e+08	5.20e+08								
Exporter-CN2 FE			9.70e+07	9.62e+07						
Exporter-CN4 FE					5.30e+07	5.28e+07				
Exporter-CN6 FE							4.07e+07	4.06e+07		
Exporter-CN8 FE									3.84e+07	3.83e+07
Importer FE	1.11e+08	9.31e+07								
Importer-CN2 FE			3.11e+07	3.04e+07						
Importer-CN4 FE					2.00e+07	1.97e+07				
Importer-CN6 FE							1.62e+07	1.60e+07		
Importer-CN8 FE									1.55e+07	1.53e+07
Distance		6.12e+08		6.33e+08		6.38e+08		6.71e+08		6.79e+08
Mean Sum of Squares in quantity regressions ($y = q$)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Exporter FE	1.23e+10	1.22e+10								
Exporter-CN2 FE			1.13e+09	1.14e+09						
Exporter-CN4 FE					5.82e+08	5.91e+08				
Exporter-CN6 FE							4.45e+08	4.52e+08		
Exporter-CN8 FE									4.25e+08	4.31e+08
Importer FE	3.84e+09	4.22e+09								
Importer-CN2 FE			6.49e+08	7.13e+08						
Importer-CN4 FE					3.98e+08	4.31e+08				
Importer-CN6 FE							3.33e+08	3.59e+08		
Importer-CN8 FE									3.24e+08	3.48e+08
Distance		6.35e+10		7.76e+10		8.60e+10		8.72e+10		8.71e+10

Notes: The results in this table are based on the full sample as described in Table 5.1, with the bottom and top 1% of the price and quantity distributions dropped and imposing a minimum of fifteen markets per variety and fifteen varieties per market for computational reasons. The results refer to dummy regressions, with and without distance regressors, on unit values and quantities expressed in kilograms.

Combining variety and market dummies

While the results on single-attribute models in Tables 5.2, 5.3 and 5.4 suggest that variety and market dummies in isolation are relevant, the variance decomposition in Tables 5.5 and 5.6 suggest that the two set of dummies should be included together to explain price and quantity variability. Also distance (approximating transport costs) shows a high level of variability captured per exogenous variable used (in fact, for distance, the partial SS and the MSS coincide and are almost constant across specifications because only one regressor is used) as compared to the individual contribution of each one of the large set of variety and market dummies employed in the regressions, which explains why the coefficients for distance are always statistically significant even though the total variability explained by the model is virtually unaffected by the inclusion of distance.

The results associated with their combinations are reported in Tables 5.7 for Belgian aggregate exports and 5.8 for the EU28 cross section, for different levels of product definition. In Table 5.7 product definition ranges from CN2 (column 1) to CN8 (column 4). In Table 5.8 also importer and exporter fixed effects are included, and the results associated with each level of product definition are shown with and without the effect of distance. Notice that the number of dummies used in the CN8 level of product definition is particularly high (more than 543,000), which required the use of the estimation procedure proposed by Guimares and Portugal (2010) to estimate models with high-dimensional fixed effects.⁵

Independently of the product-market definition, it can be seen that in both Tables the variability explained by the dummy regressions on prices is always higher than by the same regressions on quantities. The only exception is the inclusion of importer and exporter fixed effects alone, which are again shown to capture almost no variability on prices and slightly more variability in quantities even when they are considered together. Considering all the regressions, the difference between price and quantity regressions' R^2 is never smaller than 12.1% of total variability and can be as high as 34.2%. These figures may provide an indication as to how much variability could be captured by the taste mismatch variable, the parameter β in the vertical model, which is defined at the variety-market level. As for the inclusion of distance, it is again shown to be insignificant in terms of total price variability explained but statistically significant in terms of its marginal impact on prices, consistently with the single-attribute models tested earlier. It also has a slightly stronger impact on quantities, which can be attributed to taste differences, as discussed earlier.

It should be noticed that the price and quantity variability captured by the dummy regressions on the Belgian aggregate exports dataset is higher than the variability captured by the same regressions on the EU28 cross section. One possible reason is the number of dummies over the total number of observations, which are almost 50% at the CN8 product level for Belgian aggregate exports and slightly more than 25% at the CN8 product level for the EU28 cross section. Another possible reason is that there may be

⁵In contrast, for the ANOVA analysis the sample had to be restricted by raising the number of markets served by each variety and varieties present in each market to reduce the number of fixed effects to be included for computational reasons.

country-pair or product-country-pair specific demand shifters (such as a common border, a common language or a common legal system in the case of country pairs and common product market regulation in the case of product-countries pairs) that are implicitly captured when the exporting country is fixed and are lost when different exporters and importers are pooled. Notice, however, that these demand shifters should not be related to distance or transport costs, because otherwise the inclusion of the distance regressor in Table 5.4 should have reduced the gap.

As in the micro-level analysis in the previous Chapter, two important insights emerge from the regressions on the combined-attribute models. The first is that a large part of the overall price variability is captured by a combination of variety and market dummies, which is less the case for quantity variability. The total variability captured by the firm-level analysis was higher indeed, but the difference can be attributed to the higher level of aggregation of the unit of analysis for aggregate trade data. It is worth remembering that this result is in sharp contrast with models that predict that prices and quantities should be perfectly correlated because they depend on the same sources of variability. In addition it is in contrast with models predicting no variability across markets in fob prices and that marker-specific characteristics only affect quantity variability, as the standard CES-based models. Second, the empirical results suggest the linearity of demand does a good job in fitting price variability but performs consistently worse in fitting quantities. This is in line with what one would expect from the quadratic preferences employed in the verti-zontal model.

Table 5.7: Goodness-of-fit of the verti-zontal model for Belgian exports.

	(1) $y = p, q$	(2) $y = p, q$	(3) $y = p, q$	(4) $y = p, q$
CN2 Product FE	YES			
CN4 Product FE		YES		
CN6 Product FE			YES	
CN8 Product FE				YES
Importer-CN2 FE	YES			
Importer-CN4 FE		YES		
Importer-CN6 FE			YES	
Importer-CN8 FE				YES
Goodness of fit				
Price regression R^2	61.1%	65.0%	74.6%	80.0%
Quantity regression R^2	26.9%	36.9%	53.6%	63.5%
Q per capita regression R^2	31.1%	40.7%	55.3%	64.2%
Q per GDP regression R^2	28.2%	40.2%	50.5%	56.4%
Number of dummies	4,825	9,263	19,466	27,905

Notes: The results in this table are based on the restricted sample as described in Table 5.1. Quantities are expressed in kilograms. The total number of observations is 61,377.

Table 5.8: Goodness-of-fit of the verti-zonal model in the EU28 cross section, with and without distance regressor.

	(1) $y = p, q$	(2) $y = p, q$	(3) $y = p, q$	(4) $y = p, q$	(5) $y = p, q$	(6) $y = p, q$	(7) $y = p, q$	(8) $y = p, q$	(9) $y = p, q$	(10) $y = p, q$
Exporter FE	YES	YES								
Exporter-CN2 FE			YES	YES						
Exporter-CN4 FE					YES	YES				
Exporter-CN6 FE							YES	YES		
Exporter-CN8 FE									YES	YES
Importer FE	YES	YES								
Importer-CN2 FE			YES	YES						
Importer-CN4 FE					YES	YES				
Importer-CN6 FE							YES	YES		
Importer-CN8 FE									YES	YES
Goodness of fit										
Price regression R^2	2.5%	2.5%	27.1%	27.1%	46.8%	46.8%	61.0%	61.0%	68.9%	68.9%
Quantity regression R^2	4.7%	5.0%	11.3%	11.6%	20.9%	21.4%	33.0%	33.6%	43.0%	44.0%
Q per capita regression R^2	6.2%	6.5%	12.9%	13.2%	23.0%	23.5%	34.5%	35.2%	44.2%	45.0%
Q per GDP regression R^2	7.2%	7.4%	14.8%	15.0%	27.5%	27.8%	39.4%	39.8%	48.0%	48.4%
Number of dummies	210	210	14,724	14,670	117,934	117,799	358,541	358,353	543,417	543,203
Distance coefficients										
In price reg.		0.14		0.09		0.08		0.11		0.14
T-statistic		(20.0)		(13.2)		(13.8)		(19.2)		(24.2)
In quantity reg.		-0.78		-0.87		-1.09		-1.38		-1.67
T-statistic		(69.8)		(78.4)		(97.2)		(118.7)		(141.6)
In Q.per Capita reg.		-5.3e-08		-5.9e-08		-7.1e-08		-8.7e-08		-1.0e-07
T-statistic		(84.0)		(94.0)		(113.2)		(134.0)		(155.9)
In Q.per GDP reg.		-3.1e-12		-3.5e-12		-4.1e-12		-5.0e-12		-5.8e-12
T-statistic		(64.2)		(71.9)		(87.1)		(101.8)		(116.2)

Notes: The results in this table are based on the restricted sample as described in Table 5.1. Some observations are lost when distance is included as a regressor because of missing data: they are 2,100,204 in the regressions without distance and 2,099,676 when distance is included. Quantities are expressed in kilograms. All coefficients for the distance regressor are significant at the 1% confidence level.

Regressions by products and industries

The results reported in Tables 5.7 and 5.8 are obtained by using the entire samples with all the data pooled. This procedure may hide some differences across products or industries. To tackle this issue, the results on product-by-product dummy regressions are shown in Table 5.9 for Belgian aggregate exports and Table 5.10 for the EU28 cross section. In practice, this amounts to restrict the sample to one particular product, defined at the CN8, CN6, CN4 or CN2 level and then regress the restricted sample on the variety and market dummies as in specification (5.3).

While varieties are always defined as an exporter-CN8, the definition of the relevant destination market varies in the two Tables and within the Tables as follows. For Belgian aggregate exports, Table 5.9 uses two possible definitions of markets, one including only the importer country dummy, which is equivalent to consider as a destination market the importer-CN product under consideration (CN2, CN4 and CN6); the alternative is to consider a relevant destination market the importer-CN6 combination, even when the sample is divided into CN2 and CN4 products. This latter approach amounts to assuming that CN8 Belgian exports compete (i.e. have a positive degree of substitutability) with the other Belgian CN8 products only within the same CN6 product category. The former approach, instead, amounts to assuming that Belgian CN8 exports compete with the other Belgian CN8 products within the same CN2 category or CN4 category. Since in this thesis the issue of the right size of the relevant market is not addressed explicitly, the results are presented for all of them to show how robust is the theory to the choice of the relevant markets to consider.

For the EU28 cross section of exports, in Table 5.10, the definition of markets is similar, but it exploits the additional sample variability granted the presence of multiple exporters to define destination markets more narrowly. Therefore, while the first of the two alternative destination market definitions is simply the importer country, as in Table 5.9, the second definition of a destination market is the importer-CN8 combination. This amounts to assume that the 28 varieties of one CN8 products exported from the 28 member states compete only within their product category, the substitution effects vis-à-vis the rest of the economy being captured by the numéraire affecting all the products in a similar way. Since the most detailed product levels (CN6 for the aggregate Belgian exports and CN8 for the cross section) are the ones where the variability captured in quantity and price regressions is the closest, they are also the ones that are most likely to reject the model and thus represent the strictest test that can be performed.

After running the regressions on varieties and markets as defined above, the summary statistics of their results are reported in Tables 5.9 and 5.10. In column 1 is reported the weighted average R^2 across all CN products considered, where the weight is determined by the number of observations. In column 2 is displayed how many times the R^2 for price regressions is higher than for quantity regressions over the number of regressions run. In column 3 is reported the number of products considered. For each column, in the two Tables, results are reported first using the narrowest destination market definition and then using only the importer country dummy.

In Table 5.9, in the first pane first are considered all the varieties belonging to the

same CN2, which results in 89 different CN2 products. For each of these products a separate regression is run on prices and quantities with variety and market fixed effects. The weighted average R^2 associated with regressions on prices is confirmed to be higher than the corresponding R^2 for regressions on quantities, for the two different definitions of destination markets. It can be noticed that moving from an importer-CN2 to an importer-CN6 market definition the average price and quantity variability captured increases by around 20% of total variability for prices and even more for quantities. Column 2 shows the percentage of times that the goodness-of-fit in the price regressions exceeds that of the quantity regressions, which ranges from 68.5% to 78.7%.

The following two panes describe results for products defined at the CN4 and CN6 level, which are associated with a higher R^2 in both prices and quantities, with the goodness-of-fit of quantity regressions closing the gap with the price regressions but never reaching it in average terms. In the last one, it can be noted that quantity regressions capture almost as much variability as price regressions in Table 5.9. This proximity may suggest that there is little room left for the additional source of variability assumed in the verti-zonal model, the variety-market specific, β . Still, it should be noticed that, when the sample is divided into CN6 products in the Belgian aggregate export dataset, all the resulting CN8 varieties competing within the product category are produced in the same country (Belgium) and shipped to the same destination, the corresponding importer-CN6 combination, so it may be argued that a good part the differences in taste mismatch between varieties may be captured by the market dummies. In fact, the difference between the variability captured in price and quantity variations at the narrowest level of market definition is higher in Table 5.10, where different exporters and importers are considered (thus leaving the exporter-product-importer market source of variability out of the regression).

Comparing Table 5.9 and Table 5.10, the goodness-of-fit is lower for all the regressions in the latter than in the former, as found also in the previous Tables. However, the results are qualitatively the same for the different levels of product aggregation and for different market definitions. Looking at column 2, it can be spotted indeed that dummy regressions on prices capture more variability than quantity regressions the large majority of times, from 59.9% of the times when quantities per capita are considered at the CN8 product level definition to 95.8% of the times when quantities per unit of GDP are considered at the CN2 product level.⁶

Regressions at product-level thus confirm that prediction that a linear model appears to have less predictive power in quantity regressions, possibly because of a variety-destination market source of variability. As remarked in the previous Chapter, the product-by-product analysis shows that there are instances where it is not the case, as there can be products where taste differences are not very important across markets or where business-to-business sales are more important than business-to-consumer.⁷ The

⁶Results including distance are not reported here because they do not affect the results significantly.

⁷For example, as noted in the previous Chapter, in the case of intermediate products the cost-minimizing combination of inputs in production functions may differ from the utility-maximizing consumption bundle of consumers. The model is more likely to explain price and quantity variation of final

parameter for taste heterogeneity may indeed not vary across varieties for particular products, which would explain the similarity of R^2 for prices and quantities.

Table 5.9: Product-level Regressions and Goodness-of-fit for Belgian exports.

	(1) Weighted averages		(2) R^2 for Price >Quantity		(3) Number of products
Market dummy:	land-CN6	land	land-CN6	land	
by CN2					89
Price R^2	70.9%	51.1%	.	.	
Quantity R^2	59.2%	30.0%	71.9%	78.7%	
Q per capita R^2	62.0%	35.5%	70.8%	76.4%	
Q per GDP R^2	64.2%	41.1%	68.5%	68.5%	
by CN4					668
Price R^2	63.8%	55.0%	.	.	
Quantity R^2	55.7%	43.7%	61.0%	63.7%	
Q per capita R^2	58.3%	47.5%	59.4%	60.9%	
Q per GDP R^2	58.5%	49.4%	59.7%	59.1%	
by CN6					1471
Price R^2	78.8%		.		
Quantity R^2	73.4%		56.1%		
Q per capita R^2	77.0%		52.1%		
Q per GDP R^2	76.3%		54.3%		

Notes: The results in this table are based on the restricted sample as described in Table 5.1, with quantities expressed in weight (kilograms). The only additional restriction, per CN product, is that the number of regressors for each type of dummy be lower than the number of observations to ensure some variability in the sample. The regressors included are firm-CN8 and importer in the columns "land" and importer-CN6 in the columns "land-CN6", for the different CN product categories. For each CN product category, averages of all the CN products are weighted by their number of observations.

consumption goods than of intermediate goods.

Table 5.10: Product-level Regressions and Goodness-of-fit in the EU28 cross section.

	(1) Weighted averages		(2) R^2 for Price >Quantity		(3) Number of products
Market dummy:	land-CN8	land	land-CN8	land	
by CN2					97
Price R^2	55.3%	41.5%	.	.	
Quantity R^2	38.0%	21.7%	88.5%	90.6%	
Q per capita R^2	40.6%	21.8%	83.3%	93.8%	
Q per GDP R^2	38.0%	19.6%	93.8%	95.8%	
by CN4					1219
Price R^2	46.6%	34.5%	.	.	
Quantity R^2	35.2%	23.6%	78.7%	78.5%	
Q per capita R^2	38.4%	25.3%	68.5%	69.2%	
Q per GDP R^2	34.8%	22.8%	82.5%	79.9%	
by CN6					4957
Price R^2	54.6%	47.6%	.	.	
Quantity R^2	44.0%	37.8%	75.4%	75.0%	
Q per capita R^2	49.0%	42.3%	62.5%	62.1%	
Q per GDP R^2	42.5%	36.8%	79.3%	77.8%	
by CN8					9043
Price R^2	63.6%		.		
Quantity R^2	53.4%		73.3%		
Q per capita R^2	60.0%		59.9%		
Q per GDP R^2	50.6%		79.7%		

Notes: The results in this table are based on the restricted sample as described in Table 5.1, with quantities expressed in weight (kilograms). The only additional restriction, per CN product, is that the number of regressors for each type of dummy be lower than the number of observations to ensure some variability in the sample. The regressors included are firm-CN8 and importer in the columns "land" and importer-CN8 in the columns "land-CN8", for the different CN product categories. For each CN product category, averages of all the CN products are weighted by their number of observations.

In addition to subdividing the entire samples by products, as done in Tables 5.9 and 5.10, it may be also interesting to split the sample according to an aggregate industry classification to see whether in some industries taste may matter less. This is done in Table 5.11 for Belgian aggregate exports and Table 5.12 for the EU28 cross section, with CN2 products grouped by the sections to which they belong in the RAMON Eurostat classification.

The approach is the same described above for Tables 5.9 and 5.10, i.e. after having selected only the observations falling within a particular industry, the specification (5.3) is used to regress prices and quantities on variety and market dummies.⁸

For the EU28 cross section, Table 5.12 shows that the results expected from the vertical model are confirmed in all the fourteen industries, where R^2 for prices is on average 28% higher than for quantities, ranging from the 7.7% of the "Articles of paper" industry to the 40.4% of the "Leather, skins, wood" industry. Yet, there are some exceptions when Belgian exports alone are considered in Table 5.11. The industry "Food and beverages", for example, has a very low level of price variability explained by the set of dummies (just 22.36%), which is lower than the low quantity variability explained (27.95%). Also in the "Plastics and rubber" industry the goodness-of-fit of price regressions is not much higher than quantity regressions, being only 3% higher. Overall, however, the average difference of variability captured by price and quantity regressions is 17%, which is still comfortably high in terms of rejection of the theory. The low or negative differences in specific sectors may indicate industries where taste effects are not important, but more detailed industry-specific studies are needed to understand what drives the results.

Summing up, the division of the full sample in products and industries confirms the fitness of the vertical model to deal with trade data, also at the aggregate level. The results presented in the Chapter are indeed very similar to the results obtained using firm-level exports in the previous Chapter. This confirmation can thus justify the use of the model to obtain indicators on country-products using aggregate data.

⁸Also in this case, the inclusion of transport costs does not affect the results significantly, so the tables with distance regressors are not presented for compactness

Table 5.11: Industry-level Regressions and Goodness-of-fit for the Belgian exports.

INDUSTRIES (corresponding CN2 product codes)	(1) R^2 of price regression	(2) R^2 of quantity regression	(3) Number # of Observations	(4) Model degrees of freedom
Agriculture CN2 codes 1 to 15	45.16%	36.83%	6,343	998
Food, beverages CN2 codes 16 to 24	22.36%	27.95%	6,578	700
Minerals, chemicals CN2 codes 25 to 38	56.08%	31.95%	9,039	752
Plastics and rubber CN2 codes 39 and 40	36.26%	33.23%	4,989	338
Leather, skins, wood CN2 codes 41 to 46	65.25%	35.68%	1,929	260
Articles of paper CN2 codes 47 to 49	42.17%	34.22%	1,871	223
Textile articles CN2 codes 50 to 63	47.84%	30.19%	5,849	625
Footwear, accessories CN2 codes 64 to 67	53.97%	41.73%	422	116
Construction materials CN2 codes 68 to 70	40.98%	30.08%	2,255	263
Base metals, jewelry CN2 codes 71 to 83	63.11%	31.85%	8,371	698
Mechanical appliances CN2 codes 84 and 85	47.72%	22.55%	18,234	1,179
Transport equipment CN2 codes 86 to 89	53.02%	25.71%	3,211	311
Precision instruments CN2 codes 90 to 93	48.88%	18.79%	2,593	305
Furniture and toys CN2 codes 94 to 96	47.01%	26.26%	3,055	278

Notes: The results in this table are based on the restricted version of the Belgian CN8 exports sample, as described in Table 5.1. Exporter-CN8 and importer-CN8 dummies are used as regressors.

Table 5.12: Industry-level Regressions and Goodness-of-fit for EU28 cross section.

INDUSTRIES (corresponding CN2 product codes)	(1) R^2 of price regression	(2) R^2 of quantity regression	(3) Number # of Observations	(4) Model degrees of freedom
Agriculture CN2 codes 1 to 15	53.03%	25.04%	136,838	15,554
Food, beverages CN2 codes 16 to 24	49.49%	21.67%	134,802	10,192
Minerals, chemicals CN2 codes 25 to 38	55.39%	26.04%	248,344	16,133
Plastics and rubber CN2 codes 39 and 40	37.16%	24.19%	143,318	7,091
Leather, skins, wood CN2 codes 41 to 46	64.23%	23.72%	60,938	5,063
Articles of paper CN2 codes 47 to 49	34.11%	26.37%	75,430	4,281
Textile articles CN2 codes 50 to 63	53.53%	19.94%	241,444	20,047
Footwear, accessories CN2 codes 64 to 67	44.68%	15.76%	26,516	2,170
Construction materials CN2 codes 68 to 70	51.46%	23.93%	75,124	4,717
Base metals, jewelry CN2 codes 71 to 83	59.07%	26.61%	271,735	17,578
Mechanical appliances CN2 codes 84 and 85	50.59%	18.41%	525,082	28,369
Transport equipment CN2 codes 86 to 89	58.22%	22.64%	75,642	4,611
Precision instruments CN2 codes 90 to 93	51.09%	14.47%	72,367	5,168
Furniture and toys CN2 codes 94 to 96	46.59%	19.20%	97,889	5,107

Notes: The results in this table are based on the restricted version of the EU28 cross-section sample, as described in Table 5.1. Exporter-CN8 and importer-CN8 dummies are used as regressors.

5.2 From micro to macro: building indices at a country-product level

After having shown that the verti-zontal model can be fruitfully employed in a macro context in this section it is explained how the model can be used to obtain macroeconomic indicators of competitiveness at the country-product level. The identification procedure highlighted in this Chapter can contribute to the ongoing debate on macroeconomic imbalances and external competitiveness by suggesting a set of indicators of export capability at a country-product level which can be used to complement the existing toolkit of instruments based mostly on unit labor costs and relative price levels. Information on the capacity of a country's exporters to compete abroad can be extracted by combining trade and macroeconomic data. In particular, two independent components of demand for a particular variety (country-product combination) can be identified: markups-shifting quality and sales-boosting non-cost competitiveness. Together with cost efficiency and information on foreign prices and consumption levels, these additional indicators can foster our understanding of the determinants of a country's external position, thus providing better guidance for policymaking. Remember indeed that exporter and importer dummies in Table 5.3 are shown not to capture any significant level of price or quantity variability in trade data. This means that country-level analysis cannot say much about the intensive margin of trade at the product level and need to be complemented by a country-product analysis.

5.2.1 Why adding the verti-zontal model to the toolkit?

A key factor in assessing the sustainability of a country's external position is its capacity to finance the purchase of imported goods and services through its exports, to keep the current account in balance. This is why an increasing amount of attention and effort is being given to the definition of suitable indicators of external competitiveness which can be used to identify potential imbalances or dangerous long-term trends. The external position of a country is affected by several factors, stemming from both the demand and the supply side of the economy, the latter being typically associated with export performance and the former with import growth. This Section shows how the verti-zontal model can be used to extract information on the willingness to pay of consumers and on the exporters' capacity to sell at a country-product level.

There are currently few alternatives available to researchers for identifying the drivers of external competitiveness and they are mostly based on productive efficiency and relative price levels, thus drawing all the attention towards these two dimensions of competitiveness. In contrast, a methodology is proposed here to use aggregate trade and macroeconomic data to extract information on the evolution of what will be referred to as quality and non-cost competitiveness of EU Member States' exports. The term "quality" captures the characteristics of exported products that affect markups and sales positively, as in the micro context, whereas "non-cost competitiveness" captures the characteristics of an exported product that affect sales but not equilibrium markups or prices,

similarly to taste mismatch in the micro context. For example, it may be thought of as the result of the development of distribution networks, consumer awareness or a process of gradual demand build-up (Foster et al., 2012), but it may also depend on the number of buyers in the destination markets (Carballo et al., 2013) or institutional characteristics such as liberalization in the service sector or openness to trade, as suggested by the Product Market Review 2010-2011 (European Commission, 2011).⁹ In order to identify these two elements, a particular demand structure is assumed, which has the advantage of being at the same time flexible, tractable and fully identifiable.

Quality and taste in the macro trade literature

As seen in the previous Chapters, there are many alternative models of international trade currently available to researchers, but only few of them can actually be used to identify asymmetric product characteristics. In general terms, the issue of how to account for differences across product characteristics such as quality can be meaningfully dealt with only in specific theoretical frameworks allowing for product differentiation and for consumers appreciating variety.¹⁰ This requirement restricts the menu of available models to the so-called New Trade Theory, pioneered by Krugman (1980, 1979) on the basis of the model outlined by Dixit and Stiglitz (1977). The New Trade Theory recently received new impulse and became the workhorse of research in International Economics following the discovery of significant heterogeneity across firms in terms of economic performances (Bernard et al., 2003) and pricing behavior (Manova and Zhang, 2012). In fact, these findings have contributed to the development of several alternative theories of monopolistic competition, in which firms are assumed to exert the market power of a monopolist on the particular variety they produce, but are constrained by the presence of other firms in the market selling imperfectly substitutable varieties. In addition, these varieties are typically assumed to be so many that each one alone cannot influence market aggregates (such as the general price levels) and, therefore, firms take market conditions as given and do not try to set prices strategically or to collude with other firms to extract more profits from consumers.

Like in the micro environment analyzed in the previous Chapters, the main differences between existing macro models of trade lie in the particular demand structure used to describe consumer behavior. The most popular alternatives are based on constant elasticity of substitution (CES), translog, and quadratic utilities.¹¹ Whereas all of them

⁹In the Product Market Review 2010-2011 the exact term used to describe the quantity variation not explained by differences in prices is "non-price competitiveness". The term has not been used as such in this context because the estimation methodology is different and using the same term to describe related yet different concepts might confuse the reader.

¹⁰These two conditions are needed in order to avoid "corner solutions" in which all the consumers buy the same amount of all the available varieties (in the case of lack of differentiation) or they all consume only one particular variety and ignore the others (in the case of lack of love for variety).

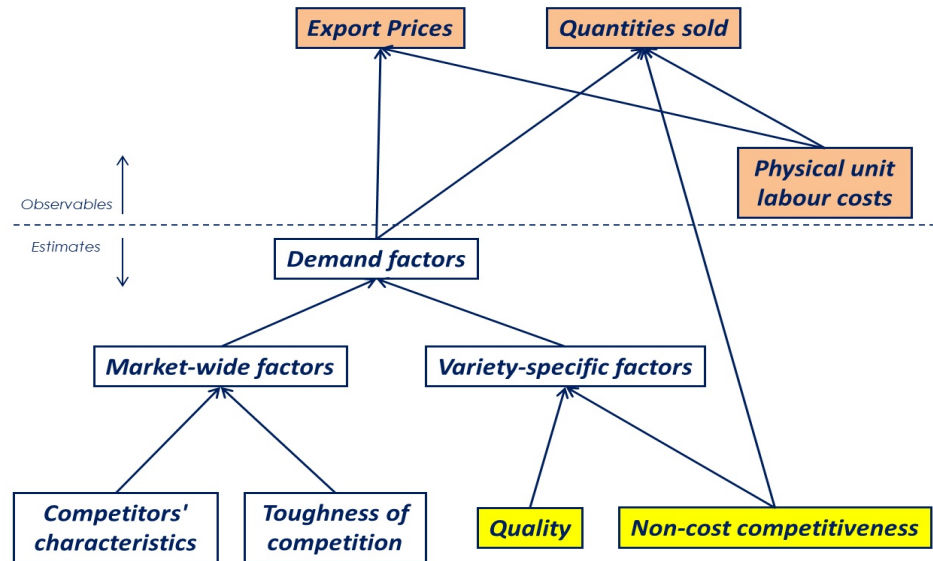
¹¹A recent paper discussing the different frameworks and their differences in expected outcomes is Feenstra and Weinstein (2010). Note also that an analysis of the properties of CES functions can be found in Zhelobodko et al. (2012).

rely on product differentiation in a monopolistic competition setting,¹² their functional forms differ in such a way that each model allows for different identification strategies and interpretation of structural parameters. In particular, frameworks based on CES utility functions, such as Melitz (2003), Baldwin and Harrigan (2011) or Feenstra and Romalis (2012), are to be preferred when the focus is on income effects and elasticities of substitution. Instead, when the interest of the researcher revolves around individual product characteristics such as quality or non-cost competitiveness, then discrete choice models yielding translog preferences and quadratic utilities provide the most appropriate setting. However, the latter have the additional advantage of being analytically tractable when variety characteristics are defined over a continuum and of allowing for asymmetric preferences. This is not the case for discrete choice models, which normally need to be defined over a small finite set of types to be solved and are characterized by symmetric varieties (Anderson et al., 1992).

Bank of Latvia's Benkovskis and Rimgailaite (2011) and Woerz and Benkovskis (2012) have recently shown how to measure the evolution of quality-adjusted relative export prices in a CES framework, building on a methodology incrementally developed by Feenstra (1994), Hummels and Klenow (2005) and Broda and Weinstein (2006). These studies show that even if export prices increased, quality-adjusted relative export prices in Latvia and the other new EU member states decreased significantly between 1999 and 2009, resulting therefore in no loss of competitiveness. Higher export prices, therefore, seemed to signal a shift towards higher quality production, rather than a loss of competitiveness. Similarly, Feenstra and Romalis (2012) use an adapted quality-augmented CES utility function in order to obtain non-homotheticity in income and provide quality-adjusted price indexes for imports and exports for virtually every country of the world, but in these models varieties are characterized by only one possible source of differentiation, incurring the problems discussed in the previous Chapter as a motivation for the development of the verti-zontal model.

In order to obtain a better characterization of product differentiation, a new methodology is illustrated here to adapt the non-homothetic quadratic utility framework presented in the previous Chapters to an aggregate macro context. Just like the firm-level studies reviewed in Chapter 2 have shown that cost heterogeneity or demand shifters alone (such as quality) do not suffice to explain trade patterns, because they leave a large amount of unexplained variability in quantities sold, the same issue has been observed also on intra-EU trade data, leading to the definition of the concept of "non-price competitiveness" as an additional source of competitiveness for Member States (European Commission, 2011). To make sense in a rigorous way of this additional source of variation affecting quantities but not prices, the verti-zontal model is used, where demand-shifting vertical differentiation is related to quality of country-product exports, whereas slope-changing horizontal differentiation can be linked to what is here referred

¹²This term emphasizes the fact that firms are assumed to be negligible in size and to take market characteristics as given (i.e. they don't internalize the impact of their individual decision on aggregates) even if they enjoy the market power of a monopolist on the particular variety that they supply. This modeling approach has been pioneered by Dixit and Stiglitz (1977) and popularized by Krugman (1980).

Figure 5.1: *Scheme of quality and non-cost competitiveness identification strategy.*

to as "non-cost competitiveness". This term has been used, rather than "non-price competitiveness", to underline its exogenous nature in this framework, as opposed to prices which are determined endogenously.

In order to be able to decompose changes in export performance into a "quality" and "non-cost competitiveness" component, the quadratic utility framework has to be adapted to deal with sector- rather than firm-level data. The advantage of such approach is that it allows varieties to be asymmetric along different dimensions, all of which can be identified in every period. To this end, some assumptions are needed both on the behavior of consumers, whose preferences must fit into a simple quadratic utility function, and on the productive capacity of firms, which are assumed to have access to the same technology within a country, not to be capacity constrained and to use only labor to adapt the scale of production.

The main intuition behind the approach proposed is that by observing costs, prices and quantities sold over time it is possible to estimate key demand parameters for each variety in the market and to distinguish between idiosyncratic and market-wide determinants of market outcomes. In particular, taking labor costs as exogenously given, overall demand effects can be determined and aggregate market effects can be disentangled from variety-specific demand effects. In turn, variety-specific demand effects can be split into quality (price-shifting vertical differentiation) and non-cost competitiveness (quantity-shifting horizontal differentiation). More details are provided in the next section. A graphic illustration of the identification procedure is shown in Figure 5.1. A more formal description of the model follows in the next section.

5.2.2 Adapting the verti-zontal model to an aggregate macro context

The identification strategy is based on the verti-zontal model, where varieties are defined as country-product combinations, which can be thought of as the combination of four components:

- A positive demand shifter capturing the willingness to pay of a consumer for the first unit consumed of a given variety of a certain type of differentiated good;
- A negative quadratic term capturing the decrease in marginal utility provided by the consumption of other units of the same variety;
- A negative quadratic term capturing the decrease in marginal utility provided by the consumption of a positive amount of any variety of the same class of goods;
- A numéraire capturing the marginal utility provided by an external good, which can be also interpreted as a Hicksian composite good representing the entire bundle of consumption of the representative consumer considered.

In order to have a simple model of monopolistic competition with variable elasticity of substitution, non-constant markups and asymmetric varieties vertically and horizontally differentiated, these four elements can be formalized in the following representative consumer's utility, considering a particular variety $s \in S$ of a certain product consumed in a market i . Following the characterization of Model V:

$$U_i(s) = \int_{s \in S_i} \alpha_s q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{\gamma}{2} \left[\int_{s \in S_i} q_{s,i} ds \right]^2 + q_0, \quad (5.5)$$

where the total mass of varieties s present in market i is expressed as S_i . Notice that The expression "mass of varieties" is typically used in the micro literature on monopolistic competition literature to stress the assumption that each individual variety is too small to affect market aggregates and thus has to take price, quality and cost indices in market i as given. It can be remarked that even in the context of macro data, where countries are observed but not individual firms, the assumption can still hold as long as firms within a country cannot coordinate their pricing behavior (or, alternatively, be big enough to represent a significant share of a country's export), so that even large countries can reasonably considered as made up of many price-taking firms.

The demand for a variety s , given a standard budget constraint $\int_{s \in S_i} p_{s,i} q_{s,i} ds + q_0 = y_i$ where y_i is the consumer's income, can be written again as:

$$q_{s,i} = \frac{\alpha_s - p_{s,i}}{\beta_{s,i}} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \gamma\mathbb{N}_i)} \quad (5.6)$$

where $\mathbb{N}_i$, $\mathbb{A}_i$ and $\mathbb{P}_i$ are market aggregates expressing effective number of competitors, quality and price levels in market i , as obtained by weighting respectively the number of firms, their quality levels and prices by each variety's own non-cost competitiveness index

in such a way that each variety marginally affects market aggregates, proportionally to expected consumers' purchases in market i , $1/\beta_{s,i}$:

$$\mathbb{N}_i \equiv \int_{s \in S_i} \frac{ds}{\beta_{s,i}} \quad \mathbb{A}_i \equiv \int_{s \in S_i} \frac{\alpha_s}{\beta_{s,i}} dr \quad \mathbb{P}_i \equiv \int_{s \in S_i} \frac{p_{s,i}}{\beta_{s,i}} dr. \quad (5.7)$$

Operating profits for variety s in market i , $\Pi_{s,i}$, can be measured as the product of markups on each unit sold, $p_{s,i} - c_s$, and quantities sold, $q_{s,i}$:

$$\Pi_{s,i} = (p_{s,i} - c_s)q_{s,i} \quad (5.8)$$

and the combined optimization problems of firms and consumers yields the following equilibrium prices and quantities:

$$p_{s,i}^* = \frac{\alpha_s + c_s}{2} - \frac{\gamma Q_i}{2}; \quad (5.9)$$

$$q_{s,i}^* = \frac{1}{\beta_{s,i}} \left(\frac{\alpha_s - c_s}{2} - \frac{\gamma Q_i}{2} \right). \quad (5.10)$$

Notice that the treatment of the variable γQ_i is very delicate in an aggregate macro context. In fact, in the model γQ_i captures the extent of competition between one variety and the mass of varieties consumed by the representative consumer. In other words, it captures the idea that the consumption of other varieties of the same good decreases consumers' willingness to pay for variety s . However, when the variety is an aggregate capturing a country's exports of a product and the competing varieties are all the imports from the rest of the world of the same product, then aggregate values may hide a lot of heterogeneity across consumers and varieties. This caveat applies to any trade model using aggregate data, but it is worth keeping in mind that the precision of the identification procedure is also affected by the level of aggregation of the analysis.

Parameter identification: quality and non-cost competitiveness

The price and quantity equations outlined above are the key to identify the vertical and horizontal differentiation parameters α_s and $\beta_{s,i}$, which correspond, respectively, to an index of quality and an index of non-cost competitiveness. These results are convenient in that variety-specific and market-variety-specific structural variables are neatly split and allow for a direct identification. Notice that equilibrium prices depend not only on each variety's intrinsic quality, α_s , and marginal costs of production, c_s , but also on the total consumption of the differentiated good in the market i , Q_i , weighted by its degree of substitutability across different varieties, γ . Equilibrium quantities depend, in addition, to the non-cost competitiveness parameter $1/\beta_{s,i}$, which can therefore be directly measured as

$$\beta_{s,i} = \frac{p_{s,i}^* - c_s}{q_{s,i}^*}, \quad (5.11)$$

where higher levels of β are associated with a lower sales, for a given level of markups, since it translates the taste mismatch parameter in the micro context.

As for quality, it can be measured both in relative or absolute terms. Relative quality differences can be directly measured as the difference between a country's α_s and a benchmark, say α_r , comparing the prices and marginal costs of production of the two varieties sold in the same market. From the difference between $p_{s,i}^*$ and $p_{r,i}^*$ stems indeed:

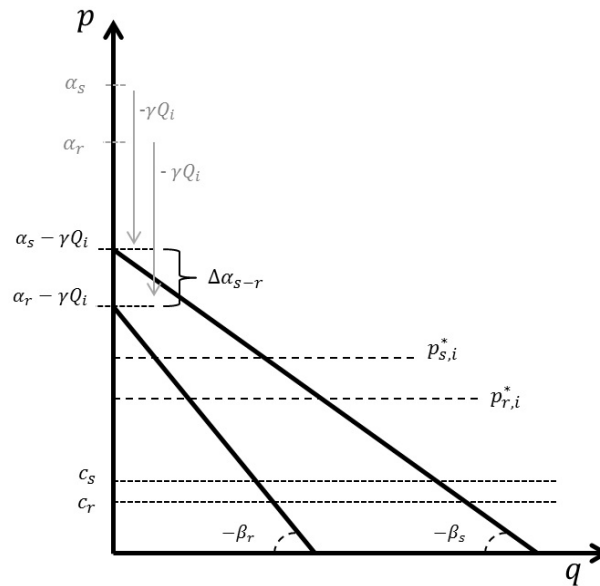
$$\alpha_s - \alpha_r = 2(p_{s,i}^* - p_{r,i}^*) - (c_s - c_r) \quad (5.12)$$

which can be rewritten as:

$$\Delta\alpha_{s-r} = 2\Delta p_{s-r,i}^* - \Delta c_{s-r} \quad (5.13)$$

A visual representation of the inverse linear demands $p_{s,i} = \alpha_s - \beta_{s,i}q_{s,i} - \gamma Q_i$ and $p_{r,i} = \alpha_r - \beta_{r,i}q_{r,i} - \gamma Q_i$ and the role of each parameter is shown in Figure 5.2.

Figure 5.2: *Visual representation of the inverse demand function and role of each parameter in the model.*



However, the relative quality difference between varieties s and r , $\Delta\alpha_{s-r}$, provides only the difference in terms of numéraire between the price at which the first marginal unit of variety s and the first marginal unit of variety r would be sold in each market, but the difference between two quality levels does not say much about the absolute quality levels of the two varieties and, in addition, it does not provide information on how big is that difference, as compared to the quality level of the two varieties. To this end, it is necessary to estimate the values of α_s and α_r in absolute terms, which requires, as a preliminary step, the estimation of the substitutability parameter γ . This step leverages two additional assumptions: the first is that the degree of substitutability

between different varieties of the same product does not vary over time, which is rather reasonable over short periods of time and well defined product categories; the second assumption is that the value of the variety with the worst quality in the market, say α_0 , is worth the same amount of numéraire in every period, which amounts to assume that the quality improvement over time of the worst-quality variety in the market follows the general quality improvement in the economy at large. Under these assumptions, it suffices to run a simple time-series regression of $[2p_{0,i}^* - c_0]$ on $[Q_i]$ to estimate $\hat{\gamma}$ at a product level. Plugging then $\hat{\gamma}$ into the price equation $p_{s,i}^*$, $\hat{\alpha}_s$ can be estimated for all the varieties. As an alternative, the constant of the time series regression can be used as the quality level of the worst-quality variety, $\hat{\alpha}_0$, and the others can be measured as $\hat{\alpha}_s = \hat{\alpha}_0 + \Delta\alpha_{s-0}$, reminding that $\Delta\alpha_{s-0} = 2\Delta p_{s-0,i}^* - \Delta c_{s-0}$.

5.2.3 Empirical implementation

To operationalize the identification strategy described above, a preliminary step is to define what a variety is in the context of a macroeconomic analysis with aggregate data. The ideal field of application of the theories of monopolistic competition is the firm- or plant-level in differentiated consumer-goods sectors, as it would better match the assumption of a similar demand structure for the different varieties and of a multitude of small-sized competitors. Unfortunately, micro-level data is still scarce in many countries and where available it can be expensive, difficult to compare across countries or incomplete (as it may be based on survey filled by firms on a voluntary basis, yielding possible selection problems). The alternative, which has been proven at the beginning of this Chapter to be empirically viable, is to turn to more aggregate trade datasets such as Eurostat COMEXT, a free, complete and rich dataset on EU exports built following homogeneous data collection and reporting guidelines across Member States. In such a context, a *variety* s is defined as a *country-product combination*. As for the definition of a *product*, different levels of aggregation are available. In the Combined Nomenclature framework, for example, 4 levels of aggregation are available, ranging from CN2, where all the goods are split into 98 2-digits product categories, to CN8, which comprises around 10.000 8-digits product codes, with the intermediate levels of CN4 and CN6. Results are illustrated here following the most disaggregate product level, the CN8.¹³

As discussed above, the second relevant issue to consider is the definition of a *market* i in which the total consumption of a product is calculated as Q_i and where the different varieties compete with a pairwise degree of substitutability γ . Ideally, in the case in which varieties are identified with country-product pairs, the market i would be a third country in which all the different varieties compete on a leveled ground facing similar barriers to entry and transport costs.¹⁴ In the case of EU28 Member States, for example, this market could be the US, but unfortunately many Member States export fewer product

¹³The results of a previous exercise with a CN2 product classification on the same type of data, see Comite (2012).

¹⁴The advantage of having the different varieties facing market-specific costs of shipment is that it leaves variety-specific or market-variety-specific differences in parameters as the only source of variability across varieties' performance in a destination market.

categories to the US than to other Member States, which means that choosing the US (or other non-EU countries) as the relevant market for the analysis would cause a significant loss of information on varieties that could otherwise be considered. For this reason, a possible alternative would be to consider the entire EU28 as the relevant market i , basing the analysis on intra-EU28 exports of each Member State. Whereas this choice may have fewer implications for very small Member States, it can be slightly more delicate for countries representing a high share of the total EU28 market, which could influence it because of their size. However it should be kept in mind that, even if aggregate country-product level trade data is used, exports of a country are normally the sum of many individual exporters,¹⁵ each having a negligible impact on market aggregates, so that the basic assumptions of the monopolistic competition framework (notably, that individual price makers cannot affect market aggregates strategically with their behavior) are not violated in substance. Furthermore, focusing on intra-EU28 trade flows has the advantage of being able to extract additional comparable information on export and import markets and have better estimates on the expected consumption of a particular product, or Q_i in the model.

The methodology presented here can then be properly used to assess quality and non-cost competitiveness of the EU Member States. After having defined a variety s (say, country-CN8 product) and market i (say, the EU internal market), it can be useful to define some relevant benchmarks. The natural choice would be to use the minimum and the maximum level reached by each parameter and then normalize all the values between 0 and 1. In addition, in the case of EU countries it may be interesting to compare each country with the EU28 average, to see whether a process of convergence is on track. Three benchmarks are therefore identified: $s = 0$ for the worst variety, $s = \max$ for the best, $s = EU28$ for the EU28 average.¹⁶ Thus, the normalization of the quality parameter between 0 and 1 can be:

$$\alpha_{s,norm} = \frac{\alpha_s - \alpha_0}{\alpha_{\max} - \alpha_0} \quad (5.14)$$

and the normalization in terms of EU average, considering the baseline EU levels equal to 100:

$$\alpha_{s,normEU28} = \frac{\alpha_s}{\alpha_{EU28}} * 100 \quad (5.15)$$

The procedure can be followed for the normalization of the other parameters.

¹⁵A notable exception is represented by sectors that are highly regulated or highly concentrated. These would be indeed better described by an oligopolistic rather than a monopolistic competition framework, but it would be impossible or arbitrary to treat each product category differently and then aggregate results over the entire economy.

¹⁶Note that the market subscript i can be omitted, since all the results refer to shipments to the same export destination (the rest of the EU), so that the subscript EU28 can be used to identify the EU28 average variety without creating confusion.

Data requirements

In terms of data requirements, the model is rather parsimonious. All the necessary information can be retrieved from two freely accessible sources: Eurostat COMEXT for the trade flows; and DG ECFIN's AMECO for the additional macroeconomic information needed to build the indices.

More precisely, in terms of **trade data** (COMEXT), all that is needed is the following:

- *Exports* from the 28 EU Member States to the rest of the EU *in values* at the CN8 level of disaggregation (billion euros);
- *Exports* from the 28 EU Member States to the rest of the EU *in volumes* at the CN8 level of disaggregation (100 Kg);
- Total *intra-EU28 imports in values*;
- Total *EU28 imports from extra-EU countries in values*.

As for the additional **macro data** (AMECO), this is the list of variables needed:

- Importer's *total consumption* at current prices (AMECO code: UCNT).
- Total *consumption's price deflator* for the EU28 (AMECO code: PCNT)
- *Compensation of employees* by main branch of the economy (NACE rev.1 ISIC categories):
 - Total economy (AMECO code: UWCD);
 - Agriculture, forestry and fishing (ISIC: A, B) (AMECO code: UWC1);
 - Industry, including energy (ISIC: C, D, E) (AMECO code: UWC2);
 - Services (ISIC: G to P) (AMECO code: UWC5);
 - Manufacturing (ISIC: D) (AMECO code: UWCM).
- *Gross Value Added* by main branch of the economy (NACE rev.1 ISIC categories) at current prices:
 - Total economy (UVG0)
 - Agriculture, forestry and fishery products (ISIC: A, B) (AMECO code: UVG1)
 - Industry, including energy (ISIC: C, D, E) (AMECO code: UVG2)
 - Services (ISIC: G to P) (AMECO code: UVG5)
 - Manufacturing (ISIC: D) (AMECO code: UVGM)
- *Adjusted wage share in the manufacturing industry* (compensation per employee as percentage of nominal gross value added per person employed. AMECO code: ALCM);

An intermediate step: building trade and macro variables

Starting from these variables, it is possible to build all the others and estimate the parameters associated with each country-product in each period. The first step is to construct the **additional trade and macro variables** that will be needed for the estimation. These are:

- *Export prices*, or p_s in the model, which can roughly be computed as the unit values (values/volumes) of the exports associated with each product category, in euros/Kg. The measure is clearly an approximation, as many different prices and products can be grouped together within a product category, but it is the best that can be done with aggregate data;
- *Unit labor cost* (ULC) at a product level, which is the ratio of labor costs over value added at a product level. There are two alternative ways of building this variable:
 - Either the *adjusted wage share in the manufacturing industry* can be extended to all the products exported by a country in a homogeneous way;
 - Or it can be computed at a main-economic-branch level by dividing the *compensation of employees at current prices* by the *gross value added produced by the branch at current prices*. The 10,000 CN8 products can be allocated to the different branches of activity based on their corresponding CN2 product categories by looking at the correspondence with each branch, as shown in the appendix. This alternative measure has the advantage of being more product-specific, but the disadvantage of displaying negative markups (higher labor costs than value added) for some country-products, especially in transition economies.
- *Physical unit labor cost* (PULC), or c_s in the model, which captures the marginal costs of producing a physical unit of the exported good and can be obtained, with some caution, by attributing a share of costs equal to the ULC to the values exported of each product. It should be kept in mind, however, that ULC are measured in terms of value added, whereas trade data captures the total revenues earned from the export of a product. This is equivalent to assuming that subsidies, direct taxes on products and intermediate consumption at a product level cancel out, in such a way that gross value added and total revenues coincide. Admittedly, this may not be the best option for all the products considered, as in some of them total revenues may be significantly larger than value added, but the first-best alternative would be to have information on value added at a product level, which is not possible since the narrowest level of aggregation of value added is at the branch level;
- *Product consumption in the import market*, which is the data equivalent of Q_i in the model, capturing the amount consumed of all the varieties of a certain product. The main issue is that this information is not always available, especially for more

disaggregate levels of product definition. To tackle this issue, quantities can be inferred by combining the data on aggregate consumption with trade data, which should provide an indication of the particular tastes of a market. In particular, the share of each product in total imports can be assumed to reflect the share of consumption of a particular product in total consumption (which is however an approximation, since trade data often covers only trade in goods, whereas total consumption also includes services). In addition, it could be argued that also the exports of a country can provide some information of local tastes, at least as far as differentiated manufactured goods are concerned. Therefore, in the examples provided here total consumption of a particular product is obtained as the average of import share and export share of that product, multiplied by total consumption. Then, to convert this value into quantities, it is divided by the average price of the intra-EU exports. Notice that this is again an approximation as well, but will not affect substantially the relative performance of each variety because it will be applied uniformly to the entire product category;

- *Deflated prices and parameters.* Since the evolution of prices in the importing market can unduly affect the estimated parameters and attribute to changes in varieties' parameters what is in reality an overall market development, export prices can be deflated by the price deflator of consumption as a robustness check. However, this correction will not affect the relative performance of each variety but just their absolute level and may be relevant only when longitudinal indicators are considered;
- *Varieties' market shares* are not needed for the estimation of the parameters, but can represent a useful consistency check of the results of the model. Market shares are in fact affected by both quality and non-cost competitiveness, which implies that in case of divergent trends, they can help assess what is the overall impact on countries' competitiveness.

Parameter identification

Following the empirical strategy illustrated in Section 5.2.2, the variables presented above can then be used to estimate the key **demand parameters** of the model as follows:

- *Non-cost competitiveness*, $\beta_{s,i}$, can be immediately measured by dividing quantities shipped by the difference between export prices and physical unit labor costs. A way to interpret this parameter is that it measures the amount of goods that a country is able to export for a given (profit maximizing) level of markups. The advantage of this concept is that it can be seen as capturing all the characteristics of a variety that affect its sales but not the price consumers will be willing to pay for it (a typical example being the size of the distribution network or consumers' awareness of a product due to, say, gradual demand build-up over time);
- The *degree of substitutability* between varieties of the same product, the parameter γ , cannot be measured directly but must be estimated. To this end, as explained

in the previous section, it is possible to run a time-series regression with dependent variable $[2p_{0,i}^* - c_0]$ as a dependent variable and $[Q_i]$ as a regressor. The export price and PULC subscripts indicate that only the lowest-quality variety in the EU28 market must be considered. To identify it, it suffices to look at the lowest inverse-demand intercept (IDI) in the dataset, $IDI_0 = \alpha_0 - \gamma Q_i$ (see Figure 5.2), which is indeed equal to $2p_{s,i} - c_s$ for the variety $s = 0$. The coefficient associated with the regressor can then be used as the product-level estimate of the degree of substitutability between varieties. The intuition is that since the term γQ_i enters symmetrically in all the varieties pricing decisions, it is enough to see how the inverse-demand intercept of the lowest-quality variety (or another chosen variety) changes in reaction to changes in the total amount of other varieties consumed to have an estimate of the parameter γ ;

- The *quality levels of the lowest-quality variety*, α_0 , can also be retrieved from the same regression as its time-invariant constant under the assumption previously discussed that the willingness to pay for the first marginal unit of the lowest-quality variety is constant over time in terms of the numéraire, which in turn captures the marginal utility of consumption of any other good in the economy;
- The *quality levels of all the other varieties*, α_s , can be computed starting from α_0 and noticing that differences in quality levels across varieties are measured as $\Delta\alpha_{s-r} = 2\Delta p_{s-r,i}^* - \Delta c_{s-r}$. This measure of quality can be seen as the potential intercept of the inverse demand function in the absence of competition (i.e. when $\gamma Q_i = 0$), which would be the highest price a consumer would be willing to pay to buy a positive amount of the variety s , even if this amount cannot be observed in the market because it would not maximize the operating profits of the firm/country producing that particular variety.

In terms of units of measurement, the quality index, α_s , unit values, $p(s,i)$, and physical unit labor costs (PULC), c_s , are expressed in $\text{€}/Kg$; the degree of pairwise substitutability, γ , and the parameter for non-cost competitiveness, $\beta_{s,i}$, are expressed in $\text{€}/Kg^2$; the price deflator, market shares and the unit labor costs (ULC) are unit-less.

Even though the three structural parameters of the model provide valuable information on the characteristics of the varieties exported, they cannot be immediately used in absolute terms for policy advice. To that end, it is necessary to relate country performances to a benchmark which can be of a cross-sectional or longitudinal nature, the former using other countries or group of countries in the same period of time and the latter following the performance of the same country over time.

An example of how the parameter identification methodology can be used to assess the competitiveness of a country is provided in the next section, based on the Latvian experience. The case of Latvia will be used throughout the Section to illustrate the empirical implementation of the estimation strategy presented above. This choice of country is mainly motivated by the fact that the idea of translating the micro-level methodology presented above into a macro setting has been first explored in the preparatory work of

Di Comite et al. (2012), but in fact the country is an ideal candidate for the purpose, as it experienced a sustained medium- and long-term trend of convergence vis-à-vis EU28 levels in most of its parameters, but at the same time it shows a lot of short-term volatility as it experienced a deep Balance-of-Payment crisis followed by a very quick recovery during the decade analyzed. For the sake of comparison, aggregate results for the other EU Member States are then shown in the annex.

5.2.4 Estimating quality and non-cost competitiveness in Latvia

The identification strategy presented above can be used to estimate each variety's parameters in every period of analysis (here years are used, but trade data is available also monthly). Such information can be aggregated further to provide information on the overall country developments. In the context of CN8 trade data, each country exports thousands of CN8 products, for which demand parameters can be identified.¹⁷ The country-product values can then be averaged, weighting each product by its relative export share in the country, and the resulting information can be used to have an idea of the overall quality and non-cost competitiveness of the exporter's tradable sector. An alternative, quicker way of having aggregate results is to use the product category called "total", which in COMEXT corresponds to the sum of all the manufacturing export products in values and quantities, but raw totals implicitly assign a higher weight to heavier products, which is not necessarily the most meaningful weighting choice.

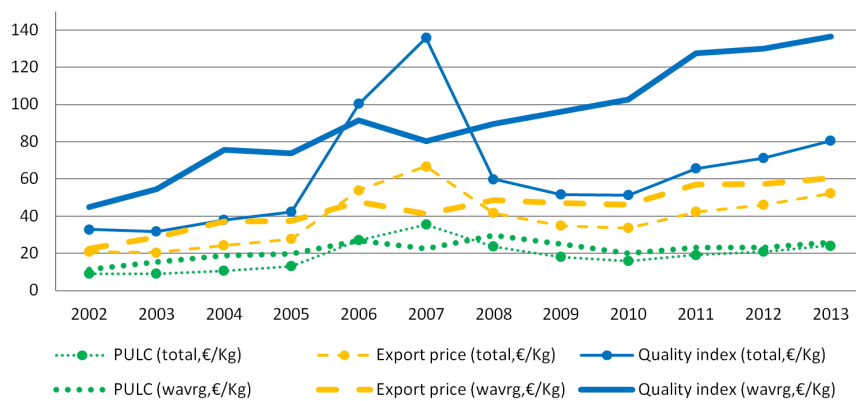
Indeed, the comparison between export-value-weighted parameters (called *wavg* in the figures) and parameters associated with the unweighted aggregate category (referred to as *total*) can be used to assess how the most important trade products fare in comparison with the overall economy. Furthermore, weighted averages allow for a more meaningful comparison between countries, or between a country and a relevant group of countries, say the EU28. Indeed, quality and non-cost competitiveness can be compared product by product and then aggregated at a country level, getting rid in this way of biases linked to exporters' product specialization. In other words, if each country performs very well in the products that it exports the most, then theoretically every country can perform very well in the indicators aggregated in this way, meaning that an increase in competitiveness for some countries does not necessarily imply a decrease in other countries by the construction of index, which is a nice feature when comparing countries with very different productive specialization patterns.

The trends are generally similar in the two approaches, but the absolute level may vary substantially, as can be seen from Figure 5.3 where unweighted totals and weighted averages are shown for PULC, export prices and the quality index. It is worth stressing that the differences in the evolution of the two series (apart from measurement errors) are explained by changes in the export composition. For example, when the relative importance of higher-value products increases as a share of total exports, the weighted-average quality index increases more than the unweighted one. Thus, comparing the

¹⁷The overall number of CN8 products in the EU28 ranges between 10,326 in 2003 and 9,229 in 2011, but in Latvia they range from 2,202 in 2006 to 3,859 in 2012.

two series can provide useful information on the resource reallocation undergoing in the economy. In fact, changes in the differences between the two series indicate how products with highest export shares are faring as compared to the rest of the export sector. Given this additional information content, they are presented together in the rest of the analysis. The relative indicators of competitiveness that can be produced based on these indices are organized as follows: first, pure cross-sectional indicators are presented, based on sample maxima and minima and on EU28 as a benchmark; then, longitudinal ones; and finally, a mixed approach is proposed.¹⁸

Figure 5.3: *Physical unit labor costs (PULC), quality and export prices of Latvian exports, raw parameters.*



Source: Author's calculations based on Eurostat Comext and AMECO data. Note: "wavrg" parameters are corrected for Latvian product specialization by measuring them at a product level and then aggregating them by weighting each product by its share in Latvian exports (in values). "Total" parameters are computed using the category "total" as an individual product.

5.2.5 Cross-sectional indicators

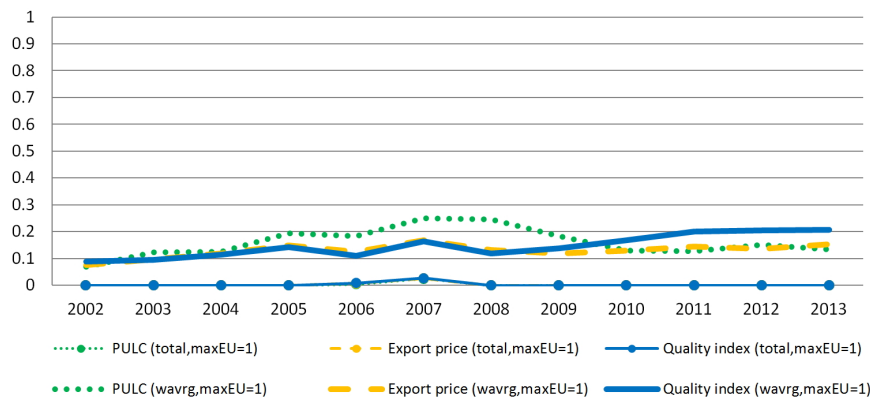
The first class of indicators that can be built through the methodology presented here consists of cross-sectional indicators comparing the performance of different varieties within the same market, in this case the EU internal market. Since different CN8 products can be very different from each other in terms of average structural parameters (costs, prices, quality and units sold), they could not be meaningfully aggregated in terms of raw values. To give a concrete example, in 2004 the cheapest Latvian CN8 export was the code 25210000 representing "limestone flux; limestone and other calcareous stone", which was sold at 1.07 euros per 100Kg; the most expensive product was the CN8 code 90013000 representing "Contact lenses", which was sold at 144,641 euros per 100Kg. Aggregating this two product in raw value into one index would then have little sense.

¹⁸The variable list, summary statistics and full dataset are available on request.

However, they can be aggregated in terms of normalized values. Attributing a value of 0 to the lowest-scoring variety for each parameter and 1 to the highest-scoring variety, the normalized values of each of the CN8 products can be weighted by relative importance of each product in terms of exported values. This procedure would yield an indicator that signals how well a country performs in the products that it exports the most, as compared to the EU28 competitors. This implies that two countries with exactly the same parameters can be associated with a different overall indicator because of differences in their export structure, the indicator being tilted in favor of the country with better performances in its most sold products.

Results for the Latvian exports are shown in Figure 5.4, considering PULC, export prices and quality indices. They are displayed on a 0-to-1 scale because these are the upper and the lower bound of the index. As far as the unweighted totals are concerned, it can be noted that Latvia lies on the lower bound in all the years except 2006 and 2007, when another Member State (Croatia) takes its place. This means that out of the 28 exporters of the sample Latvia is the one with the lowest levels for the three parameters in the *total* category. Yet, since Latvian product parameters are not the lowest ranked for all the CN8 products, its position improves when weighted averages of the normalized values of all the products are considered. In particular, it can be noticed that in the last decade the normalized weighted average quality index more than doubled, while the PULC in 2011 are almost back to the levels of 1999, after having spiked during the overheating high-inflation years of 2007 and 2008. This observation suggests that Latvian exporters managed to keep production costs low while at the same time improving the quality of their output, resulting in higher markups.

Figure 5.4: *Physical unit labor costs (PULC), quality and export prices of Latvian exports, 0-to-1 scale.*



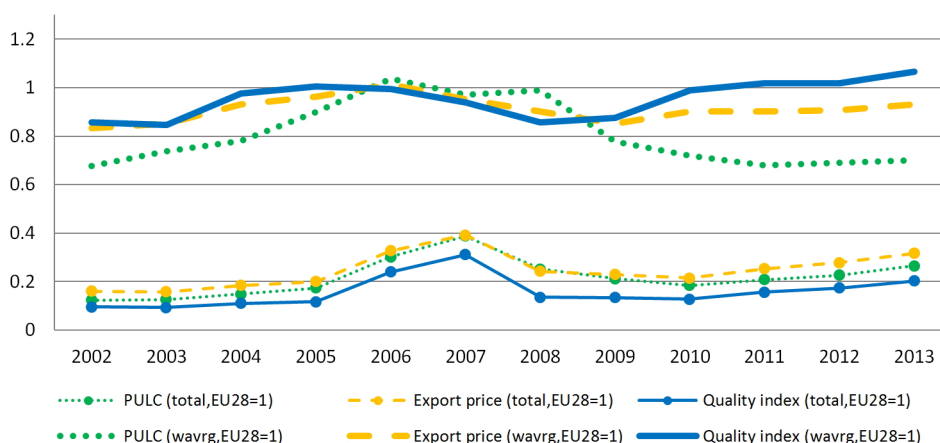
Source: Author's calculations based on Eurostat Comext and AMECO data. Note: "wavrg" parameters are corrected for Latvian product specialization by measuring them at a product level and then aggregating them weighting each product by its share in Latvian exports (in values). "Total" parameters are computed using the category "total" as an individual product.

5.2.6 Normalization to EU28=100

As an alternative to a cross-sectional normalization based on the moving minimum and maximum values of EU competitors, a fixed benchmark can be used to track the evolution of Member States' figures and put them into context. This approach has the advantage of being more robust to outliers because the minima and the maxima in the sample can be driven by exceptional circumstances or temporary shocks. On the other hand, the disadvantage is that by using this approach alone it is impossible to distinguish between changes in the numerator (the Member State) and changes in the denominator (the benchmark). The latter has thus to be chosen carefully and should be meaningful. A natural candidate to be used as a benchmark is the aggregate EU28 average, which can be thought of as one of the exporting countries in the sample, keeping in mind that while prices, costs and the quality index will be EU averages, the non-cost competitiveness parameter will by construction be rather the sum of EU Member States (since total quantities sold will be divided by the average markup).

As an example, in Figure 5.5 total and *wavrg* quality indices, export prices and physical unit labor costs for Latvia are compared to the EU28 averages (setting EU28=1).

Figure 5.5: *Evolution of ULC, quality and export prices of Latvian exports as compared to the EU average, EU28=100.*



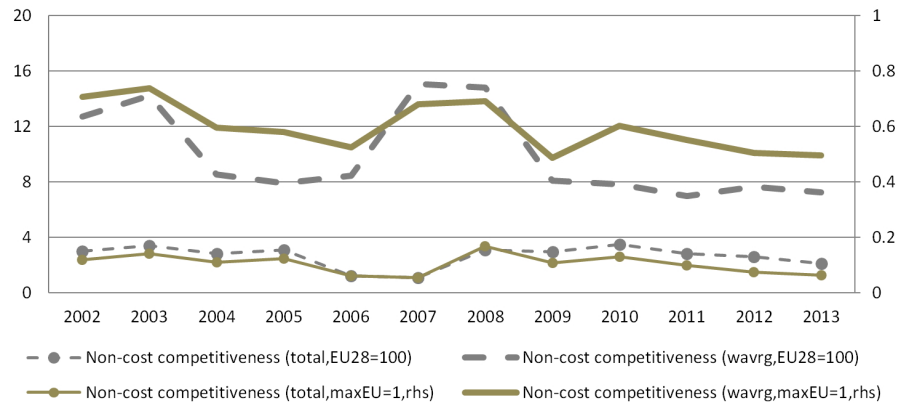
Source: Author's calculations based on Eurostat Comext data. Note: "wavrg" parameters are corrected for Latvian product specialization by measuring them at a product level and then aggregating them by weighting each product by its share in Latvian exports (in values). "Total" parameters are computed using the category "total" as an individual product.

Again, it can be noticed that weighted averages parameters are higher than un-weighted totals and in this case provide a more realistic assessment of the country's performance. As for the latter, since Latvia is still specialized in low-value added products, average export prices and production costs would appear to be just 20 to 30% of EU average in 2013. However, this extreme result is nuanced when weighted averages

are considered, as taking product specialization into account leads to a more credible relative position in terms of prices (90%) and PULC (70%), resulting in a higher weighted average quality index than the EU benchmark. This somehow surprising result arises from the fact that each product is compared one-by-one to the benchmark, assigning a weight to each according to the economic structure of the country considered, which means that on the CN8 products that Latvia exports the most, it does not differ much from EU averages. Another way of looking at the weighted average indices is to imagine that, if the benchmark had exactly the same production structure of the Latvia, it would coincide with the *total* indicator, which is instead very far away in reality because of the different export structure of the EU28 and Latvia, even if the gap is slowly decreasing over time.

The same exercise is repeated for the indicator of non-cost competitiveness in Figure 5.6, where unweighted total and the weighted averages are considered, both in comparison to the EU28 (on the left-hand side, EU28=100) aggregate and on a 0-to-1 scale (on the right-hand side), based on the maximum and minimum value among EU competitors.

Figure 5.6: *Evolution of non-cost competitiveness of Latvian exports as compared to EU, EU28=100.*



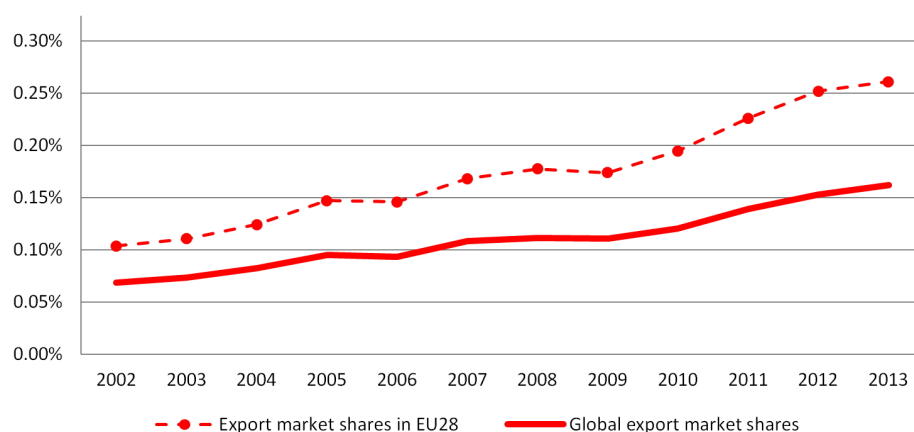
Source: Author's calculations based on Eurostat Comext data. Note: "wavrg" parameters are corrected for Latvian product specialization by measuring them at a product level and then aggregating them by weighting each product by its share in Latvian exports (in values). "Total" parameters are computed using the category "total" as an individual product.

As mentioned above, when dealing with non-cost competitiveness in the way it is computed in this framework (as the quantities sold for a given level of difference between prices and costs) one has to keep in mind that country aggregates, such as the EU28, are expected to have higher absolute levels because aggregate prices, costs and quality for the EU28 are the equivalent of averages whereas aggregate quantities are sums. However, even when considering individual competitors such as the 0-to-1 scale, it is very likely that country size matters; For example, Germany as a whole can export more than Latvia also because more firms are involved in export activities due to a larger internal market

in Germany that results more efficient firms (either for competition and selection or for the scale of production) that can enter export markets more easily. Therefore, it should not come as a surprise that the absolute level of Latvian non-cost competitiveness is so low as compared to the EU28 aggregate and EU Member States' maximum, both in the unweighted totals and in the weighted averages, whose values are respectively 3% and 7% of EU28 in 2013, as shown in Figure 5.6. Notice, however, that in the 0-to-1 scale (solid lines, right-hand side axis) Latvia does not perform too badly, in terms of weighted averages it is at exactly in the middle between the minimum and the maximum value, even though in total terms it is just at 10% because of its export structure.

Latvian non-cost competitiveness seems to be on a downward trend in the last decade, but it should be noticed that the non-cost competitiveness indicator should not be considered in isolation, as it just captures the ability to sell a variety for a given level of prices and costs, but not the profitability of each unit sold, which is instead better captured by the quality and PULC indicator in Figure 5.5. Remember that Latvian quality and cost indicators improved over the last decade, therefore the overall effect on total exports and market shares is *ex ante* uncertain, in this case, and can only be assessed by looking at it explicitly. This is done in Figure 5.7, where it is shown that both intra-EU and global market shares increased almost constantly over time and more than doubled in ten years, so that it can be claimed that the quality upgrade and cost containment effects outweighed the effect of a slightly decreasing capacity to sell at a given markup level.

Figure 5.7: *Evolution of market shares of Latvian intra-EU exports as compared to total intra-EU exports.*

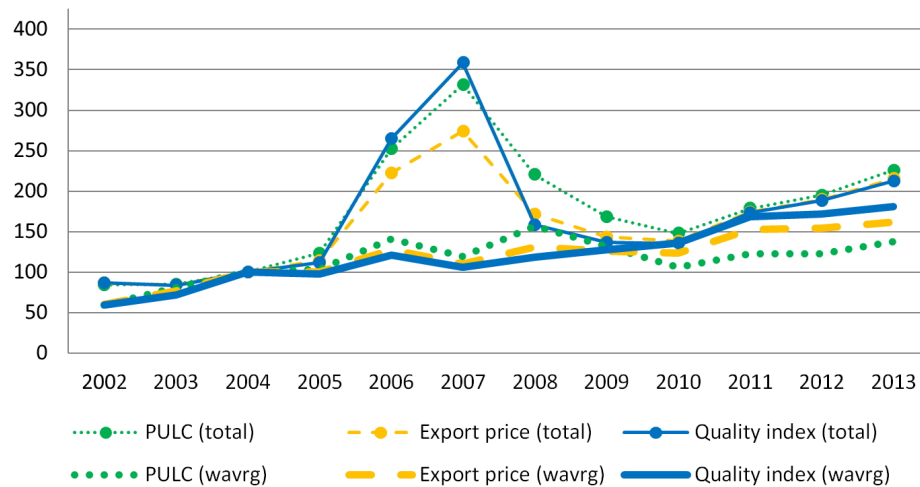


Source: Author's calculations based on Eurostat Comext data. Note: EU28 average values=100. "Wavrg" parameters are corrected for Latvian product specialization by measuring them at a product level and then aggregating them by weighting each product by its share in Latvian exports (in values). "Total" parameters are computed using the category "total" as an individual product.

5.2.7 Longitudinal indicators

An alternative way to use the countries' structural parameters is to track their evolution over time in absolute terms. One of the advantages of this approach is that it does not rely on a benchmark and thus the resulting indicator only captures the evolution of a given parameter. The disadvantage is that it does not provide much information on whether the country is keeping up with international developments or it is losing competitiveness in relative terms. The way a longitudinal indicator is usually built is by setting the reference year equal to 100 and then normalizing the subsequent years in terms of the reference. In addition, it may be worth deflating export prices by the consumption price deflator of the importer in order to get rid of changes in price levels due to general price effects rather than changes in the underlying parameters.¹⁹ This was not necessary for the cross sectional indices, as all the varieties were evaluated in terms of the same numéraire, but it does matter when the comparison is over time. In practice, however, the price deflation only results in a downward shift of the quality index induced by the difference between export prices as they appear in the dataset and deflated export prices, but the impact of the correction seems to be minor in the EU sample used here.

Figure 5.8: *Evolution of Latvian PULC, export price, quality index and non-cost competitiveness as compared to 1999 levels.*



Source: Author's calculations based on Eurostat Comext data. Note: Latvian parameter values in 2004=100. "Wavrg" parameters are corrected for Latvian product specialization by measuring them at a product level and then aggregating them by weighting each product by its share in Latvian exports (in values). "Total" parameters are computed using the category "total" as an individual product.

¹⁹In terms of the model, the consumption price deflator would capture the evolution of the numéraire, q_0 , as it represents the evolution of prices of a composite bundle of all the goods in the economy at the EU28 level.

Illustrating the case of Latvia, Figure 5.8 sets 2004 as the reference year (values in 2004=100) illustrates the longitudinal evolution of the cost, price, quality and non-cost competitiveness indicators, which follow closely the cross sectional indicators, suggesting that the EU28 can indeed be considered a good benchmark for future analyses. The main value added of this class of indicators, as compared to the previous, is that they can tell whether some parameters increased more than others in absolute terms and not compared to a benchmark. For example in 2007, Figure 5.8 shows that the cumulative increase Latvian PULC over time was higher than export prices and quality, but Figure 5.5 would not show it so clearly, as in the same period PULCs appear to have similarly increased in several EU countries.

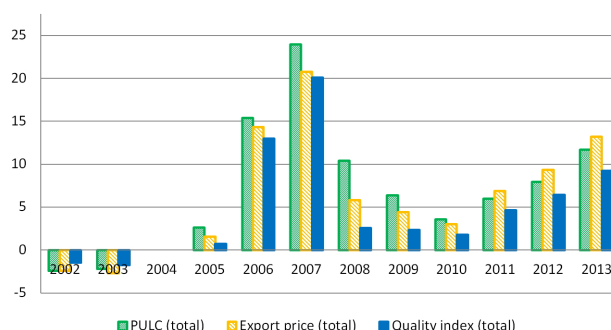
However, there is a main caveat to keep in mind when using longitudinal indicators alone: idiosyncratic features, such as the exchange rates with main trading partners or global features, such as the world price levels of a particular type of goods, can drive some of the results. In order to overcome this potential problem, the next class of indicators is presented.

5.2.8 Cross-sectional longitudinal indicators

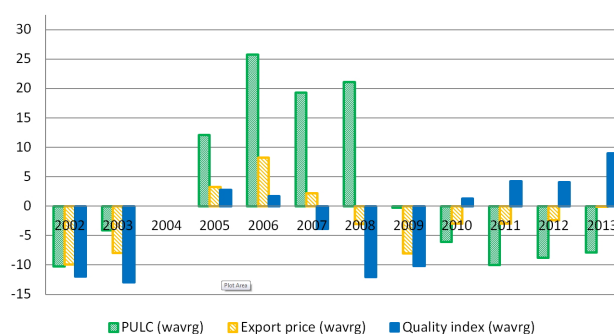
The cross sectional and longitudinal approaches can be merged in order to obtain an indicator that tracks the relative cumulative evolution of certain parameter vis-à-vis a benchmark. Using again EU28 as the relevant reference point, Figure 5.9 shows how the distance between Latvian and EU28 parameters changes over time. To build these indicators, first a cross sectional analysis has to be undertaken, defining the relative parameter values of the Member State as compared to the EU28, which can be set again equal to 100, as in Figure 5.5. The proposed cross-sectional longitudinal indicator is then just the difference between the relative value of a Member State's parameter in 2004 and its relative value in the following (and previous) years. For example, if the relative weighted average quality index of Latvian products is 97.7% of the EU28 level in 2002 and 106.7% in 2013, the value of the cross-sectional longitudinal indicator in 2013 will be 9, as is actually shown in Figure 5.10(b). This kind of analysis can provide interesting insights. For instance, focusing on the pane in which Latvian weighted average results are displayed, it is striking how in 2013 the physical unit labor costs differentials with respect to the EU28 have come back to the levels of 2002/2003 whereas the quality index improved by almost 10 percentage points. In addition, it can be noted that this indicator has the advantage of not being subject to changes in valuation given, for example, by exchange rate volatility of trade partners.

This cross-sectional longitudinal indicator can be used to obtain a yearly value for cumulative changes with respect to a reference period of time, even though it should be treated carefully because it is subject to the risk of interpreting outliers as long-term trends. Even the indicators encapsulating cross sectional and longitudinal elements cannot be taken at face value but need to be integrated with more in-depth analysis, which is why they can be considered useful indicators to add to the competitiveness measurement toolkit enriching rather than replacing the existing ones.

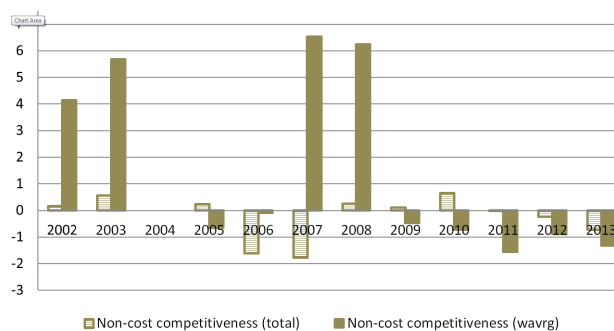
Figure 5.9: Percentage point changes in Latvian-to-EU28 ratios with respect to 1999 values for PULC, export prices, quality and non-cost competitiveness.



(a) *Total* PULC, export price and quality indices



(b) *Wavrg* PULC, export price and quality indices



(c) *Total* and *wavrg* non-cost competitiveness

Source: Author's calculations based on Eurostat Comext data. Note: in every period the difference is reported between the Latvian-to-EU28 ratios in the year considered and Latvian-to-EU28 ratios of the same parameter in 1999. "Wavrg" parameters are corrected for Latvian product specialization by measuring them at a product level and then aggregating them by weighting each product by its share in Latvian exports (in values). "Total" parameters are computed using the category "total" as an individual product.

5.3 Concluding remarks

In this Chapter a methodology has been proposed to complement the current indicators of external competitiveness by providing insights into the capacity of a country's firms to compete abroad. In particular, it was shown how information on product "quality" and "non-cost competitiveness" can be obtained by combining product-level trade data with estimates of product-level macroeconomic data on marginal costs of production and consumption. In order to achieve this result, as a preliminary step, it has been tested whether the verti-zontal model presented in the previous Chapters is fit to deal with aggregate trade data. After testing the validity of the model in a macro context, it has been shown how to interpret its parameters and outcomes to deal with aggregation and data issues related to the different modeling environment. Finally it has been illustrated a concrete example of how to use the model to obtain competitiveness indicators at the country product level, showing the evolution of the parameters for Latvia refining the analysis described in *Comite (2012)*.

The identification strategy proposed is extremely parsimonious in terms of data requirements and is based on a tractable yet comprehensive model of monopolistic competition with asymmetric product differentiation. Building on the specific properties of a utility function displaying variable elasticity of substitution and heterogeneity in product characteristics, the verti-zontal model can be used with aggregate data to identify two independent components of demand. One, which can be interpreted as an indicator of product quality, captures all the country-product characteristics that shift demand outwards and then increase consumers' willingness to pay, indicating the possibility to charge higher margins and sell more. The other, which can be associated with the exporters' capacity to sell a particular variety for a given level of markups, has been defined non-cost competitiveness and captures all the product characteristics that affect quantities sold but not prices.

In the Chapter, it has been shown how these concepts of differentiation can be applied to trade and macro data to extract information on the evolution of countries' competitive performance over time. Different types of country-product indicators, cross sectional and longitudinal, can thus be built to perform in-depth analyses. It has also been shown that country-level characteristics may indeed not be sufficient to describe trade patterns. For example, focusing on the intensive margins of trade for the CN8 exports from EU countries, importer and exporter dummies alone cannot explain more than 2.5% of the total data variability, even combined. This would thus represent a theoretical upper bound on how well country-level characteristics can explain the intensive margin of trade patterns. To go beyond this threshold, the analytical focus has to be shifted towards the country-product level, using models that allow for asymmetric varieties such as the aggregate trade variation of the verti-zontal model presented in this Chapter.

In terms of the data needs, the model is very parsimonious. Unit values and quantities shipped can be easily found at exporter-product-importer level from Eurostat. The same is true for unit labor costs for EU Member States, which can be found on Eurostat or the online dataset AMECO, even though at a higher level of aggregation than trade data.

There are many directions in which the empirical identification methodology can be further improved. For instance, it would be possible to exploit the high frequency of trade statistics to move from a yearly to a monthly analysis, even though macro statistics may have to be somehow adapted to match the same time frequency (which would require specific assumptions to fill the missing data). Also, it would be possible to obtain better estimates of marginal costs of production, which take into account non-labor related variable costs such as energy or input materials, but this would require additional data and new assumptions on the production function of firms in different sectors, which is not readily available for all the EU Member States. Furthermore, consumption estimates at a product level have been inferred only indirectly in this Chapter, following a procedure aimed at getting the most out of the narrowest possible data requirements, but more precise estimates could be obtained following more sophisticated approaches or more detailed data. Better measures of product consumption would contribute towards improving the reliability of the longitudinal indicators, even if the cross sectional indicators would be affected only in absolute terms but not in relative terms, which is one of the strength of the framework.

Finally, it should be noted that the model is completely agnostic about what drives product differentiation and how quality upgrading or better non-cost competitiveness is achieved. Endogenizing firms' choice of quality or non-cost competitiveness levels is certainly a promising future avenue of research for both empirical analysis and policy prescriptions, as it may help design reforms to improve competitiveness. Possible methodologies that can be followed to address some of these issues, among others, are discussed in Chapter 6, where the most promising possible future avenues of research are outlined.

Annex A.1 - Branch-to-Product (CN2) conversion table

In the following table is shown how branch-level unit labor costs (ULCs) derived from Gross Value Added and Compensation of employees have been allocated to the different CN2 product categories in order to obtain the product-level physical unit labor costs (PULCs) used in the analysis. Higher levels of product disaggregation (CN4, CN6, CN8) follow the classification of

the corresponding CN2 product.

AMECO branches (following NACE) (rev.1 sections)	CN2 product code	Product description
Agriculture, forestry and fishing (A + B)	1	LIVE ANIMALS
Agriculture, forestry and fishing (A + B)	2	MEAT AND EDIBLE MEAT OFFAL
Agriculture, forestry and fishing (A + B)	3	FISH AND CRUSTACEANS, MOLLUSCS AND OTHER AQUATIC INVERTEBRATES
Agriculture, forestry and fishing (A + B)	4	DAIRY PRODUCE; BIRDS' EGGS; NATURAL HONEY; EDIBLE PRODUCTS OF ANIMAL ORIGIN.
Agriculture, forestry and fishing (A + B)	5	PRODUCTS OF ANIMAL ORIGIN, NOT ELSEWHERE SPECIFIED OR INCLUDED
Agriculture, forestry and fishing (A + B)	6	LIVE TREES AND OTHER PLANTS; BULBS, ROOTS AND THE LIKE; CUT FLOWERS AND ORNAMENTAL FOLIAGE
Agriculture, forestry and fishing (A + B)	7	EDIBLE VEGETABLES AND CERTAIN ROOTS AND TUBERS
Agriculture, forestry and fishing (A + B)	8	EDIBLE FRUIT AND NUTS; PEEL OF CITRUS FRUIT OR MELONS
Agriculture, forestry and fishing (A + B)	9	COFFEE, TEA, MATE AND SPICES
Agriculture, forestry and fishing (A + B)	10	CEREALS
Agriculture, forestry and fishing (A + B)	11	PRODUCTS OF THE MILLING INDUSTRY; MALT; STARCHES; INULIN; WHEAT GLUTEN
Agriculture, forestry and fishing (A + B)	12	OIL SEEDS AND OLEAGINOUS FRUITS; MISCELLA- NEOUS GRAINS, SEEDS AND FRUIT; INDUSTRIAL OR MEDICINAL PLANTS
Agriculture, forestry and fishing (A + B)	13	LAC; GUMS, RESINS AND OTHER VEGETABLE SAPS AND EXTRACTS
Agriculture, forestry and fishing (A + B)	14	VEGETABLE PLAITING MATERIALS; VEGETABLE PRODUCTS NOT ELSEWHERE SPECIFIED OR IN- CLUDED
Agriculture, forestry and fishing (A + B)	15	ANIMAL OR VEGETABLE FATS AND OILS AND THEIR CLEAVAGE PRODUCTS; PREPARED EDIBLE FATS; ANIMAL OR VEGETAB
Manufacturing (D)	16	PREPARATIONS OF MEAT, OF FISH OR OF CRUS- TACEANS, MOLLUSCS OR OTHER AQUATIC INVER- TEBRATES

Manufacturing (D)	17	SUGARS AND SUGAR CONFECTIONERY
Manufacturing (D)	18	COCOA AND COCOA PREPARATIONS
Manufacturing (D)	19	PREPARATIONS OF CEREALS, FLOUR, STARCH OR MILK; PASTRYCOOKS' PRODUCTS
Manufacturing (D)	20	PREPARATIONS OF VEGETABLES, FRUIT, NUTS OR OTHER PARTS OF PLANTS
Manufacturing (D)	21	MISCELLANEOUS EDIBLE PREPARATIONS
Manufacturing (D)	22	BEVERAGES, SPIRITS AND VINEGAR
Manufacturing (D)	23	RESIDUES AND WASTE FROM THE FOOD INDUSTRIES; PREPARED ANIMAL FODDER
Manufacturing (D)	24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES
Industry, including energy (C + D + E)	25	- SALT; SULFUR; EARTHS AND STONE; PLASTERING MATERIALS, LIME AND CEMENT
Industry, including energy (C + D + E)	26	ORES, SLAG AND ASH
Industry, including energy (C + D + E)	27	MINERAL FUELS, MINERAL OILS AND PRODUCTS OF THEIR DISTILLATION; BITUMINOUS SUBSTANCES; MINERAL WAXES
Manufacturing (D)	28	INORGANIC CHEMICALS; ORGANIC OR INORGANIC COMPOUNDS OF PRECIOUS METALS, OF RARE-EARTH METALS, OF RADIO
Manufacturing (D)	29	ORGANIC CHEMICALS
Manufacturing (D)	30	PHARMACEUTICAL PRODUCTS
Manufacturing (D)	31	FERTILISERS
Manufacturing (D)	32	TANNING OR DYEING EXTRACTS; TANNINS AND THEIR DERIVATIVES; DYES, PIGMENTS AND OTHER COLOURING MATTER;
Manufacturing (D)	33	ESSENTIAL OILS AND RESINOIDS; PERFUMERY, COSMETIC OR TOILET PREPARATIONS
Manufacturing (D)	34	SOAP, ORGANIC SURFACE-ACTIVE AGENTS, WASHING PREPARATIONS, LUBRICATING PREPARATIONS, ARTIFICIAL WAXES,
Manufacturing (D)	35	ALBUMINOIDAL SUBSTANCES; MODIFIED STARCHES; GLUES; ENZYMES
Manufacturing (D)	36	EXPLOSIVES; PYROTECHNIC PRODUCTS; MATCHES; PYROPHORIC ALLOYS; CERTAIN COMBUSTIBLE PREPARATIONS
Manufacturing (D)	37	PHOTOGRAPHIC OR CINEMATOGRAPHIC GOODS
Manufacturing (D)	38	MISCELLANEOUS CHEMICAL PRODUCTS
Manufacturing (D)	39	PLASTICS AND ARTICLES THEREOF
Manufacturing (D)	40	RUBBER AND ARTICLES THEREOF
Manufacturing (D)	41	RAW HIDES AND SKINS (OTHER THAN FUR SKINS) AND LEATHER
Manufacturing (D)	42	ARTICLES OF LEATHER; SADDLERY AND HARNESS; TRAVEL GOODS, HANDBAGS AND SIMILAR CONTAINERS; ARTICLES OF
Manufacturing (D)	43	FUR SKINS AND ARTIFICIAL FUR; MANUFACTURES THEREOF

Manufacturing (D)	44	WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL
Manufacturing (D)	45	CORK AND ARTICLES OF CORK
Manufacturing (D)	46	MANUFACTURES OF STRAW, OF ESPARTO OR OF OTHER PLAITING MATERIALS; BASKETWARE AND WICKERWORK
Manufacturing (D)	47	PULP OF WOOD OR OF OTHER FIBROUS CELLULOSIC MATERIAL; RECOVERED (WASTE AND SCRAP) PAPER OR PAPERBOARD
Manufacturing (D)	48	PAPER AND PAPERBOARD; ARTICLES OF PAPER PULP, OF PAPER OR OF PAPERBOARD
Manufacturing (D)	49	PRINTED BOOKS, NEWSPAPERS, PICTURES AND OTHER PRODUCTS OF THE PRINTING INDUSTRY; MANUSCRIPTS, TYPESCRIPTS
Manufacturing (D)	50	SILK
Manufacturing (D)	51	WOOL, FINE OR COARSE ANIMAL HAIR; HORSEHAIR YARN AND WOVEN FABRIC
Manufacturing (D)	52	COTTON
Manufacturing (D)	53	OTHER VEGETABLE TEXTILE FIBERS; PAPER YARN AND WOVEN FABRICS OF PAPER YARN
Manufacturing (D)	54	MAN-MADE FILAMENTS; STRIP AND THE LIKE OF MAN-MADE TEXTILE MATERIALS
Manufacturing (D)	55	MAN-MADE STAPLE FIBERS
Manufacturing (D)	56	WADDING, FELT AND NONWOVENS; SPECIAL YARNS; TWINE, CORDAGE, ROPES AND CABLES AND ARTICLES THEREOF
Manufacturing (D)	57	CARPETS AND OTHER TEXTILE FLOOR COVERINGS
Manufacturing (D)	58	SPECIAL WOVEN FABRICS; TUFTED TEXTILE FABRICS; LACE; TAPESTRIES; TRIMMINGS; EMBROIDERY
Manufacturing (D)	59	IMPREGNATED, COATED, COVERED OR LAMINATED TEXTILE FABRICS; TEXTILE ARTICLES OF A KIND SUITABLE FOR IND
Manufacturing (D)	60	KNITTED OR CROCHETED FABRICS
Manufacturing (D)	61	ARTICLES OF APPAREL AND CLOTHING ACCESSORIES, KNITTED OR CROCHETED
Manufacturing (D)	62	ARTICLES OF APPAREL AND CLOTHING ACCESSORIES, NOT KNITTED OR CROCHETED
Manufacturing (D)	63	OTHER MADE-UP TEXTILE ARTICLES; SETS; WORN CLOTHING AND WORN TEXTILE ARTICLES; RAGS
Manufacturing (D)	64	FOOTWEAR, GAITERS AND THE LIKE; PARTS OF SUCH ARTICLES
Manufacturing (D)	65	HEADGEAR AND PARTS THEREOF
Manufacturing (D)	66	UMBRELLAS, SUN UMBRELLAS, WALKING STICKS, SEAT-STICKS, WHIPS, RIDING-CROPS AND PARTS THEREOF
Manufacturing (D)	67	PREPARED FEATHERS AND DOWN AND ARTICLES MADE OF FEATHERS OR OF DOWN; ARTIFICIAL FLOWERS; ARTICLES OF H

Manufacturing (D)	68	ARTICLES OF STONE, PLASTER, CEMENT, ASBESTOS, MICA OR SIMILAR MATERIALS
Manufacturing (D)	69	CERAMIC PRODUCTS
Manufacturing (D)	70	GLASS AND GLASSWARE
Manufacturing (D)	71	NATURAL OR CULTURED PEARLS, PRECIOUS OR SEMI-PRECIOUS STONES, PRECIOUS METALS, METALS CLAD WITH PRECIO
Manufacturing (D)	72	IRON AND STEEL
Manufacturing (D)	73	ARTICLES OF IRON OR STEEL
Manufacturing (D)	74	COPPER AND ARTICLES THEREOF
Manufacturing (D)	75	NICKEL AND ARTICLES THEREOF
Manufacturing (D)	76	ALUMINUM AND ARTICLES THEREOF
Manufacturing (D)	78	LEAD AND ARTICLES THEREOF
Manufacturing (D)	79	ZINC AND ARTICLES THEREOF
Manufacturing (D)	80	TIN AND ARTICLES THEREOF
Manufacturing (D)	81	OTHER BASE METALS; CERMETS; ARTICLES THEREOF
Manufacturing (D)	82	TOOLS, IMPLEMENTS, CUTLERY, SPOONS AND FORKS, OF BASE METAL; PARTS THEREOF OF BASE METAL
Manufacturing (D)	83	MISCELLANEOUS ARTICLES OF BASE METAL
Manufacturing (D)	84	NUCLEAR REACTORS, BOILERS, MACHINERY AND MECHANICAL APPLIANCES; PARTS THEREOF
Manufacturing (D)	85	ELECTRICAL MACHINERY AND EQUIPMENT AND PARTS THEREOF; SOUND RECORDERS AND REPRODUCERS, TELEVISION IMAG
Manufacturing (D)	86	RAILWAY OR TRAMWAY LOCOMOTIVES, ROLLING STOCK AND PARTS THEREOF; RAILWAY OR TRAMWAY TRACK FIXTURES AND
Manufacturing (D)	87	VEHICLES OTHER THAN RAILWAY OR TRAMWAY ROLLING STOCK, AND
Manufacturing (D)	88	AIRCRAFT, SPACECRAFT, AND PARTS THEREOF
Manufacturing (D)	89	SHIPS, BOATS AND FLOATING STRUCTURES
Manufacturing (D)	90	OPTICAL, PHOTOGRAPHIC, CINEMATOGRAPHIC, MEASURING, CHECKING, PRECISION, MEDICAL OR SURGICAL INSTRUMENT
Manufacturing (D)	91	CLOCKS AND WATCHES AND PARTS THEREOF
Manufacturing (D)	92	MUSICAL INSTRUMENTS; PARTS AND ACCESSORIES OF SUCH ARTICLES
Manufacturing (D)	93	ARMS AND AMMUNITION;
Manufacturing (D)	94	FURNITURE; BEDDING, MATTRESSES, MATTRESS SUPPORTS, CUSHIONS AND SIMILAR STUFFED FURNISHINGS; LAMPS AND
Manufacturing (D)	95	TOYS, GAMES AND SPORTS REQUISITES;
Manufacturing (D)	96	MISCELLANEOUS MANUFACTURED ARTICLES
Services (G + P)	97	WORKS OF ART, COLLECTORS' PIECES AND ANTIQUES
Services (G + P)	98	COMPLETE INDUSTRIAL PLANT

Part III

The ways forward

Chapter 6

Future avenues of research

After having described in the previous Chapters the spatial interpretation of the verti-zontal model, its flexible structural form, empirical validation and potential use, in this Chapter some promising future avenues of research are outlined in which the Model could be fruitfully extended. Specifically, first the model is employed to test empirically some of the implications for the transport market of the quadratic utility framework without heterogeneities presented in Chapter 1. Then, further empirical validation of the verti-zontal model and of its interpretation and implications are proposed. Finally, theoretical developments of the verti-zontal model are proposed, which have the merit of deepening the comprehension of the framework and its richness, but the disadvantage of becoming less prone to be tested empirically because of the higher number of degrees of freedom.

6.1 Empirical test of the transport costs analysis

In virtually all trade theories transport costs are taken as nearly exogenous parameters, depending on either the value of the goods shipped (the so-called iceberg transport costs) or the distance between the producer and the destination market (as in gravity models), implicitly assuming that shipping costs do not depend on the direction of the shipment. However in Chapter 1 it has been shown that it would not be rational for the providers of the transport sector to charge the same price in the two directions, whatever the level of competition on the route (except perfect competition with prices equal to marginal costs, of course). The equilibrium prices emerging in the transport market would indeed depend on the characteristics of the exporter firms and importing markets.

In Chapter 1, this point has been made theoretically, so it would be interesting to take the model to the data to see if it can be useful to rationalize the observed transport cost patterns. Based on the observation of the transport prices charged by UPS to ship the same good in one direction and in the other of the same route (Guillin, 2014), prices are found to be systematically asymmetric in the two directions. For example, shipping the same pallet from Hong Kong to London is found to be twice as expensive as shipping it from London to Hong Kong. Of course, the fact that transport prices are asymmetric does not imply that they should behave as described in Chapter 1, but it may be worth to outline an model that can be used to test its hypotheses. As for the transport price data, two alternative approaches are present in the literature: either a direct observation of transaction-level tariffs as Kleinert and Spies (2011) do or the methodology followed by Pomfret and Sourdin (2010) who estimate transport costs by comparing fob and cif values of exports. In other words, as Anderson and van Wincoop (2004) put it *Partial and*

incomplete data on direct measures of costs go with inference on implicit costs from trade flows and prices.

Browsing the literature, it is possible to find several papers aimed at describing a transport market, as for example Hummels et al. (2009), Behar and Venables (2010) or Behrens et al. (2009). Different factors have been shown to influence transport prices, including port efficiency (Blonigen and Wilson, 2008), regional trade agreements (Pomfret and Sourdin, 2009), imbalances in trade flows (Behrens and Picard, 2011; Jonkeren et al., 2011), distance (Anderson and van Wincoop, 2003), time (Hummels and Schaur, 2012) or technology choices (Kleinert and Spies, 2011). Each of these elements may be more or less important as a control depending on the dataset at hand, but they should not affect the main point raised in Chapter 1: the transport price charged by carriers may be influenced by the demand conditions in the destination of the shipment. For example, in the case of a monopolistic carrier, it is shown in equation (6.4) that it would charge exactly the markup that the producer would have charged in the absence of transport costs, which depends only on the producer's marginal costs (c_s) and quality (α_s) and on the destination's level of competition (Q).

One important deviation from Chapter 1 is that a pure analysis of transport costs doesn't have to include all the complex interactions of the long-run location problem analyzed in Chapter 1. Therefore, room is left to use the verti-zontal model proposed in Chapter 3 in a partial equilibrium setting, which allows for more flexibility in dealing with the empirical implementation of the theoretical model. Hence, the next sub-Section outlines a simple verti-zontal model of asymmetric transport costs.

A verti-zontal model of asymmetric transport costs

Merging the modeling strategy of Chapter 1 with the verti-zontal functional form, the model here focuses on the interaction between a transport sector providing an undifferentiated shipping service and a differentiated-good sector. For the sake of the argument, the transport sector is assumed to be populated by a monopolist with negligible variable costs of delivering the service but high fixed costs of setting up a network, so that entry is inhibited in the shipping market even if the carrier makes operating profits. The linear transport costs charged by the carriers are endogenously determined in the transport sector. The focus is on a market i , where consumers have access to a high number of varieties produced at home, in region i , or abroad, in any other region $j = -i$. Each variety has a negligible mass and cannot choose its price strategically to affect market aggregates. In addition, the world is composed of many connected regions, each link being characterized by potentially different and asymmetric transport costs. To keep the argument as simple as possible, the share of a particular region's exports to market i is assumed to be negligible for market aggregates, so as not to give incentive to the carrier in the transport sector to price the shipping service strategically to affect the price indices in the world markets, i.e. a carrier shipping variety s from market j to market i does not internalize the impact on the price index P_i of charging a higher transport price $t_{s,ji}$.

The differentiated good sector

As in the verti-zontal model (3.48), a representative consumer is assumed to live in region i whose preferences over different varieties of a differentiated good, $q_{s,i}$ can be described as

$$U_i = \int_{s \in S_i} \alpha_s q_{s,i} ds - \int_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{\gamma}{2} \int_{s \in S_i} \int_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_{0,i}, \quad (6.1)$$

where $q_{0,i}$ is a region-specific numéraire good; $q_{s,i}$ is the quantity consumed by the representative consumer in i of a variety $s \in S_i$ which can be produced domestically, $q_{s,ii}$, or abroad, $q_{s,ji}$. Throughout the section, after the variety identifier s is reported in the subscript first the region in which the variety is produced and then the region in which the variety is sold. The parameter α_s , as usual, defines the intensity of preference accorded to the consumption of the differentiated good, as compared to the region-specific numéraire, $q_{0,i}$, whose marginal utility in region i is normalized to unity and which can be thought of as a Hicksian composite good capturing the marginal utility of consumption of any other good available in the region. The parameter $\beta_{s,i}$ can be seen as capturing the taste mismatch between variety s ' horizontal characteristics and the ideal of the representative consumer in i . As for γ , it represents the degree of substitutability between any pair of varieties.

Consumers maximize their utility subject to the budget constraint:

$$\int_{S,i} p_{s,ii} q_{s,ii} ds + \int_{S,i} p_{s,ji} q_{s,ji} ds + q_{0,i} = Y_i$$

where $p_{s,ii}$ and $q_{s,ii}$ are the price (in terms of the numéraire) and quantities sold of a differentiated variety bought by a consumer living in the same region as the producing firm; $p_{s,ji}$ and $q_{s,ji}$ are the price and quantity sold of a variety of differentiated good bought by a consumer living in a region different from the one where the good was produced; $q_{0,i}$ is the quantity consumed of the numéraire whose price is normalized to unity in region i ; Y_i is the income of the representative agent living in i .

The demand associated with this preference system is linear and extremely tractable:

$$q_{s,i} = \frac{\alpha_s - \gamma Q_i - p_{s,i}}{\beta_{s,i}}$$

where $Q_i = \int_{S,i} q_{s,i} ds$ is the total amount purchased by the representative agent in i of the differentiated varieties. It can be noted that the price elasticity associated with this demand is not constant, but it decreases in prices:

$$\epsilon_{s,i} = -\frac{p_{s,i}}{\alpha_s - \gamma Q_i - p_{s,i}}$$

This expression ranges from 0, when $p_{s,i} = 0$, to $-\infty$, when prices equal the intercept of the inverse demand function, $\alpha_s - \gamma Q_i$. This property is key to the results because the intensity of the price elasticity in the differentiated good sector will indirectly affect the profit-maximizing price that carriers will charge for their transport service. To see this, first the firm problem is solved with a fixed cost of entry and a constant marginal cost of production; then the carrier problem is solved. The operating profit function of a firm producing a variety s of the differentiated good in i and selling it in all the regions can be written as follows:

$$\Pi_{s,i} = (p_{s,ii} - c_{s,i})q_{s,ii} + \sum_{j \neq i} (p_{s,ij} - c_{s,i} - t_{ij})q_{s,ij} - f_{s,i}.$$

Since markets are segmented and marginal costs of production are assumed to be independent of the scale of production, the operating profit function of all the firms selling their variety in i can be generalized as

$$\pi_{s,ji} = (p_{s,ji} - c_{s,i} - t_{ji})q_{s,ji}$$

where $t_{ji} = 0$ when $j = i$ and all the other $t_{ji} \neq 0$ are endogenously determined in the transport sector. The profit-maximizing price will then be

$$p_{s,ji}^* = \frac{\alpha_s - \gamma Q_i + c_{s,j} + t_{ji}}{2}. \quad (6.2)$$

Markups will be:

$$p_{s,ji}^* - c_{s,j} - t_{ji} = \frac{\alpha_s - \gamma Q_i - c_{s,j} - t_{ji}}{2}$$

and quantities sold in equilibrium will be:

$$q_{s,ji}^* = \frac{p_{s,ji}^* - c_{s,j} - t_{ji}}{\beta_{s,i}} = \frac{\alpha_s - \gamma Q_i - c_{s,j} - t_{ji}}{2\beta_{s,i}} \quad (6.3)$$

Notice that when $i \neq j$ the equilibrium inter-regional quantities sold $q_{s,ji}^*$ can be interpreted as the demand for the transport sector, which is indeed decreasing in the linear transport cost, t_{ji} , which is determined as described in what follows.

The segmented transport sector

To keep the argument as simple as possible, it is assumed that the transport service is undifferentiated and provided by a monopolist carrier.¹ In addition, it is assumed that the business model of the carrier implies high fixed costs of setting up a network and negligible variable costs per unit shipped (which, together with the assumption of an undifferentiated transport service also justifies why the focus is on the case of a monopolist). The intuition is that if a train or a plane is scheduled to depart on with regular schedule, its operating costs will be the almost same whether it is full or empty but the fixed costs will be relevant.

The carrier is assumed to provide the inter-regional shipment service charging a price t_{ij} per unit shipped. Similarly to the firms in the differentiated sector, the carriers k maximizes profits, which can be written as

$$\Pi_k = \sum_{j \neq i} \int_{s \in S, ji} t_{s,ji} q_{s,ji} ds - f_k$$

where f_k is the fixed cost of setting up the inter-regional distribution network, t_{ji} is the price charged for the transport service from region j to region i , and $q_{s,ji}$ are the quantities shipped by all the varieties s_{ij} produced in j and sold in i . Notice that, given the lack of heterogeneity across firms within a region, the only source of variability across varieties is the region of production and the region of consumption. Hence all the shipments from one region to another will be charge the same price and the profit function can be simplified as

$$\Pi_k = \sum_{j \neq i} t_{ji} \int_{s \in S, ji} q_{s,ji} ds - f_k$$

The carrier is able to perfectly discriminate firms based on the varieties shipped and charge the profit-maximizing transport price on each bilateral trade flow. The operating profit function of the carrier can thus be further simplified into the minimalistic form

$$\pi_{k,ji} = t_{ji} q_{ji}.$$

¹Given the assumption of an undifferentiated service, the generalization to the case of an oligopolistic or perfectly competitive market is straightforward. It would be more complex to model a differentiated transport sector in which different service characteristics and modes of transport compete in a differentiated transport sector, but the argument would not be substantially affected.

This expression intuitively highlights the carrier's trade-off between higher transport costs and the volume of shipments. Notably, the exact terms of this trade-off will be influenced by the the price elasticities in the importing market, as can be seen from (6.2) that firms will pass through to their costumers half of the transport costs determined in the transport market. Plugging (6.3) into (6.1) operating profits can indeed be rewritten as

$$\pi_{k,ji} = \frac{t_{ji}}{\beta_{s,i}} \left(\frac{\alpha_s - \gamma Q_i - c_{s,j} - t_{ji}}{2} \right)$$

which implies that the optimal transport tariff will be

$$t_{ji}^* = \frac{\alpha - \gamma Q_i - c_{s,j}}{2}. \quad (6.4)$$

Note that in this case the monopolist carrier is actually absorbing the entire markup that would be generated by the firm producing and selling in market i if $c_{s,j} = c_{s,j}$, as the term $\frac{\alpha - \gamma Q_i - c_{s,j}}{2}$ is exactly the domestic markup (i.e. the markup in absence of inter-regional transport costs). From (6.2), it can be noted that the producer will only charge $\frac{t_{ji}^*}{2}$ on top of that.

For the purposes of the empirical estimation strategy, it should just be noted that market size (Q_i) is always negatively associated with transport costs, as they lower the margins of exporters and so lower the capacity of the carrier to extract profits from them:

$$\frac{\partial t_{ij}}{\partial Q_j} = -\frac{\gamma}{2}.$$

The main hypothesis that can be taken to the data is therefore that the level of competition in the importing market (for which market size can be a proxy), controlling for everything else (including bilateral trading partners fixed effects), is negatively related to transport prices. If confirmed by the data, this factor can be used in future research on transport costs next to the supply-side factors currently employed.

6.2 Empirical identification of the Verti-zontal parameters

This Section focuses on future empirical exercises that may involve the use of the verti-zontal model presented in the previous chapters. The first one concerns the possibility of relating the preference parameters identifiable through the model to an external indicator of quality or taste mismatch. The second consists in the investigation an issue that is receiving increasing empirical attention lately: the possible link between consumer income and the preference for high-quality goods (Bastos and Silva, 2010), beyond the standard Balassa-Samuelson effect (Samuelson, 1994). Finally, it is shown how the verti-zontal model can be used to rationalize the link between input quality and firm profitability (Verhoogen, 2012).

6.2.1 External validation of quality and taste mismatch

The preference parameters defined in the verti-zontal model have been shown to be easily identifiable. The corresponding quality and taste mismatch parameters display a remarkable internal model consistency but have not been related to an external source of validation which can justify the interpretation attributed to them. The factor analysis undertaken in Chapter 4 goes in the direction of suggesting some possible sources of vertical and horizontal differentiation. Yet, given the nature of the dataset, which does not include variety-specific marginal costs of production, it is not a formal test of the theory but rather a preliminary exploratory exercise.

A simple methodology can be proposed to determine whether the quality and taste mismatch parameters identifiable with the verti-zontal model can be legitimately interpreted as such. In other words, the internal consistency of the parameters of the verti-zontal model grant that the empirical approach presented in Chapters 4 and 5 can be used to identify one set of firm-level characteristics associated with higher sales and prices, associated with the parameter α . So this parameter is essentially a demand shifter pushing the linear demand function outwards, but can it be called quality? And similarly, the taste mismatch parameter β is essentially a demand function slope shifter, affecting quantities sold in equilibrium but not price: is it enough to call it a taste shifter?

As for the quality parameter, one possible way to proceed would be to compare the variety-specific α_s with some objective indicator of quality. For example, for some categories of goods such as wines there are some rankings or scores given by experts and generally associated with price, for example Crozet et al. (2012) use an external classification of champagne to calibrate the productivity and quality parameters using CES preferences and (Brooks, 2003) exploits blind tasting evaluations. Of course, higher prices in the verti-zontal model do not imply higher quality, if costs are not accounted for, which meant that a formal comparison between α_s and the quality rank or mark assigned to each variety s needs to rely on a micro-level dataset with information on firm costs. For example, it is well documented that a land price gap exist between arable lands associated with specific "appellations" are involved (e.g., Champagne, Cognac), with land prices in prime lands being significantly more expensive (SAFER, 2012). It is thus theoretically possible that higher costs drive prices and entrepreneurs find it optimal to produce champagne for a taste effect (i.e. the profitability may not derive from higher markups but from an increase in sales).

It would be of course also possible to use the European car dataset employed in Chapters 2 and 4, but information would be needed on the marginal costs of production associated with the car characteristics driving prices up. It may be noted from Chapter 4 that more fuel efficient cars are indeed associated with higher prices: are they more valued by consumers or just more expensive to produce? From the factor analysis in Tables 4.3 and 4.7 they are in fact associated with lower quantities sold, which would suggest higher costs of production rather than higher quality, but of course a factor analysis does not measure marginal effects and does not control for the impact of other correlated variables. This means that among the car characteristics associated with higher prices and lower quantities, quality and cost elements may be simultaneously present.

Finally, an alternative approach to have an external measure of quality which may be readily available is to exploit product classifications that include information on inputs or product characteristics. For example, chocolate exports are classified in terms of cocoa content (the higher implying higher prices) or alcoholic beverages are classified by alcohol content (again, the higher, the more expensive). These two indicators pose different empirical challenges. For example, product characteristics need indeed to be universally recognized by consumers as an indication of higher quality. This means that while in some cases it may be reasonable to assume so (for example, everyone would probably agree that fuel efficiency is a good attribute, keeping everything else constant), others may be more questionable (which may be the case of alcoholic content, which may not be equally valued in all the destination markets or may have a non-monotonic relation with the perception of value for consumers). As for the alternative approach of looking at the input, such as the cocoa content of chocolate exports, the cost of the alternative inputs should be controlled for to be sure to distinguish cost effects from quality effects. This is because cocoa is a commodity whose price fluctuates following exogenous shocks such as weather, which need not be perfectly correlated with the other costs of production, which means that there may theoretically be cases in which higher cocoa content is associated with lower costs of production than the alternative varieties. This calls again for a micro-level dataset where costs can be

accounted for.

However, solved the data issues mentioned above, the approach to test the consistency between the external definitions of quality and the one resulting from the verti-zontal model would be straightforward. For example, it could be observed whether higher α_s correlate with higher alternative definitions of quality. Or, more generally, concordance in ranks could be compared.

As for the definition of taste mismatch, similar empirical problems arise. First of all, micro-level datasets are needed to be able to compare markups with quantities sold - possibly also having information on the transport margins incurred by the exporter (which are interpreted as linear transport costs in the model). Once the data availability issue has been solved, one related and even more delicate issue of finding an external indication of taste mismatch with respect to the taste of specific markets. One possible solution would be to exploit information on variations of the same firm-product variations. Identical varieties of computers or mp3 readers, for example, are available in different colors for the same price - or similarly DVDs or individual music tracks are often sold at the same price even if sales differ substantially. These instances of different varieties sold at the same price, and arguably involving the same costs or production, but sold in different quantities would be an ideal setting to measure differences in β_s . Of course, the main issue would be that there would be no external definition of taste mismatch, but identification $\beta_{s,i}$ would coincide with the observation of a low taste mismatch, which would not really help in defining an objective external source of identification. In addition, ideally $\beta_{s,i}$ should depend on characteristics of the variety and not on the variety itself.

To make a concrete example in the case of cultural industries, a paper by Chung and Song (2008) studies the film industry in Korea by analyzing the commercial success of movie shown on Korean theaters and finds that *"if cultural elements in a foreign movie were switched to Korean, the probability of watching that movie increases by 87.5 percent on average"*. In other words, for market $i = Korea$ adding Korean cultural elements reduces the $\beta_{s,i}$ of a movie s by altering one of the dimensions of horizontal differentiation. In terms of market aggregates, it means that the $\beta_{s,i}$ -weighted indices of the Korean movie market are affected by the presence of Korean cultural elements in such a way that, holding everything else equal, adding Korean cultural elements in all the movies shown in Korean theaters would increase the toughness of competition in that particular market. This is an example of a possible use identification and use of the parameter $\beta_{s,i}$ is a very specific case, but it may be admittedly difficult to find dataset which provide sufficiently extensive information on horizontal characteristics of products as to estimate the impact of individual features or to measure the impact on the market.

Another issue is that taste heterogeneity certainly overlaps with other possible explanations for the sales variation of firm-products across countries, which have to be distinguished from consumer taste. For example, Arkolakis (2010) underlines the importance of distribution networks in determining total sales and Foster et al. (2012) note that firms appear to build up their demand gradually over time (even if in the next Section an alternative mechanism is suggested to motivated the same empirical finding). These alternative explanations may be highly correlated with taste factors, which can pose some identification challenges (for example, the absence of a distribution network for a given variety may stem from the mismatch between the variety and local tastes).

However, quality and taste mismatch as defined in the context of the verti-zontal model are ready to be confronted with external data. The main issue seems to lie on the availability of appropriate data, which can combine detailed information at micro level and a sufficiently large sample to justify the identification of market aggregates.

The reason to undertake this empirical effort is that the quality and taste parameters so identified would then become available for a much wider set of product markets, including those for which external quality and taste indicators do not exist. Also, the empirical identification of

the demand parameters can then be used to strip price indices from quality and taste changes to get better estimates of GDP growth indicators as currently also pursued by Feenstra and Romalis (2012).

6.2.2 Income and preference for quality

Turning now to the issue of how the preference parameters estimated through of the verti-zontal model could be used in future research, there is one proposal suggested by a referee in the reviewing process of Di Comite et al. (2014) that deserves some attention. The referee suggested using the quality and taste mismatch parameters to investigate whether richer (representative) consumers (i.e. richer countries) have a preference for higher quality goods. In other words, in the theoretical setting of the verti-zontal model no correlation is assumed between α_s and $\beta_{s,i}$, but there could indeed be destination-specific characteristics that determine a relation between quality and taste mismatch. A typical determinant of taste for quality could be income, as suggested theoretically by Gabszewicz and Thisse (1979) and more recently tested empirically by Bastos and Silva (2010).

A methodology which can be followed to this end is outlined here, even if preliminary research undertaken in the preparation of the Di Comite et al. (2014) paper has not yielded any statistically significant result. In a nutshell, the most straightforward approach to test this hypothesis is to see whether the market-specific relation between α_s and $\beta_{s,i}$ is related to market i 's per capita income. The steps to follow are thus the following.

First, one product must be chosen for which several varieties are observed in the dataset. Ideally the dataset should include information on costs of production and export prices, but even in the absence of costs of production an alternative could be to focus on product with little scope for differences in cost of production (because of institutional or technological issues, for example products using the same commodity inputs in sectors and countries where the cost of labor is highly regulated). Once markups are measured, or estimated (or costs are assumed constant across varieties and prices and quantities observed), then the different export destination may be associated with a destination specific $\beta_{s,i}$ for each variety s exported to i . Notice that for each of these varieties also α_s (or differences in α_s) can be estimated.

Hence the second step is take at each destination country individually and regress $\beta_{s,i}$ (or $\frac{1}{\beta_{s,i}}$, to facilitate the interpretation of the results) over α_s . The resulting coefficient could be defined as the *taste for quality* in the sense that, for each market i , it shows how much sales, conditional on markups and thus indirectly on quality, are related to quality. Since the verti-zontal model allows for the separate estimation of these two parameters, it provides an improvement on existing approaches using prices alone. The result of this second step is thus a market-specific indicator of preference for high quality.

The final step is thus to identify the country characteristics of interest and regress countries' *taste for quality* over them. The hypothesis of richer consumers preferring high-quality goods would not be rejected if, for example, per capita GDP of destination markets would be found to be positively associated with the *taste for quality* estimates. To help intuition, Figure 6.1 provides an example of the expected observations for a quality-income sorting of countries. With a country "disliking quality" ($i = 1$) and a country "liking quality" ($i = 4$), which happen to be a poor country the former and a rich country the latter. It can be noticed that this methodology would also allow to identify a level of income per capita for which consumers would be "quality indifferent", i.e. with $\beta_{s,i}$ not being correlated with α_s .

In the case of the Belgian exporters' data, in the absence of information on marginal costs the approach has been adapted to deal with differences across varieties. After having selected appropriate products in order to assume constant marginal costs (as for example chocolate with

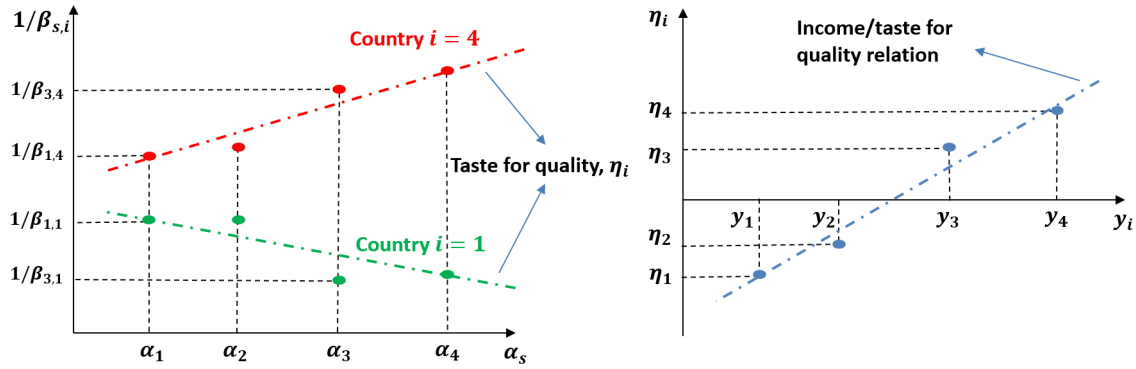


Figure 6.1: Illustration of the methodology to identify a preference for quality and its relation with income.

a specific content of cocoa), differences in quality ($\Delta_{\alpha_s, \alpha_r}$) have been measured in each market as

$$\Delta_{\alpha_s, \alpha_r} = 2\Delta_{p_{s,i}, p_{r,i}},$$

where $\Delta_{p_{s,i}, p_{r,i}} = p_{s,i} - p_{r,i}$. For the sake of tractability, the variety with the lowest α_r is defined as $s = 0$ with normalization $\alpha_0 = 0$ and all the others are expressed in terms of distance from the worst-quality variety, so that

$$\tilde{\alpha}_s = 2\Delta_{p_{s,i}, p_{0,i}}.$$

Similarly, following the same assumptions the distance in $\beta_{s,i}$ between two varieties ($\Delta_{\beta_{s,i}, \beta_{r,i}}$) can be measured as

$$\Delta_{\beta_{s,i}, \beta_{r,i}} = \frac{p_{s,i} - c}{q_{s,i}} - \frac{p_{r,i} - c}{q_{r,i}} = \frac{p_{s,i}q_{r,i} - p_{r,i}q_{s,i} - c(q_{r,i} - q_{s,i})}{q_{s,i}q_{r,i}},$$

which can again be normalized in such a way that

$$\tilde{\beta}_{s,i} = \frac{p_{s,i}q_{0,i} - p_{0,i}q_{s,i} - c(q_{0,i} - q_{s,i})}{q_{s,i}q_{0,i}},$$

Unfortunately, in the case of the Belgian exporters' data, no statistically significant relation has been found, but the approach may well deserve to be further refined and applied to similar research questions in the future.

A similar exercise could be undertaken by shifting the perspective from the income of the importer to the income of the exporter. As noted by (Schott, 2004), poorer countries tend to export lower-priced goods to the US than richer countries. Since also marginal costs of production may be lower in poorer countries, in the light of the verti-zontal model it would not be possible to say a priori that the quality of their exports is lower, but with a firm-product level dataset covering more exporting countries, this claim could be tested by fixing one destination country and measure the different α_s of the exporters.

However, it should be remembered that the exporter and importer dummies in Table 5.3 in Chapter 5 were not able to capture any relevant amount of variability in prices or quantities in the sample. It is thus likely that the impact of income (or other country-specific features such as income distribution) will be very limited on the intensive margins of trade. Therefore, it may be useful to analyze separately the intensive and extensive margins of trade in this context, to

test whether richer markets differ from poorer markets in terms of the product range consumed, as opposed to buying higher-quality varieties of the same set of goods.²

6.2.3 Vertical linkages and input quality

Finally, the last empirical development reviewed in this Section in which one variation of the quadratic utility framework presented here can be fruitfully employed is the analysis of the link between firm profitability and quality of inputs. The focus in the literature has often been on the possibility of producing better goods by employing better inputs (Verhoogen, 2012), but in the context of a vertical linkages framework à la Krugman and Venables (1995), the issue can be seen from a different perspective: what if higher-quality inputs can be used to substitute capital the fixed investments needed to set up a firm? To make a concrete example, if a firm can make a choice between buying a software on the market, or developing one on its own, then the quality and cost of inputs may influence the amount savings derived from the vertical linkages (i.e., the external sourcing of part of the production process).

In terms of data, a firm-level dataset with information on firms' total profits and detailed information on inputs may suffice (for example, capital goods' imports should be considered separately from consumption goods' imports). Of course, more data can always help as a control, but since this particular hypothesis does not involve considerations on marginal costs or markups, there is no specific need for firm-product or firm-product-destination details.

As for the theoretical setting to develop to test the hypothesis of higher-quality (capital goods') imports being associated with higher profits, the following model could be followed, which combines the mechanisms described in Picard and Tabuchi (2013) with the functional presented as Model II, i.e. a simple quadratic utility framework with quality heterogeneity.

Consider a world economy populated by unskilled workers supplying labor services to a competitive industry producing a homogeneous good (numéraire) and to a monopolistically competitive industry in which each firm produces a variety of a horizontally and vertically differentiated good. The production of the differentiated good involves also skilled workers. In particular, differentiated varieties s are associated with a constant marginal cost of production, equal to the wage (normalized to unity) of c_s unskilled workers. To start production, firms are assumed to face three types of fixed costs, which are given by the requirement to employ, respectively, physical capital equipment, intermediate goods and skilled labor. All the producers in the monopolistic sector employ the same technology and are thus homogeneous in their marginal cost of production.

To make the model tractable, consumer utility and firms' savings can be characterized by the same functional form, therefore superscripts ζ and ι are used to distinguish consumers' demand for final goods from producers' demand for intermediates in each market.

Consumer preferences in market i are thus captured by a representative consumer whose quadratic preferences can be described as

$$U_i = \int_{s \in S_i} \alpha_s q_{s,i}^\zeta ds - \frac{\beta}{2} \int_{s \in S_i} (q_{s,i}^\zeta)^2 ds - \frac{1}{2} \gamma \left(\int_{s \in S_i} q_{s,i}^\zeta ds \right)^2 + q_0^\zeta \quad (6.5)$$

where $q_{s,i}^\zeta$ is individual ζ 's consumption of variety $s \in S_i$ of the differentiated good and q_0^ζ is the consumption of the numéraire, and the parameters α_s , β and γ can be interpreted exactly as in

²Looking at the EU28 cross section dataset used in Chapter 5, for example, it can be seen that while the Netherlands import 9,569 CN8 products from the other EU countries, the Czech Republic, with a similar population, imports only 8,968 CN8 products.

Model II. As usual, the budget constraint of an individual ζ is

$$\int_{s \in N} p_{s,i} q_{s,i}^{\zeta} ds + q_0^{\zeta} = Y_i^{\zeta} + \bar{q}_0^{\zeta} \quad (6.6)$$

where $p_{s,i}$ is the price of variety s , I^{ζ} is the individual's income and $\bar{q}_0^{\zeta}$ is her initial endowment of the numéraire, which is assumed to be sufficiently large to ensure that consumers have positive demands for the numéraire in equilibrium.

As in equation (3.19), maximization of (6.5) subject to (6.6) yields the following representative consumer ζ demand function in market i :

$$q_{s,i}^{\zeta} = \frac{\alpha_s - p_{s,i}}{\beta} - \frac{\gamma(A_i - P_i)}{\beta(\beta + \gamma N_i)} \quad (6.7)$$

where the only difference with respect to (3.19) lies in the presence of the superscript ζ , signaling that this is the part of demand stemming from final consumption. Therefore it also holds that

$$N_i = \int_{s \in S_i} ds \quad A_i = \int_{s \in S_i} \alpha_s ds \quad P_i = \int_{s \in S_i} p_{s,i} ds,$$

where the same market indices apply to consumers and firms.

While in the competitive sector one unit of the homogeneous good is produced with one unit of unskilled labor and fixes the unskilled workers' wages to unity, in the monopolistic sector, a firm producing variety s employs c_s units of unskilled labor to produce one unit of the good and it incurs in a fixed cost of production that consists of two inputs: physical capital equipment and intermediate goods (and services). Specifically, the capital requirement to run a firm amounts to K units of the numéraire but, as in Picard and Tabuchi (2013), each firm of type s can acquire $q^t(\cdot)$ units of all intermediate goods at a price $p(\cdot)$ to reduce its cost of physical capital or operation: thus, physical capital and intermediate goods are input substitutes.³

This means that a part of the physical capital can be replicated by a set of intermediate inputs at a lower cost. Specifically, the use of a set of all intermediate inputs $q^t(\cdot)$ (available in the country where the firm is producing) reduces the requirement for physical capital by $C(\cdot)$ units of numéraire, where $C(\cdot)$ is modeled employing the same functional form as the composite good in the consumers' preferences, that is

$$C(q_{x,i}^t) = \int_{x \in S_i} \alpha_x q_{x,i}^t dx - \frac{\beta}{2} \int_{x \in S_i} (q_{x,i}^t)^2 dx - \frac{1}{2} \gamma \left(\int_{x \in S_i} q_{x,i}^t dx \right)^2 \quad (6.8)$$

and the total cost of intermediates is given by $\int_{x \in S_i} p_x q_{x,i}^t dx$. Notice that this cost of intermediates and the expression for $C(\cdot)$ in (6.8) are common to all firms in the monopolistic sector. Hence, fixed costs are given by the following expression

$$f = K - C(\cdot) + \int_{x \in S_i} p_x q_{x,i}^t dx.$$

As in Picard and Tabuchi (2013), each firm has to set the price p_s for its variety and to determine its demand of intermediate inputs $q^t(\cdot)$ produced by other firms. Since the former decision affects operating profits and the latter fixed costs, the two decisions can be disentangled into the maximization of operating profits and the minimization of fixed costs. Given that firm's

³As compared to Picard and Tabuchi (2013), for the sake of tractability, the parameters denoting input-output multipliers, m and k , are set equal to 1.

cost minimization has the same form as the consumer's utility maximization, it entails that the intermediate demand for variety x of each firm has the same form as (6.7) and it is given by

$$q'_{s,i} = \frac{\alpha_s - p_{s,i}}{\beta} - \frac{\gamma(A_i - P_i)}{\beta(\beta + \gamma N_i)}. \quad (6.9)$$

The minimized fixed cost is then given by

$$F = K - S[p(\cdot)] \quad (6.10)$$

where $S[p(\cdot)]$ are the cost savings due to the use of intermediates and they are given by

$$\begin{aligned} S_i[p(\cdot)] = & \frac{\alpha_s^2 N_i}{2(\beta + \gamma N_i)} - \frac{\alpha_s}{\beta + \gamma N_i} \int_{x \in S_i} p_{x,i} dx + \frac{\int_{x \in S_i} (p_{x,i})^2 dx}{2\beta} + \\ & - \frac{\gamma}{2\beta(\beta + \gamma N_i)} \left(\int_{x \in S_i} p_{x,i} dx \right)^2, \end{aligned} \quad (6.11)$$

which is very similar to the indirect utility functions capturing the welfare of consumers resulting from the system of preferences expressed in (6.5), with the only difference being the income part of the equation, since consumer surplus also include the exogenous initial allocation of numéraire and income:

$$\begin{aligned} W_i[p(\cdot)] = & \frac{\alpha_s^2 N_i}{2(\beta + \gamma N_i)} - \frac{\alpha_s}{\beta + \gamma N_i} \int_{s \in S_i} p_{s,i} ds + \frac{\int_{s \in S_i} (p_{s,i})^2 ds}{2\beta} + \\ & - \frac{\gamma}{2\beta(\beta + \gamma N_i)} \left(\int_{s \in S_i} p_{s,i} ds \right)^2 + Y_i^\zeta + q_0, \end{aligned} \quad (6.12)$$

which is similar to the indirect utility function shown in (1.13), with the only difference that varieties are here vertically differentiated.

These elements suffice to understand the intuition behind the model. Considering together the market outcomes associated with Model II in Section 3.3.2 and the analysis of the link between profits and consumer surplus in Section 3.7.3, it is immediately clear why an increase in the quality of inputs maps into an increase in cost savings on the fixed costs of setting up a firm and thus into higher profits.

First of all, notice that by working on fixed costs, the Model II results immediately apply to the model presented here with vertical linkages in the short run. The only noticeable change in the model may be just in the long run by altering entry and exit patterns because of lower fixed costs. However, in the short run firms' profit-maximizing prices and quantities are not affected, so the model from the consumer side solves exactly like Model II.

As for the supply side, everything else being exogenously fixed, the key element is the cost savings' function $S[p(\cdot)]$, but since it mirrors consumer surplus, the same properties apply as the ones highlighted in Section 3.7.3. Specifically, consumer surplus as been shown to be equal to exactly half of the firms' profits in the quadratic utility framework, but it has also been shown in Model II that changes in quality are associated with changes in markups and quantities in the same direction:

$$\frac{\partial p_{s,i}^*}{\partial \alpha_s} = \frac{1}{2} \quad ; \quad \frac{\partial q_{s,i}^*}{\partial \alpha_s} = \frac{1}{2\beta}.$$

Therefore higher quality of intermediates implies higher profits for the producer of the intermediates and lower fixed costs for the firm buying them. With data on intermediates producers

in addition to intermediates purchasers it would be also possible to check the properties, stemming from the discussion in Section 3.7.3, on the relation between buyers' profits and purchasers' savings on fixed costs.

6.3 Theoretical extensions of the verti-zontal model

After having outlined three possible future empirical lines of research, this Section is devoted to possible directions in which the Verti-zontal framework can be developed theoretically to solve issues that cannot be tackled by alternative existing model in a similarly elegant way.

First, one assumption of the quadratic utility setting is altered to obtain a framework capable of reconciling monopolistic competition and oligopolistic behavior; then, based on the results obtained in Model VIII (the Verti-zontal with an endogenous substitutability parameter, $\gamma_{s,i}$) it is shown how a complex issue such as the endogenization of firms' location in the characteristics space (in both vertical and horizontal terms) can be turned into an analytically tractable problem; finally, a verti-zontal model with vertical linkages is outlined and suggested as a way to study the link between the quality of inputs and firm profitability.

6.3.1 Oligopolistic competition

Monopolistic competition and oligopoly theory have always been seen as alternative frameworks with little in common. Depending on the market structure at hand, an IO researcher has normally to take a decision between looking at it through the lens of monopolistic theory or treat the firms as oligopolists.

The main difference is that firms under an oligopoly look at each other and make strategic choices depending on the expected competitors' response. Under monopolistic competition, instead, firms just take market aggregates as exogenous values that they cannot influence with their behavior (the assumption of negligibility of each variety for the market).

The fact that these two frameworks are so different does not mean that they cannot be simultaneously present in a market, as shown by Parenti (2013). Yet, firms competing under one regime or the other have to be modeled differently and assumed of a different nature.

However, it can be shown that these two market structures can be reconciled into a unifying functional form by slightly altering the way in which firms interpret their place in the market. From the description of verti-zontal model (Model V in Chapter 3) it is possible to see how the sales of a particular variety in the market are directly related to the taste mismatch between the variety produced and the representative consumer in the destination markets.

Consistently with the monopolistic competition literature, firms are there assumed to take market indices as given and consider their influence on the aggregates negligible like a drop in the sea. But what if a variety enjoys a dominant position in a market (think of Coca Cola in the soft drinks market) or what if high fixed costs limit the number of entrants in a particular market? Should monopolistic competition just be dismissed as the wrong tool of analysis or can the framework become more flexible in order not to have to draw a line between what is monopolistic competition and what is an oligopolistic market? Empirically it is not a trivial question, as in reality the number of firms in a market is always a finite number, but then how to choose a threshold to switch from one framework to the other?

Here a solution is proposed, for future research, to bridge the gap between the two market structures. The mechanism is rather straightforward: firms are allowed to correctly internalize the real impact that their pricing strategy will have on the aggregate market indices but are not allowed to collude with other firms (which is consistent with assuming many competitors of small size, even if not a continuum of competitors as in the standard monopolistic competition

frameworks). Technically, this implies that the instead of aggregating the mass of varieties through integrals, the total number of varieties is summed up in the price index:

$$\mathbb{P}_i = \sum_{s \in S_i} \frac{p_{s,i}}{\beta_{s,i}}.$$

Hence each firm s , knowing its $\beta_{s,i}$, can internalize its impact on the general price level in market i for the differentiated good:

$$\frac{\partial \mathbb{P}_i}{\partial p_{s,i}} = \frac{1}{\beta_{s,i}}. \quad (6.13)$$

This means that if variety s ' taste mismatch with the representative consumer in market i is bad enough, i.e. if $\beta_{s,i} \rightarrow +\infty$, then the impact on the price index disappears and a firm behaves exactly as in standard monopolistic competition model such as the verti-zontal.

The interesting case is when $\beta_{s,i}$ is small enough to have a noticeable impact on the price index, as is shown here. Consider the oligopolistic variation of the verti-zontal utility function,

$$U_i = \sum_{s \in S_i} \alpha_s q_{s,i} ds - \sum_{s \in S_i} \frac{\beta_{s,i}}{2} q_{s,i}^2 ds - \frac{\gamma}{2} \sum_{s \in S_i} \sum_{r \in S_i} q_{s,i} q_{r,i} ds dr + q_0,$$

yielding the demand function

$$q_{s,i} = \frac{\alpha_s - p_{s,i}}{\beta_{s,i}} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{\beta_{s,i}(1 + \gamma \mathbb{N}_i)}$$

where

$$\mathbb{N}_i \equiv \sum_{s \in S_i} \frac{ds}{\beta_{s,i}} \quad \mathbb{A}_i \equiv \sum_{s \in S_i} \frac{\alpha_s}{\beta_{s,i}} ds \quad \mathbb{P}_i \equiv \sum_{s \in S_i} \frac{p_{s,i}}{\beta_{s,i}} ds. \quad (6.14)$$

Maximizing operating profit,

$$\pi_{s,i} = (p_{s,i} - c_{s,i}) q_{s,i},$$

firms take accurately into account their impact on the price index as note in (6.13) and measure the impact of price variations on profits as

$$\frac{\partial \pi_{s,i}}{\partial p_{s,i}} = q_{s,i} - \frac{p_{s,i} - c_{s,i}}{\beta_{s,i}} + \frac{(p_{s,i} - c_{s,i})\gamma}{\beta_{s,i}^2(1 + \gamma \mathbb{N}_i)}.$$

It can already be noted from this point that the first two terms coincide with the verti-zontal model (i.e., Model V in Chapter 3), but the oligopolistic nature of the solution includes a positive third term, which shifts equilibrium prices upward, the more so the lower is $\beta_{s,i}$, following the predicted impact of individual price changes on market aggregates. This term accounts for the fact that an increase in prices for variety s in market i will increase the price index faced by all the varieties in the market and thus relax the competitive pressure for all the competitors, including variety s which thus increases its profits.

The resulting optimal pricing strategy, as a function of the price index, can be written as

$$p_{s,i}(\mathbb{P}_i) = \frac{\alpha_s + c_{s,i}}{2} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{2(1 + \gamma \mathbb{N}_i)} + \frac{(p_{s,i} - c_{s,i})\gamma}{2\beta_{s,i}(1 + \gamma \mathbb{N}_i)}, \quad (6.15)$$

which is again a combination of the pricing strategy shown in (3.52) and a third term whose relevance depends on the intensity of the taste mismatch $\beta_{s,i}$ yielding a higher price than in the

pure monopolistic competition case in which (6.13) is not internalized. Notice also that, when $\beta_{s,i} \rightarrow +\infty$, then (6.15) converges to (3.52).

Finally markups can be written as a function of the price index $\mathbb{P}_i$ and taste mismatch as

$$p_{s,i} - c_{s,i} = \left[\frac{\alpha_s - c_{s,i}}{2} - \frac{\gamma(\mathbb{A}_i - \mathbb{P}_i)}{2(1 + \gamma\mathbb{N}_i)} \right] \frac{(1 + \gamma\mathbb{N}_i)}{(1 + \gamma\mathbb{N}_i) - \frac{\gamma}{2\beta_{s,i}}}, \quad (6.16)$$

where the part in square brackets coincides with the monopolistic competition result Model V's equation (3.52) once (3.51) is taken into account and the second term is bigger than one as long as the parameters γ and $\beta_{s,i}$ are positive, since it is commonly assumed (and discussed in Chapter 3) that $\beta_{s,i} > \gamma$.

Notice that (6.16) converges towards the monopolistic competition solution when $\beta_{s,i} \rightarrow +\infty$, but for finite value of $\beta_{s,i}$ it implies higher markups because firms internalize the impact of their prices on the market indices.

This framework can be further developed and embedded into a problem à la Parenti (2013). Yet, the main message concerns the possibility of introducing the oligopolistic idea of strategic interactions in a context of weak interactions. In other words, firms can be seen as competing against the market and behave strategically taking into account the reaction of the market, even without revealing the identities of the competitors in the same market.

6.3.2 Localized competition and endogenous location choices

Another promising development of the quadratic utility framework concerns the endogenization of location decisions based on the endogenization of the substitutability parameter as presented in Model VIII of Chapter 3. The main idea is that even if firms could choose the quality and location on the horizontal characteristics space at no cost, they would still not cluster all in one spot. The intuition is simple, if the substitutability between pairs of varieties depends on their distance in the characteristics space, a localized dispersion force interact with the agglomeration force of chasing demand. This result is known in location theory, but the advantage of a framework based on monopolistic competition is that always involves smooth interior solutions, as opposed to the classic Hotelling (1929) problem which may have no solutions, as noted by d'Aspremont et al. (1979) in the case of a simultaneous decision on selling prices and location, which eludes any Nash equilibrium solution, if the costs associated with distance are low enough (for example, they are unitary, i.e. just proportional to the distance covered).⁴ Notice that there are recent examples of theoretical IO models with similar properties to the ones presented in this section, such as Vogel (2008) who develops a Hotelling-like model with cost-heterogeneous firms and shows that firms choose asymmetric locations in the linear city model, but those models cannot be easily implemented empirically in an international trade context because are based on the assumption of perfect substitutability which results in consumers buying only one variety, as opposed to this framework where consumers rather buy all the varieties displaying positive markups (even if in quantities depending on horizontal differentiation).

Similarly to traditional models of differentiation, the model presented could be used to study the pure location problem of a variety in the characteristics space. For example, holding quality

⁴Any optimal strategy, given the competitor's strategy, would push the competitor to change her strategy, which then makes the first competitor's strategy not optimal anymore and so on, endlessly. Analytical tractability is restored only when distance is costly enough (for example, when transport costs are quadratic, such as $t = kx^2$, where k is a constant and x is the distance covered), even if the problem would yield trivially to a corner solution where firms locate as far as possible from each other to relax any price competition and enjoy full market power.

and costs fixed, the profit maximizing positioning of firms can be studied as a function of profits in the different locations. The typical situation in which this may be useful is the case of cultural industries, where it could be argued that price variation is limited and horizontal differentiation important and thus firms could tailor their products to their most profitable markets or, alternatively, proposing varieties relatively appealing to different markets (Chung and Song, 2008). Another interesting field of application is on the decision about how much to invest in quality upgrading (Kranich, 2007), who uses expenditures in by R&D activities as a proxy for quality.

More in general, the main objective of economic geographers has traditionally been to model the equilibrium spatial distribution of firms and consumers in a rich, tractable and formally consistent way (Fujita et al., 2001), so the variation of a monopolistic competition framework presented here can be a contribution in this direction. The strand of literature on firm location starts from the seminal works of Weber (1909) and Hotelling (1929), where firms just have to choose a profit-maximizing location abstracting away from any consideration of product differentiation or heterogeneity in quality, producing costs or even prices.

It is worth noting that the extremeness of these early results is partly attributable to the assumption of homogeneity of the products sold. In fact, as soon as product differentiation is introduced in the picture, products start to be perceived by the consumers as imperfect substitutes and non-corner solutions become achievable, but localized competition becomes more difficult to maintain. On the basis of this observation product differentiation has become a key ingredient in all New Economic Geography, which got rid of localized competition and formalized a non-localized common differentiation across all the varieties in a market (Dixit and Stiglitz, 1977; Krugman, 1991), following the tradition of Chamberlin (1933), Spence (1976), Perloff and Salop (1985) and Salop (1979).

There are recent examples of papers reconciling localized features à la Lancaster (1966) with non-localized competition mechanisms, as for example Chen and Riordan (2007) with the spokes model of non-localized spatial competition where consumers have one favorite variety and have the same distance from all the others (because they have to walk from the tip of a spoke to the center and then back to the tip of another spoke) or Carballo et al. (2013), where consumers consume only their ideal varieties and firms have to chase them by producing that particular variety (at a higher cost, the further is their core competence in producing a particular variety). In contrast, in the verti-zontal model consumers are allowed to purchase varieties that do not match their ideal, but do it at a "walking cost" of $\beta_{s,i}$, i.e. their utility becomes more concave and they get sooner tired of consuming a variety, the further it is from their ideal. Of course, the framework of Carballo et al. (2013) where firms can produce non-core varieties at a higher cost and the Verti-zontal where consumers can choose non-ideal varieties reaching more rapidly their satiation point are not mutually exclusive, but may rather be seen as describing the same problem from the demand and the supply perspective.

A two-incumbent example with one entrant

As for the location choice of firms once endogenous substitutability parameters are taken into, since the approach can be generalized to any quadratic preference framework, it is here illustrated for all the variations presented in Chapter 3. To provide the basic intuition of the endogenous location problem when substitutability is endogenous, in Figures 6.2 and 6.3 is first presented the simplest two-incumbent example with one entrant. Imagine that in market i , represented by one representative consumer, only two varieties are present, characterized by the same $\alpha = 10$, the same marginal costs $c = 4$ and located in the $(\beta_1; \beta_2)$ space on the points (1;2) and (2;1).⁵

⁵For the sake of the argument, the incumbents are said to be two, but in reality it would be more correct to say that there is a mass of firms, half of which is located in one point and the other half in

The representative consumer is located at $(0;0)$. One new entrant with the same quality and cost levels as the incumbent has to choose one location on the characteristics space (this means that the corresponding variation in Chapter 3 would be Model VII, from which the equations are drawn). Where would it find more profitable to locate?

In standard location theories the answer is straightforward: the new entrant will locate exactly where the representative consumer is. However, when endogenous substitutability patterns are taken into account, this choice will be suboptimal. The new entrant would indeed find it profit-maximizing to locate further away from the consumer in order to relax competition with the incumbents. In the particular example illustrated here, the profit-maximizing location lies on $(-0.82; -2.46)$, where operating profits are $\Pi_{s,i} \approx 1.23$, resulting from quantities $q_{s,i} \approx 0.63$ and markup $p_{s,i} - c_{s,i} = \mu_{s,i} \approx 1.95$. The profit level conditional on location are shown on the green left graph of Figure 6.2, where the vertical black line shows the location of the representative consumer and the dashed blue vertical line the profit-maximizing location of the new entrant. The other two graphs in the same Figure show the corresponding markups (in the middle) and quantities (to the right) and help understand what drive the result.

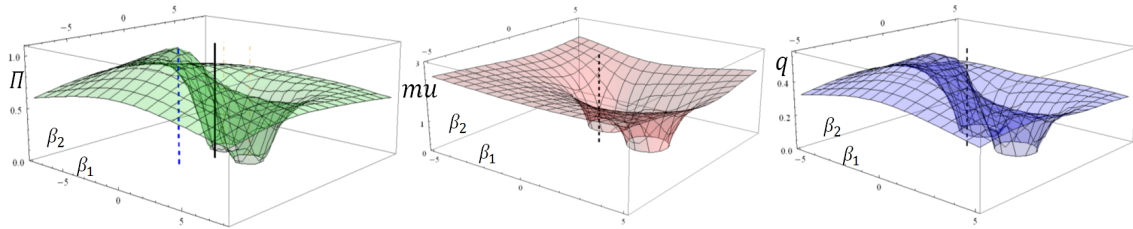


Figure 6.2: Profits, prices and quantities as a function of location in the two-incumbent example.

It can be noticed indeed that incumbent competitors distort the "profitability" space around them by reducing both the level of markup that can be charged to the consumers and the quantities sold. That is because the γ parameter directly affects the pricing decisions (for of all the variations). On the other hand, the parameter $\beta_{s,i}$ alone has been shown not to affect markups when it varies across varieties. This implies that, as competition wanes, markups of the new entrant tend to converge to the monopolist level (in the example, $p_{s,i} - c_{s,i} = 3$), which is a clear dispersion force. On the other hand, the further the new entrant locates from the consumer, the lower will be its sales, which means that the new entrant has a clear incentive to locate as close as possible to the representative consumer in $(0;0)$, capturing a classic agglomeration force.

The interaction of these two forces results in a framework that ensures interior solutions and allows for an endogenous asymmetric location of firms, which is quite a new result in the field of location theories. In addition, the framework proposed here also shows in which direction a firms should move to get the highest marginal increase in profitability. Imagine that a new entrant draws randomly its initial location and then it is allowed to relocate. Where would it find profit maximizing to move?

In Figure 6.3 the answer is provided by plotting on the left a heat map for profits (the redder, the more profitable the location) and on the right a map of levels with the vectors associated with the highest gradient for each point in the horizontal characteristics space (the orange arrows). The interpretation is that if a firm were allowed to make just a marginal step in one direction,

the other. This is because, to keep the problem as simple as possible, the new entrant is not assumed to affect the incumbents' outcomes.

the orange arrows show which direction would be optimal to follow. For example, it is not always optimal for firms to go directly towards the profit-maximizing $(-0.82; -2.46)$ point, if between the initial location and that point the firm has to approach the competing varieties.

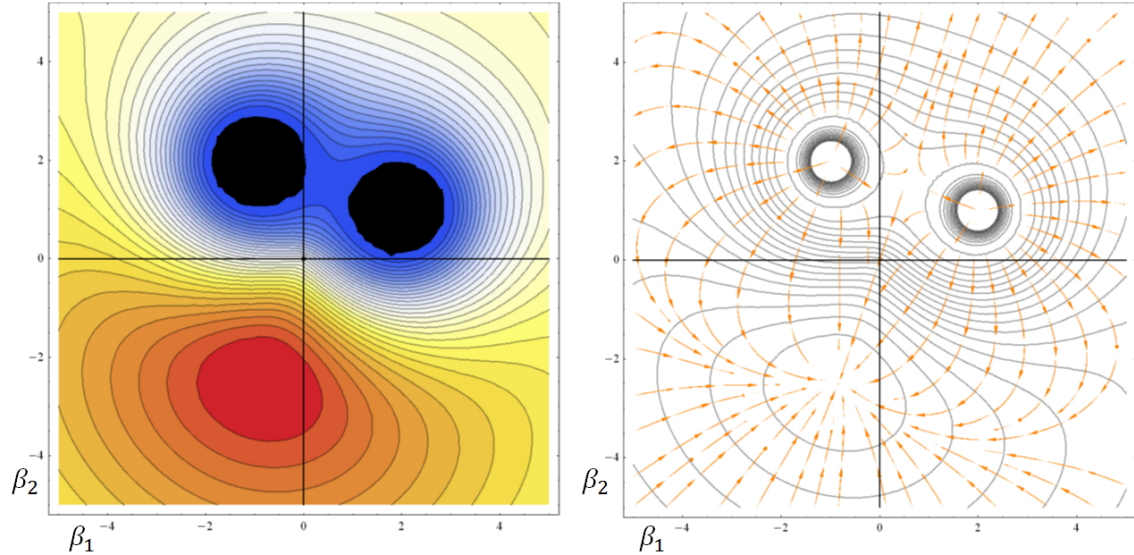


Figure 6.3: Profit levels and stream plot of its gradient field in the two-incumbent example

Endogenous location in the quadratic utility variations

As explained in this example, the location problem of a new entrant variety is now analyzed in the quadratic utility variations presented in Chapter 3. Thus, where not stated otherwise, all the characteristics of the varieties in terms of quality, cost, horizontal and vertical differentiation are exactly the ones described in the tables of Figures 3.5 for Model I, 3.6 for Model II, 3.7 for Model III, 3.8 for Model IV, 3.10 for Model V, 3.11 for Model VI, 3.13 for Model VII, 3.15 for Model VIII. This means that also the market outcomes (prices, markups, quantities) and the degree of substitutability for the incumbents are exactly the ones reported in Chapter 3.

The exercise consists in determining the expected profits for a new entrant conditional on her location choices in the horizontal characteristics space. Notice that the most correct interpretation of the simulation is in terms of mass of firms, rather than individual firms (to abide by the monopolistic competition assumption of negligibility of each firm and not having to account for each firm's $\beta_{s,i}$ as shown in the previous section). Analyzing the location choice of one potential entrant, implicitly it is also assumed that the presence of this entrant would not affect the market outcomes of the mass of incumbents. However, notice that this feature is irrelevant in terms of the problem analyzed. Indeed, the profitability of new entrants with endogenous substitutability does not depend on market outcomes, but rather on the structural parameters of the incumbent competitors (i.e. their α_s , $\beta_{s,i}$, $\beta_{1;s,i}$, $\beta_{2;s,i}$, $c_{s,i}$). This implies that even if the entry of a new competitor affects the incumbents' market outcomes, this change in market outcomes will not feed back into the market outcomes of the new entrant.⁶ New entrants are assumed to have the

⁶Notice that this is also true because in the quadratic utility framework there are no income effects. In fact, if the share of income devoted to the consumption of the differentiated variety were fixed, then

same quality and cost levels as the $\beta_{s,i}$ -weighted average in the market and the only endogenous choice concerns the location on the $(\beta_1; \beta_2)$ axes. The formula used to determine the endogenous value of the substitutability parameter is thus adapted from equation (3.37):

$$\gamma_{s,i} = \sum_{r=1}^8 \frac{(\alpha_r - c_{r,i})}{\beta_{r,i} d_{sr,i}}.$$

Distance $d_{sr,i}$ can be calculated in terms of horizontal differentiation or also in terms of distance in vertical characteristics. In order to isolate the role played by horizontal differentiation, the distance is measured for all the simulations just in terms of horizontal characteristics. At the end of the Section it is also illustrated how introducing vertical differentiation (slightly) alters the patterns. For the sake of tractability, horizontal differentiation is again defined just in terms of two abstract orthogonal dimensions of differentiation, called β_1 and β_2 . In the main simulations distance between varieties is thus measured as

$$d_{sr,i} = \sqrt{(\beta_{1;s,i} - \beta_{1;r,i})^2 + (\beta_{2;s,i} - \beta_{2;r,i})^2},$$

which means that the full formula to express substitutability can be written as

$$\gamma_{s,i} = \sum_{r=1}^8 \frac{(\alpha_r - c_{r,i})}{\beta_{r,i} \sqrt{(\beta_{1;s,i} - \beta_{1;r,i})^2 + (\beta_{2;s,i} - \beta_{2;r,i})^2}}. \quad (6.17)$$

and, of course, markups are measured as in equation (3.92), which yields the following profit function:

$$\pi_{s,i} = \frac{1}{\beta_{s,i}} \left[\frac{\alpha_s - c_{s,i}}{2} - \frac{\gamma_{s,i} (\mathbb{A}_i - \mathbb{C}_i)}{2(2 + \Gamma_i)} \right]^2, \quad (6.18)$$

which clearly shows the role played by substitutability in translating tougher competitive conditions into lower form profits.

Models without endogenous substitutability

Before turning to the analysis of the Models where the degree of substitutability depends on the particular location of a firm in the characteristics space, it is worth to have a look at the location-specific profitability patterns for Models I, II, III and V, in which the same γ is applied to all the varieties independently of their actual location.

When γ is not allowed to vary, indeed, each variety in the market suffers from the same competitive pressure, γQ_i , which can be seen as a parallel shift downwards for firms' profits in market i . Depending on the Model chosen, the extent of the downward shift depends on different market indices (either weighted or unweighted) that determine Q_i .

However, the lack of endogenous substitutability implies that the price charged for a particular variety is independent of the location of the variety on the horizontal characteristics space and thus location-specific differences in profits are only driven by changes in quantities. Hence the expected level of location-specific profits show for all the model without endogenous substitutability the same pattern shown in Figures 6.4 and 6.5.

In particular, Figure 6.4 represents a model without heterogeneity in β , as the thin dashed orange lines represent the location of the incumbent competitors. Notice that the location of

the market outcomes of competitors would indeed affect also the new entrant. The quadratic preference framework thus makes the location problem more tractable.

the competitors is relevant just insofar as it determines the total amount of quantities sold Q_i because of the taste mismatch effect, which is why it may shift the entire distribution of expected profits upwards or downwards without affecting the general pattern.

In this case, of course, the profit-maximizing location of the entrant (the thick dashed blue line) coincides with the location of the representative consumer (the thin black line).

It is also unsurprising that, as shown in Figure 6.5, firms' profits increase monotonically as they get closer to the representative consumer taste.

This trivial example is not particularly interesting per se, but it can be used as a term of comparison for the next cases analyzed.

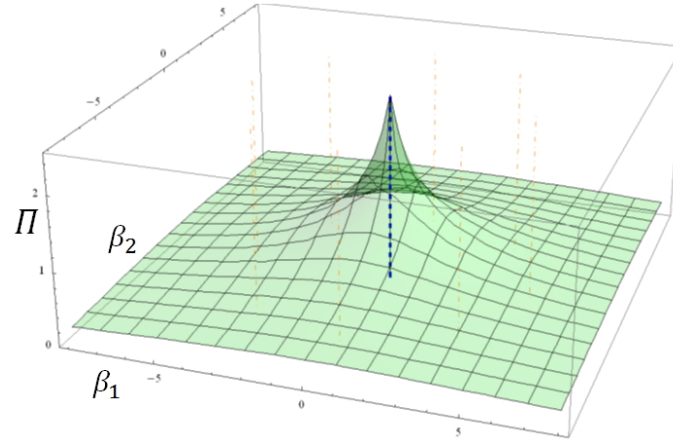


Figure 6.4: Profit patterns as a function of location in Models I, II, III and V without location-specific substitutability

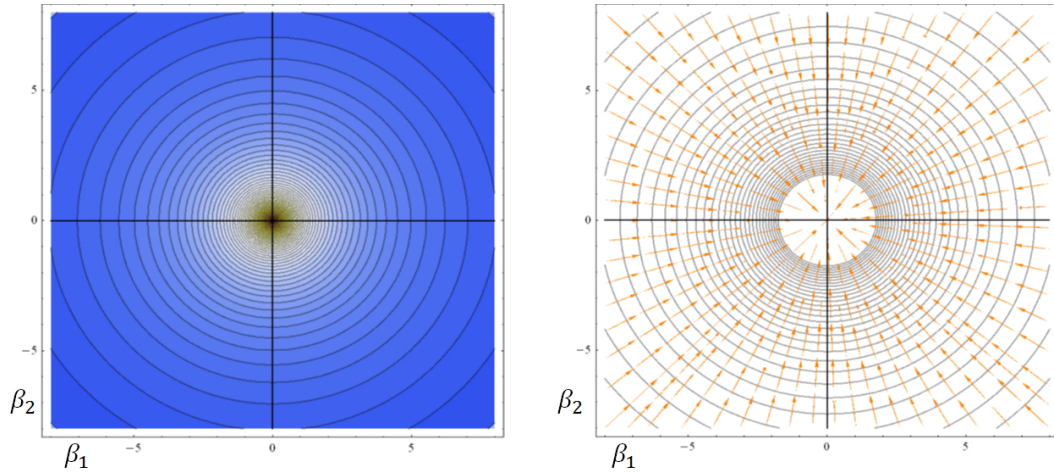


Figure 6.5: Profit levels and stream plot of its gradient field in Models I, II, III and V without location-specific substitutability

Symmetric outcomes: Model IV

Turning to the variations where the value of the substitutability parameter depends on the location of a variety on the horizontal characteristics space, the first example in Model IV, shown in Figures 6.6 and 6.7, based on the characterization of the economy describe in Figure 3.8.

Since costs, quality levels and horizontal differentiation are not variety-specific in Model IV, the result is a symmetric plot with a global profit maximum at the center (where the entrant tailors its product characteristics to the representative consumer taste) and a continuum of local maxima further away from the consumer (and the competitive pressure of the incumbents).

It can be appreciated from Figure 6.6 how the worst location for the entrant is close to the incumbent, as the similarity between the extant and the new variety would drive their markups down.

Turning to Figure 6.7 it can also be noticed an interesting feature in terms of possible dynamics. If a firm is randomly assigned a set of characteristics determining a level of taste mismatch higher than the incumbents, then a firm deciding to locally improve its operating profits would be driven further away from the consumer and the global maxima into a remote local maximum. Therefore initial conditions may determine a suboptimal location even after a firm is allowed to relocate.

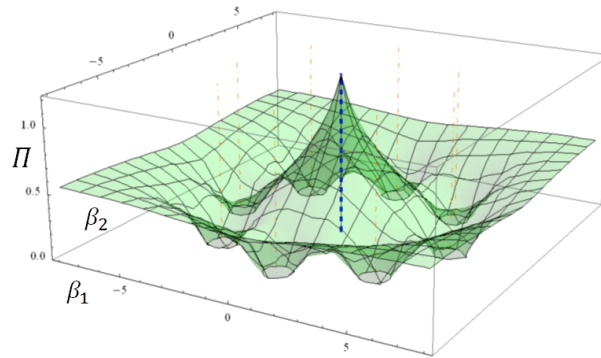


Figure 6.6: Profit patterns as a function of location in Model IV

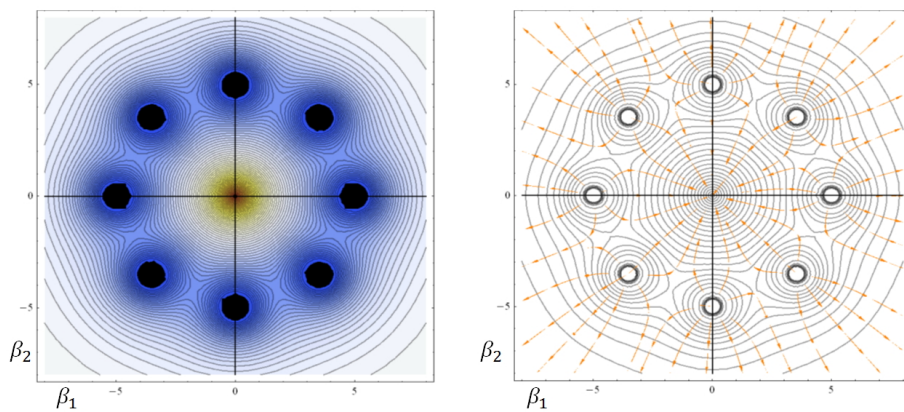


Figure 6.7: Profit levels and stream plot of its gradient field in Model IV

Asymmetric outcomes with symmetrically located competitors

There are two ways to break the symmetry the previous example without altering the location of firms. One is to allow for cost heterogeneity in Model IV is to allow for cost heterogeneity, as in Figures 6.8 and 6.9, the other possibility is to allow for quality differentiation, which amounts to consider Model VI, as in Figures 6.10 and 6.11.

Model IV's variety have all the same characteristics as show in Figure 3.8, except for the values of cost for each variety, for which the values are taken from the table in Figure 3.5. The simulation on Model VI considers instead the values in the table of Figure 3.11 exactly as reported.

In both cases the location of competitors is symmetric, but the differences in their characteristics distort the expected profit distribution in asymmetric ways. The numerator of the pair-specific component of the substitutability equation (6.17) is indeed a function of characteristics which are independent of the horizontal location of firms.

The general pattern is, however, similar to the one of Model IV, both in terms of the existence of global and local maxima and the possibility for firms to be stuck in a suboptimal equilibrium if starting from too far away for the consumer and then following their highest gradient to improve their operating profits.

One consideration to add is that in both the symmetric and the asymmetric case, there is no insurance that the global maximum coincide with the location of the consumer (0;0). If incumbent varieties match consumer's taste better than in the example, then the locus of global maxima points may well be represented by the circle (in the symmetric case) or the irregular area (in the asymmetric case) around the incumbent varieties.

The relative importance of distance from the consumer (agglomeration force) and competition effects (dispersion force) of course depends on the calibration of the model, i.e. on the specific values attributed to the parameters. There is thus some room for empirical calibration or validation of the model, the only problem being that often the two exercises are mutually exclusive, in the sense that determining the parameters to fit the empirical observation and then testing the model on the same empirical observation would not be possible.

Yet, one of the interesting properties of the framework proposed here is that the profitability of each variety depends on the others' structural parameters (α , β , γ , c) rather than only apparently on market outcomes. It is indeed true that it is the price index or total quantities that enter the demand function of each variety, but they are also a function of the structural parameters. This may allow for the separation of the problem of identifying the structural parameters of firms and thus the calibration of the model, from the problem of determining the market outcomes of new entrants or existing firms as a result of changes in competitors' characteristics (say, quality upgrading, cost increases or relocation on the characteristics space).

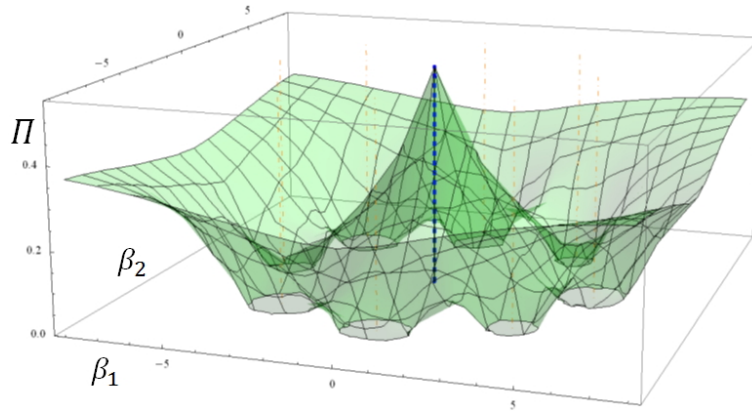


Figure 6.8: Profit patterns as a function of location in Model IV with heterogeneous costs

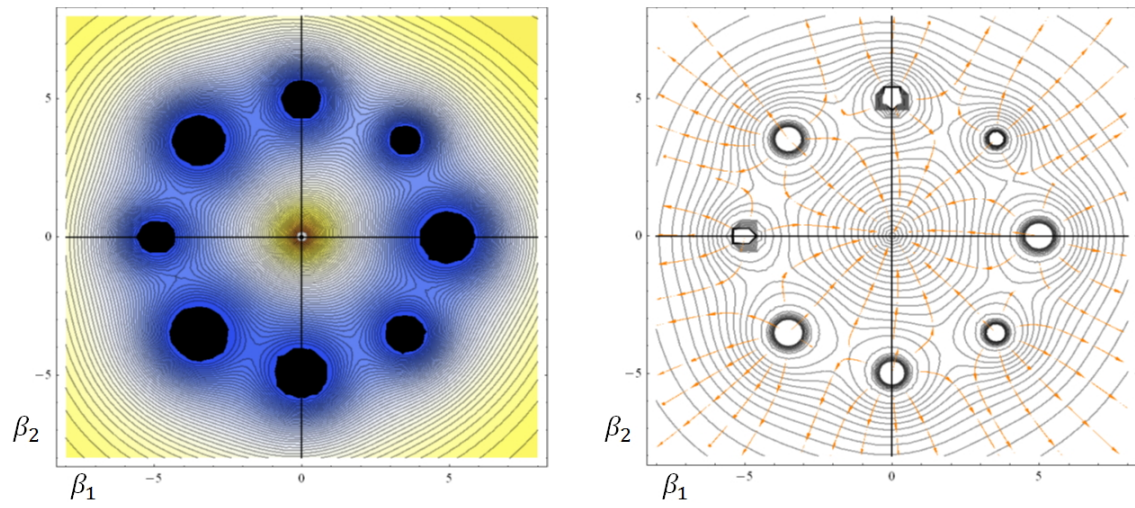


Figure 6.9: Profit levels and stream plot of its gradient field in Model IV with cost heterogeneity

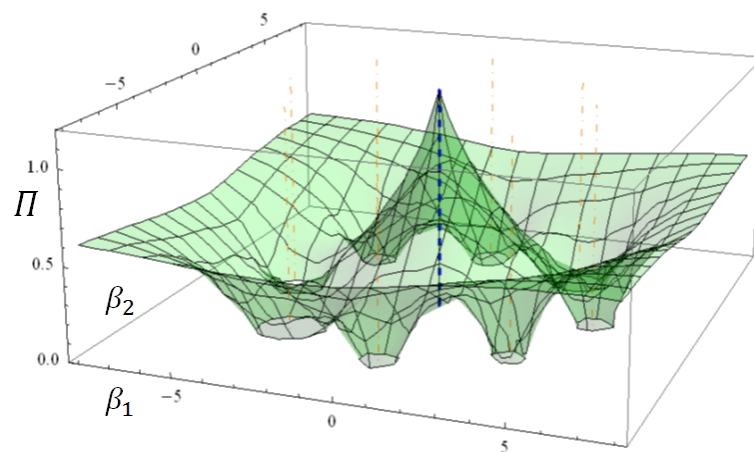


Figure 6.10: Profit patterns as a function of location in Model VI

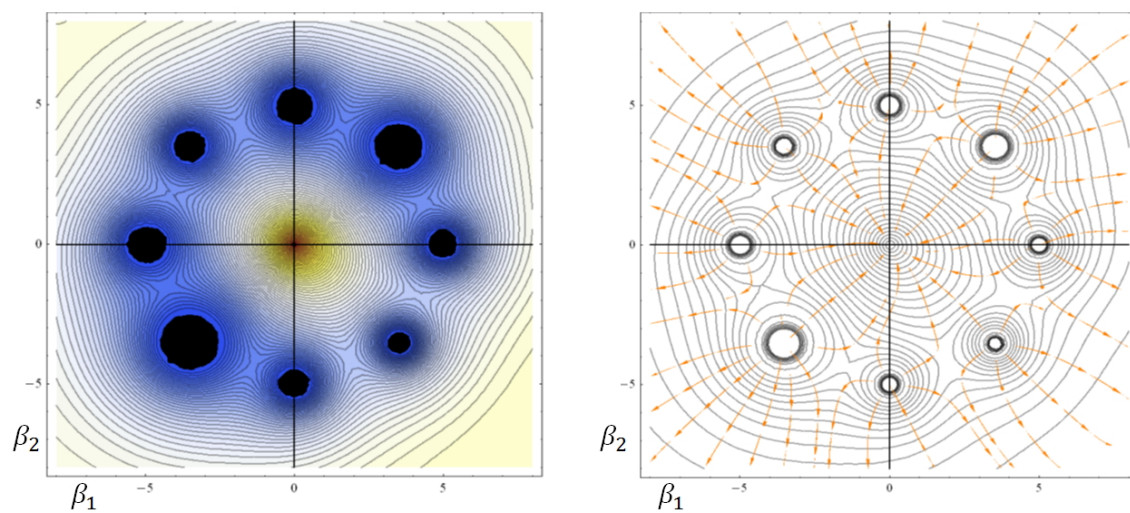


Figure 6.11: Profit levels and stream plot of its gradient field in Model VI

Heterogeneity in horizontal differentiation: Models VII and VIII

Probably the most interesting cases to study are the ones in which the parameters β and γ are both variety specific. This is the case in Models VII and VIII, whose simulation details are described in the tables of Figures 3.13 and 3.15. The two models are considered together because the presence of variety-specific quality levels (in Model VIII) doesn't affect substantially the patterns of the simulation, when only horizontal characteristics are taken into account to determine the level of substitutability $\gamma_{s,i}$.

The location-specific expected profits in Model VII are shown in Figure 6.13 and its profit levels and highest profit-marginal-increase stream plots are in Figure 6.14. As in the symmetric case, it can be noticed that the area around incumbents' location is the least profitable for new entrants. Interestingly, the competitive impact of the incumbents on the entrant's profitability is different for each variety, even in the absence of differences in costs or quality. In fact, the only reason for the different impact of incumbents' competition is their proximity to the consumer.

The intuition is straightforward. Varieties which match better local taste are sold in higher quantities because of a lower $\beta_{s,i}$, *ceteris paribus*, and this means that the total amount of goods sold in market i , Q_i , is not composed of varieties sold in different shares (even if they are characterized by the same cost and quality). But this means that a substitutability parameter attributing the same value γ to all the varieties in the market would not take into account the pair-specific nature of the concept of substitutability.

Adding quality heterogeneity (or similarly cost heterogeneity) as in Model VIII does not alter the logic substantially, except that varieties further away from the representative consumer may exert a competitive pressure similar to the closer varieties if their quality (cost) is high (low) enough, as the resulting higher markup counterbalances the higher taste mismatch in determining equilibrium quantities. In Figure 6.15 are plotted the expected profits (to the left), markups (in the middle) and quantities (to the right) for a new entrant in a market populated by incumbents as described in the table of Figure 3.15. As usual, the corresponding levels and stream plot of highest gradient vectors is on Figure 6.16.

To provide some additional intuition on the role played by the location-specific endogenous level substitutability, in Figure 6.12 is plotted the conditional level of $\gamma_{s,i}$ alone. The higher the substitutability, the tougher the competition and hence the lower the markups; Substitutability has thus a location-specific impact on both prices and quantities, as opposed to horizontal differentiation ($\beta_{s,i}$) affecting only quantities or vertical differentiation (α_s) having the same impact independently of the location of a variety.

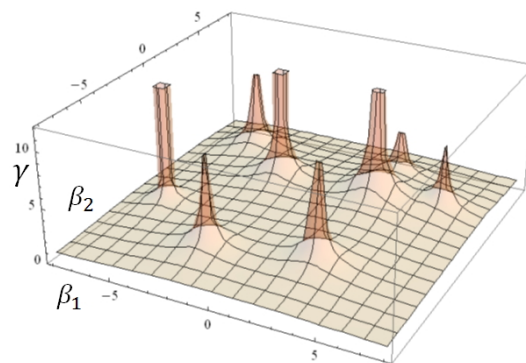


Figure 6.12: Substitutability intensity as a function of location in Model VIII

As for the previous cases, also in Model VIII multiple dynamic equilibria are possible, depending on the initial conditions of a variety, and there is not assurance that a variety end up locating in a global maximum spot by continuously improving its operating profits.

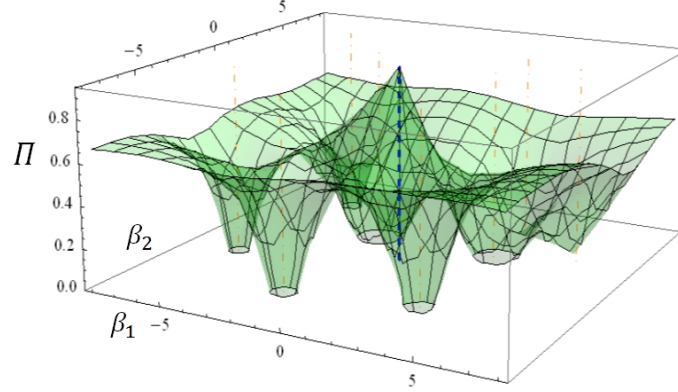


Figure 6.13: Profit patterns as a function of location in Model VII

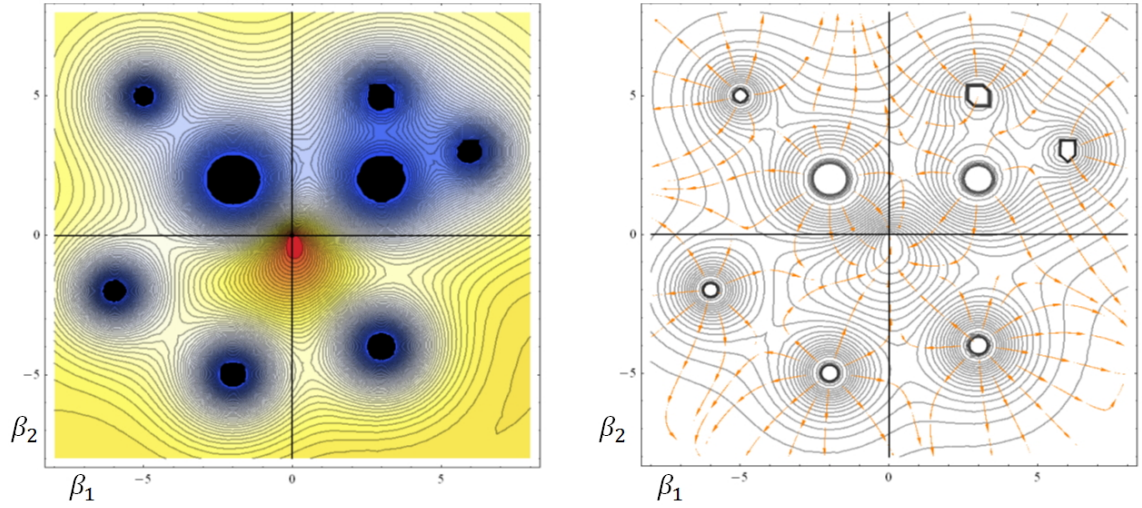


Figure 6.14: Profit levels and stream plot of its gradient field in Model VII

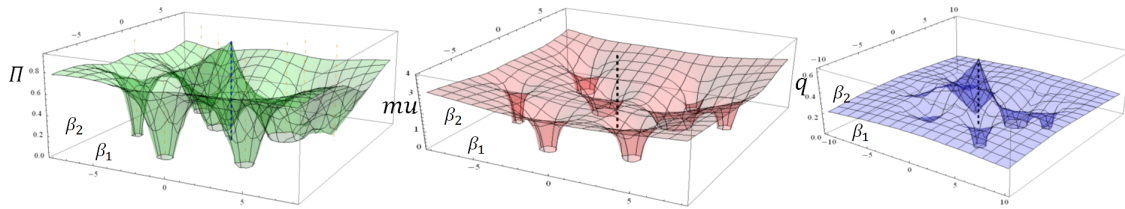


Figure 6.15: Profits, prices and quantities as a function of location in Model VIII

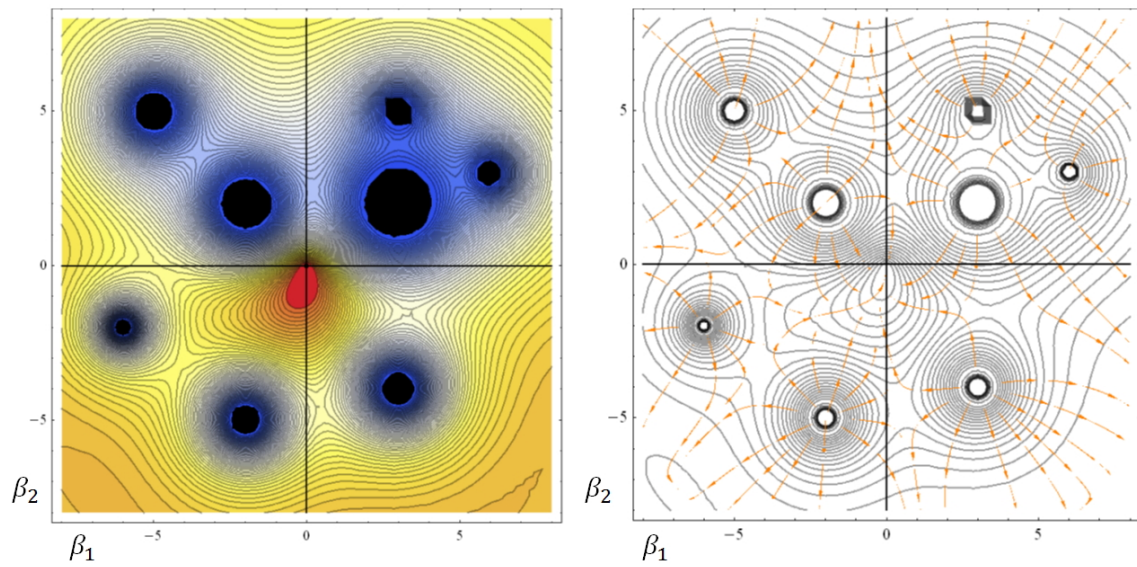


Figure 6.16: Profit levels and stream plot of its gradient field in Model VIII

Altering two firms' locations in Model VIII

One consideration on the simulations based on the parameter values adopted in Chapter 3 is that in all the cases the (at least local) profit-maximizing location for a new entrant has always been exactly on the representative consumer location or very close to it.

However, as show in the two-variety example that need not be the case, but it just resulted from the fact that the incumbent varieties were distributed around the consumer and did not allow for any profitable niche farther away from the consumer. To make this point clear, in Figure 6.18 it is shown what would have been the outcome of the Model VIII simulation with a minimal alteration of the parameters in the table of Figure 3.15. The only change is that firms on the bottom left quadrant are moved to the top right. In particular Firm 5 is moved from $(-2; -5)$ to $(2; 5)$ and Firm 6 from $(-6; -2)$ to $(1; 2)$.

As expected, the change is remarkable in terms of preferred location. Due to the new distribution of the parameter $\gamma_{s,i}$, shown in Figure 6.17, the expected profits, markups and quantity distributions as a function of location are substantially re-drawn. For example, the profit-maximizing location in this case is $(-1.69; -2.71)$ and it happens to be a global maximum which can be reached smoothly starting from any initial point by a constant marginal improvement of the operating profits.

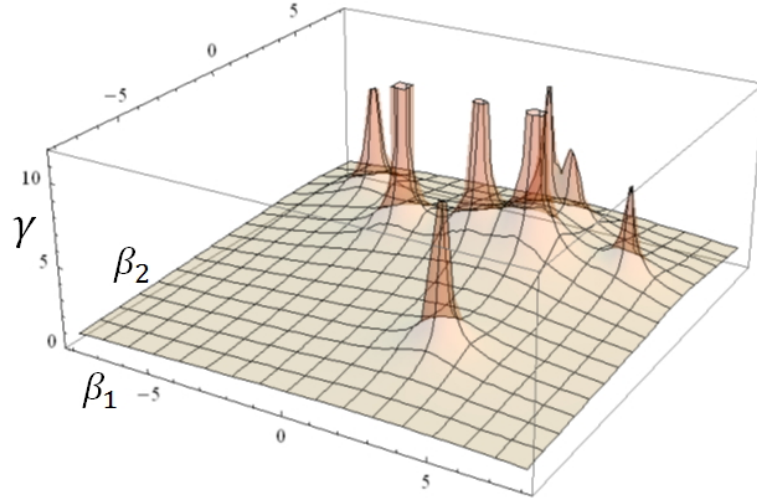


Figure 6.17: Substitutability intensity as a function of location in Model VIII with altered firm location

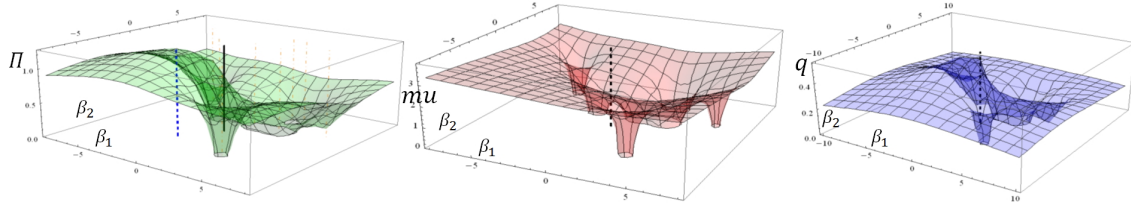


Figure 6.18: Profits, prices and quantities as a function of location in Model VIII with altered firm location

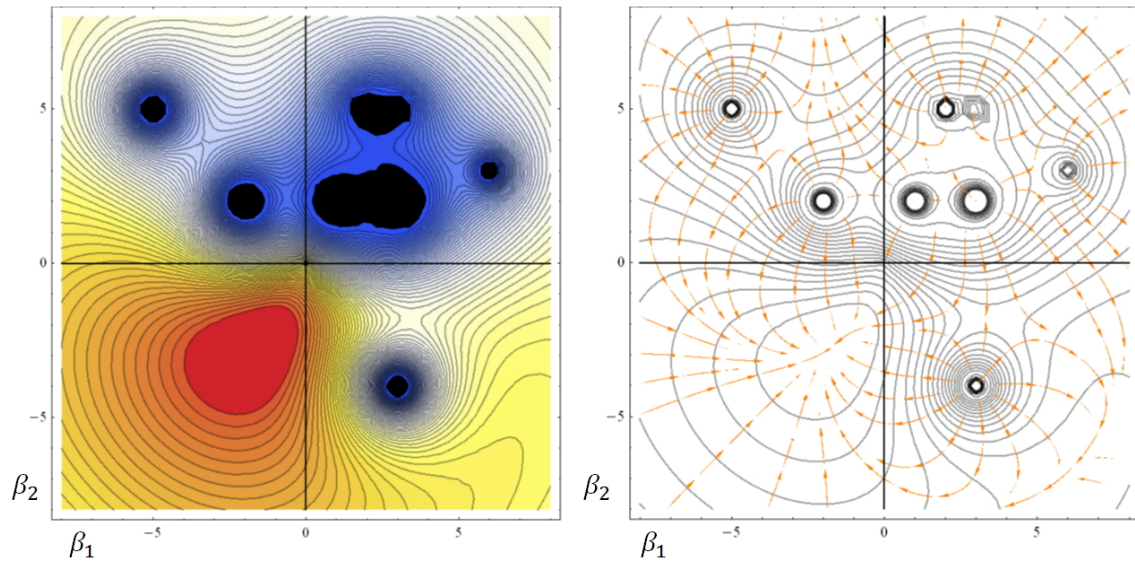


Figure 6.19: Profit levels and stream plot of its gradient field in Model VIII relocating firms 5 and 6

Substitutability and quality differences

In the foregoing part of the section, substitutability has been measured only in terms of horizontal differentiation following equation (6.3.2). This amounts to assuming that two varieties of very different quality but with the same horizontal characteristics would be more substitutable than two varieties with exactly the same quality but slightly far away on the horizontal characteristics space.

While convenient in terms of tractability, the formula to determine the substitutability parameter can be augmented to include also the vertical distance between pairs of varieties, thus considering at the same time the vertical and the horizontal dimensions of differentiation. Equation (6.3.2) can thus be changed into

$$\gamma_{s,i} = \sum_{r=1}^8 \frac{(\alpha_r - c_{r,i})}{\beta_{r,i} \sqrt{(\beta_{1;s,i} - \beta_{1;r,i})^2 + (\beta_{2;s,i} - \beta_{2;r,i})^2 + (\alpha_s - \alpha_r)^2}}. \quad (6.19)$$

Equation (6.19) may not appear very different from 6.17 and in the variations without quality heterogeneity it will be irrelevant, but in the models with quality differences it feature an interesting property: when two varieties coincide in the horizontal characteristics space, if their quality level differs, the substitutability parameter may still be finite (as opposed to equation 6.17 where $\gamma_{s,i} \rightarrow +\infty$ when two varieties have the same horizontal characteristics).

In terms of the simulation, this property make the results smoother, as shown in Figures 6.20 and 6.21, where the Model VIII parameters reported in the table of Figure 3.15 have been used without alteration, which makes them directly comparable to Figures 6.15 and 6.16.

The difference between the two sets of figures is so stark that in Figure 6.21 five varieties almost seem to have disappeared in terms of expected profitability of the new entrant. The reason is the following. In this simulation, the entrant is assumed to be exogenously assigned a level of quality (α_s) which is 10% higher than the weighted average in the market, which results in a value of 11.6.⁷ This means that the denominator of equation (6.19), for all the variety pairs, cannot be lower than the vertical distance between the entrant and each incumbent. Since the closest varieties in terms of quality are varieties of Firms 2, 3 and 5, the location of these firms are the only place in the horizontal characteristics space where the entrant would suffer from significant market competition. In the rest of the space, even when overlapping in horizontal characteristics with incumbent varieties, the expected profits of the entrant would not be significantly affected.

To illustrate this point further, a simple experiment is undertaken. In Figures 6.22 and 6.23 the quality of Firm 8, the one producing the highest-quality variety in the market, has been reduced from $\alpha_8 = 15$ to $\alpha_8 = 11$. In the case in which substitutability is not affected by quality differences, this would have resulted in a lower quality index in the market $< \mathbb{A}_i$ and higher expected markups and profits for the entrant everywhere in the characteristics space. However, when quality differences matter for substitutability, this is not the case. The quality-downgraded variety is now indeed the closest variety to the entrant in terms of vertical differentiation. For this reason, the area on the bottom left of Figure 6.23 is now turned into the least appealing location for the entrant as compared to the previous case, even if the only change in the economy has been a reduction in quality of one competitor.

⁷The reason why in this particular simulation the entrant is not assumed to have exactly weighted average quality, as in most of the other cases, is purely illustrative, because the weighted average value, 10.55, happened to be very close to the quality level of two existing varieties and thus blurring the overall intuition on the role of vertical distance.

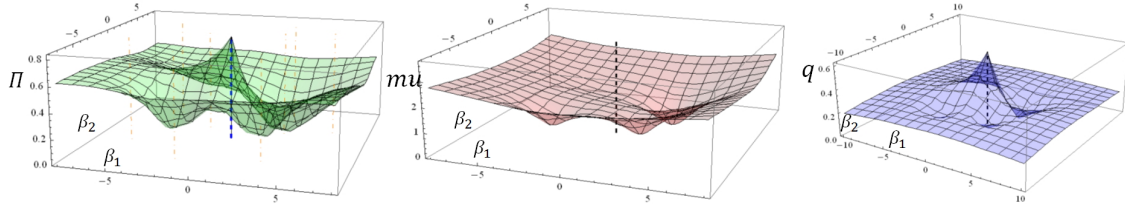


Figure 6.20: Profits, prices and quantities as a function of location in Model VIII with quality difference affecting substitutability

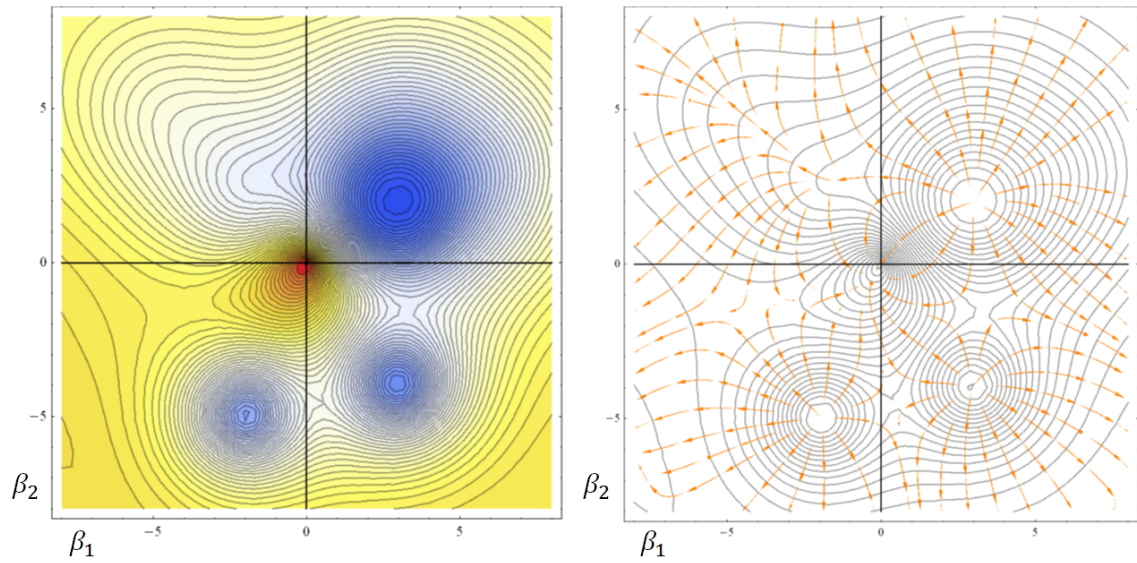


Figure 6.21: Profit levels and stream plot of its gradient field in Model VIII with quality difference affecting substitutability

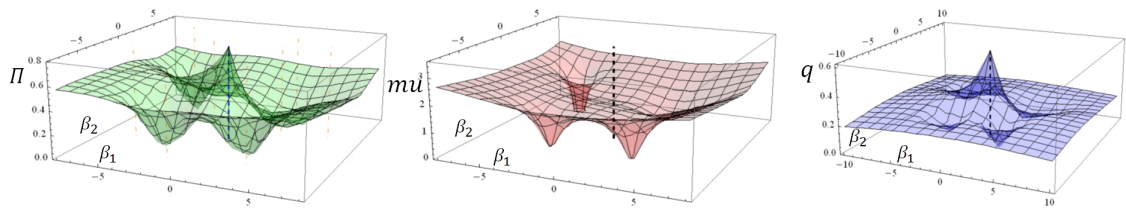


Figure 6.22: EndogLocationModel8deltaQualityAlteration

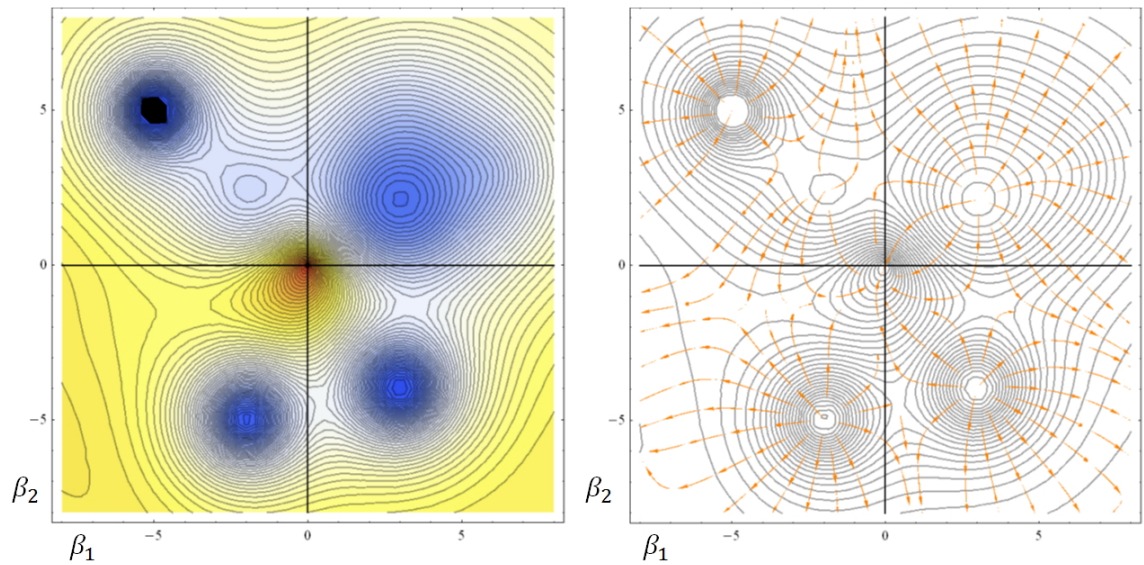


Figure 6.23: Profit levels and stream plot of its gradient field in Model VIII including distance in quality altering the quality of Firm 1

Possible empirical applications

In terms of the empirical applications of this theoretical development, recent papers have been documenting firm behavior which would be consistent with a theory of monopolistic competition with endogenous location. For example using firm-level data from Chile, Álvarez et al. (2013) find that previous export experience influences firms' decisions to introduce a new product to new markets. They rationalize it by suggesting that new exporters may reduce their information gathering costs by observing other exporters' decisions and thus previous experience exporting a product, or to a market, helps reduce entry costs for firms in international markets. In the perspective of the verti-zontal model with endogenous location decisions in the characteristics space, an alternative explanation could be that firms learn about their varieties' characteristics ($\beta_{s,i}$) and their competitors' proximity ($\gamma_{r,i}$, which in turn depends on the different $\beta_{r,i}$) would reduce the uncertainty over their export markets performance by collecting information on the taste of local consumers in the different export markets. Therefore $\beta_{s,i}$ may also capture knowledge of local markets preferences and spatial distribution of competitors.

This explanation would be consistent also with the intuition of Foster et al. (2012), suggesting that firms may expand their production following a process of demand accumulation (e.g., building a customer base) and possibly fine-tuning of their products to local tastes. Indeed they find that active accumulation driven by plants' past production decisions quantitatively dominates passive demand accumulation. Therefore, even in the presence of a demand accumulation process, this is not exogenous but depends on firms' decisions, one of which could be the relocation of its varieties in the characteristics space. On the basis of the framework presented here, a model can be proposed in which firms may change their location on the characteristics space at a cost: when the expected benefit from the movement exceeds the cost of adaptation, then firms would move, otherwise they may be stuck in a sub-optimal location in terms of operating profits which would be rational choice in terms of total profits.

Finally, turning to the version of the model with substitutability patterns affected by quality differentiation, the framework could be straightforwardly applied to the study of districts or clusters of firms (Markusen, 1996). Even assuming that firms in a district employ the same technology and have the same horizontal differentiation, the simple fact of differentiating the different varieties in terms of quality may relax competition and be mutually beneficial for all the participants. Actually, even reducing quality may increase the operating profits of a firm, if its reduction in markup due to the lower α is compensated by a reduction in γ . This intuition could contribute to the literature on industrial districts and clusters of firms (Duranton et al., 2010) or to better policy design (Kourtit et al., 2013).

Concluding remarks

In this Chapter, several possible lines of research have been outlined, which suggests that quadratic utilities still have much potential to contribute significantly in the field of international trade. In particular, it has been shown the capacity of the verti-zontal framework to simplify empirical identification problems and turn complex theoretical concepts into tractable and intuitive exercises, which may contribute to expand the capacity of trade economists to create new and useful knowledge.

Conclusions

The increasing availability of micro-level trade data calls for the development of a new generation of trade models in which rich patterns of multi-dimensional heterogeneity across firms can be easily aggregated and identified. To this end, this Thesis has explored the possibility of integrating location and trade theories of monopolistic competition to propose a spatially motivated alternative to existing models. In particular, it has shown how asymmetric product differentiation and heterogeneous consumers can be embedded into a standard quadratic utility framework à la Ottaviano et al. (2002) and Belleflamme et al. (2000) to achieve the double objective of providing solid theoretical underpinnings to the structure of preferences and improving the fit of observed data patterns.

A priori, there would be no reason to believe that these two objectives can be achieved simultaneously. An improvement in the capacity to fit trade data patterns may indeed not be easy to justify in terms of an underlying theoretical model, as in the case of non-parametric estimations or when different sources of variability or shocks are employed on an ad hoc basis with the only aim of better describing the data. At the same time, a theoretically sound framework with a clear interpretation of each parameter and an intuitive structure needs not perform well when taken to the data.

The concomitance of these two objectives is therefore somehow serendipitous and the surprise associated with the discovery motivates the provocative title "More linear than you would say", which refers to the possibility of rationalizing trade patterns through a quadratic utility yielding a space-augmented linear demand, as tested in Chapters 4 and 5 with micro and aggregate trade data, using the vertical model presented in Chapter 3.

Specifically, the first part of the Thesis has analyzed all the alternative modeling choices available to a trade economist who intends to use a quadratic utility framework with demand heterogeneity (in Chapter 3) after having provided a spatial interpretation for each demand parameter (in Chapter 2) and having shown a standard application of quadratic utilities in a New Economic Geography setting (Chapter 1).

The theoretical analysis has departed from the standard specifications of preferences used in existing trade models based on monopolistic competition by enriching the demand side and relaxing the implicit assumption that all varieties within the same country face symmetric demands. In particular, varieties have been allowed to be vertically differentiated as well as to have a different match with local consumers' tastes and varying substitutability patterns vis-à-vis each other variety in each market. In addition, the same variety sold in different countries has been allowed to face a different demand depending on the interactions between local tastes, substitutability and competition effects. This has led to a new and tractable framework, inflected into different model variations, in which taste and quality heterogeneities interact with cost differences and rich patterns of substitution.

The framework developed in this Thesis clearly distinguishes between vertical and horizontal differentiation in the presence of consumers displaying love for variety and having the possibil-

ity to concomitantly purchase different products in varying quantities, which is unprecedented, considering that existing definitions of horizontal and vertical differentiation stem from discrete choice models with indivisible varieties and with consumers making mutually exclusive choices. In addition, the models presented here are able to replicate several results obtained in differentiated oligopoly theory and providing a reconciliation of the two main approaches to product differentiation, i.e. those developed by Hotelling (1929) and Chamberlin (1933).

Since the parameters in the utility function stem directly from the description of a spatial problem, a clear interpretation rooted in the location theory can be provided, which improves upon the firm- and country-specific-shock approach that has been used in empirical work to fit the data with little theoretical underpinnings (Bernard et al., 2011; Hallak and Schott, 2011; Munch and Nguyen, 2014). The parameters of the class of models proposed here can be written as a function of observables and no assumption on distribution or functional forms for demand shocks need to be made. This also leads to identifiable structural parameters on quality and taste mismatch that account for parallel and slope shifters in demand, which allows for a quantification of the model primitives and for a comparison with alternative explanations put forward in the literature to explain the strong quantity variation of identical varieties across countries found in the data.

Empirically, in the second part of the Thesis, one variation has been selected to deal with trade data involving the whole manufacturing, the verti-zontal model, which is characterized by the combination of vertical differentiation at a variety level, horizontal differentiation at a market-variety level and constant substitutability (Model V in Chapter 3). This model contrasts with most existing trade models of monopolistic competition that identify cost efficiency as the main (if not the only) determinant of firm performance in export markets and where demand is typically assumed to be symmetric across varieties and countries, independently of the products and countries considered. It thus differs from existing models in allowing the demand function to vary across varieties within a destination country (which amounts to assuming that *preferences are asymmetric*) and for the same variety across destination countries, depending on consumer taste and product characteristics (which amounts to assuming that *consumers across countries are heterogeneous in taste*).

An important prediction arising from taste heterogeneity in consumer preferences is that firm-product-country exports can be idiosyncratic and display additional variability even after controlling for firm-product specific productivity and parallel demand shifters. The analysis in Chapter 4 confirms these results using, first, a publicly available dataset on the European car market (Goldberg and Verboven, 2005) and, then, a detailed firm-product-country data for Belgian exporting firms provided by the National Bank of Belgium.

The missing source of variety-market variation in quantities cannot be interpreted by any type of preferences used in models based on productive efficiency nor by models that rely on efficiency and quality. In the verti-zontal model, instead, it can be rationalized as heterogeneity in taste mismatch in the horizontal characteristics space. With the introduction of a location-theory-motivated taste mismatch, the model can thus address the concerns raised by a growing number of empirical studies that fail to find evidence in support of existing models when confronted with micro-level data on the basis of substantial unexplained variability in quantities sold (Baldwin and Harrigan, 2011; Brooks, 2006; Manova and Zhang, 2012).

As a final remark, notice that all the parameters analyzed in this Thesis have been assumed exogenous, with no particular individual or joint distributional property. While some parameters are normally assumed to be correlated, such as quality and marginal costs for example, the focus of the Thesis on short-run market outcomes has not required any restriction. Still, it is possible to imagine all the parameters resulting from rational decisions of entrepreneurs, for example through quality-increasing or marginal-cost-reducing fixed investments in research and develop-

ment, which leaves room for future research on firms' choice of their products' characteristics, as discussed in Chapter 6 together with other future avenues of research.

Summing up, it is evident that the world around us is not linear and the same is true of trade flows, which are irregular, cyclical and full of outliers. Furthermore, it can be added that imposing one particular structure to describe complex phenomena is always a simplification and quadratic utilities are probably one of the most extreme forms of simplification of reality that can be conceived. Still, in this Thesis it has been shown how looking at trade patterns through the lens of the linear demands stemming from quadratic preferences can allow us to interpret the empirical observation of market outcomes in a theoretically intelligible way, at the same time providing a spatial justification for the system of preference adopted and fitting the data surprisingly well.

As famously stated by Box and Draper (1987), *essentially, all models are wrong, but some are useful*. Following this maxim, with all their limits, models based on quadratic utilities can provide an approximation of reality which is at the same time conceptually sound and empirically convenient, hence striking the right balance to inspire future scientific developments in trade theory. All in all, the field of international trade may benefit immensely from a more widespread adoption of quadratic utilities and this Thesis can hopefully contribute in raising awareness on their potential.

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