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Firm relocation, North-South technology transfer and welfare

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January 2014

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

Composition du jury:

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Le chemin est long du projet à la chose

Molière

Mon enfant,
ma soeur,
Songe à la douceur
D'aller là-bas vivre ensemble!
Aimer à loisir,
Aimer et mourir
Au pays qui te ressemble!
Les soleils mouillés
De ces ciels brouillés
Pour mon esprit ont les charmes
Si mystérieux
De tes traîtres yeux,
Brillant à travers leurs larmes.
Là, tout n'est qu'ordre et beauté,
Luxe, calme et volupté.

Beaudelaire, *L'invitation au voyage*

Remerciements

Je remercie tous ceux qui, de près ou de loin, consciemment ou pas, au début, à la fin ou tout le long m'ont aidé à réaliser cette thèse.

L'ami Raouf, tu as participé à ce travail sous toutes ses formes. Sympathique, accueillant, concerné, drôle et décontracté, tu m'as aidé à avancer et poussé à relativiser. Tu as été de bon conseil, bien souvent là où on ne l'attend pas de la part d'un promoteur. Nos discussions ont dépassé celles d'un professeur et de son étudiant et je ne me souviens pas avoir été en désaccord avec toi. Je te remercie pour ces bons moments et je suis sur qu'il y en aura d'autres à venir! Hélène, telle la digne mère Latzer, tu as su soutenir ton cadet quand c'était nécessaire. Ce fut un plaisir de coécrire avec toi: aussi sérieux qu'amusant, un bel équilibre! Antonio, Florian, Frédéric et Vincent, vos commentaires avisés ont sans aucun doute permis d'améliorer ce travail. Merci également à tous ceux qui m'ont conseillé, lors de discussions ou lors de séminaires.

A tous ceux qui m'ont permis de m'évader, en votre compagnie, la tâche a été plus légère. Les innombrables lunchs à Louvain, les apéros, les soirées, les nuits et les matins ont été indissociables de mes années passées dans les couloirs du département d'économie. Que nous nous y soyons croisés ou non, vous m'avez fait passer de belles années de recherche.

Amélie, muse, boussole et soutien, je te remercie d'avoir été là, d'avoir réussi à me motiver et de m'avoir supporté. Cette thèse ne se serait pas écrite sans toi. Enfin, à toi Manon, arrivée sur ma route en fin d'aventure, je t'invite également au voyage.

General Introduction

Do people gain from North-South relocation of firms? This question is important for two main reasons. First, people are affected by the arrival and by the departure of firms because it changes their environment in terms of job opportunities and in terms of the price of the goods they can consume. These affect their welfare. Second, it is more and more common to see firms moving their activities from high wages regions in the North to low wages regions in the South. Understanding the consequences of firms relocation helps to take measures in order to favor positive effects and correct negative ones.

In this thesis I analyze the effects of firm relocation from different geographical and thematic points of view. First, from the southern perspective, I show that an important channel through which firm relocation affects the host country is via the relationship between multinationals and their suppliers. Because the multinational demands product in the local economy, it increases the possibility of local jobs and because the multinational surely benefits from the better performance of its suppliers, it may be willing to help them in reaching higher quality standards. Based on the Kivu example in Dem. Rep. Congo, I show that when firms are located closer to their suppliers it may be a win-win situation. Multinationals boost demand of their suppliers and also have access to the local market where prices are lower. This allows the multinational to produce more and demand more inputs which in turn improve the working possibilities in the southern labor market. Moreover, this geographical proximity also encourages the multinational to directly transfer technology to its suppliers. I show that the multinational has incentives to do so since it boosts its own productivity even if this better inputs are also used by its competitors. With this transfer, the South becomes more productive.

Second, from the northern perspective, I show that beyond the fact that workers see their job opportunities lowered following the delocation of firms to the South, consumers have access to cheaper goods beause some goods are produced at lower costs in the South. People hence redirect their expenses towards these low priced goods which compensates their lower job opportunities or lower wages. However, if the production costs or the wages in the South are very low, more firms will have an incentive to move which will hurt harder workers who are also consumers still consuming some high priced goods produced in the North. Thus, people who are workers-consumers see an increase in their welfare when firms delocate towards regions that have not too low wages.

This thesis ends with the question of why firms sell different qualities and produce them in different regions. The traditional economic arguments of differences in costs of production and difference in technology across regions explain why firms choose to settle production plants in different regions, which is the reason to become multinationals. Here, it is shown that because there are inequalities among consumers, firms choose to produce different qualities of the same product which they sell at different prices. Rich people will hence buy the high quality version of a good at a high price while poors will buy the low quality version of this good at a lower price. In doing so, the firm will be able to capt more spendings because it targets more specifically the willingness to pay of each type of consumers.

Finally, it is worth noting that if North-South relocation of firms is extensively studied in this work, it is still part of a much broader picture. This thesis tackles some economic issues among a much larger set and it uses hypothesis which are by nature restrictive and can be discussed even if I tried to make them as realistic as possible. Moreover, if economics is undoubtfully one of the most relevant discipline to shed light on the effect of multinationals, it is of course not the only one.

Chapter 1

How does technology transfer affect backward linkages? A motivating example theoretical analysis

Abstract

This paper develops a model in which the presence of a multinational leads to a technology transfer to its local suppliers and also modifies the degree of backward linkages in the local economy. First, we identify the domestic market characteristics under which the multinationals increase the level of backward linkages when they enter these markets. Moreover, we investigate the conditions under which the multinational could even benefit itself from transferring technology to its local suppliers. Finally, when the multinational transfers technology, we show when the level of backward linkages in the local economy increases.

1.1 Introduction

Technology diffusion has been a matter of concern for economists for decades. The underlying theory tries to capture the different channels by which a technology can diffuse from one country to another. This is why in the earliest modelling of diffusion mechanisms, authors use leader-follower models to caracterize the mechanisms of diffusion. That is, they split the world economy into two groups, a leader and a follower. The leading economy innovates and the following economy imitates or adapts the various products that have been invented in the leading economy.

The technology diffusion can be studied in different ways, what is mainly used in the literature [see Nelson and Phelps (1966), Barro and SalaiMartin (1998)] is to model the technological level by the number of intermediate products or by the quality of the products. The main idea of these models is that the follower economy catches up with the leading economy since imitation of new products or invention is cheaper than innovation.[1] Hence, convergence between leading and following countries follows directly from this mechanism. Furthermore, after the convergence takes place, leapfrogging may emerge [see Brezis, Krugman, and Tsiddon (1991)], that is, the follower eventually becomes the leader. Empirically, these theories are quite consistent with the data if we look at the English and Dutch economies in the 1700s, the United States and Germany in the 1800s and maybe Japan and United States in the early 2000s. In any case, if this kind of convergence and even leapfrogging seems to fit the economic mechanism between some countries, it fails to explain why it doesn't between others, that is, why we do not observe convergence between Least developed countries (LDCs) and developed economies nowadays.

In the context of technological diffusion between developed countries and LDCs, that is respectively between north and south, foreign investment from rich economies to poor ones could possibly play a significant role in diffusing technologies. Hence, policy makers in developing economies will try to attract foreign direct investment (FDI), expecting FDI inflows

[1]Note that in Nelson and Phelps (1966), the convergence is in growth and the follower economy never catches up the leader economy.

to spread management and marketing techniques, new technologies and capital into domestic firms. Spillovers from FDI can take place through various channels when multinational corporations (MNCs) increase the productivity of domestic firms. Spillovers can appear (i) if the local firms improve their efficiency by copying the MNCs affiliate through observation or by hiring ex-MNC workers, (ii) if the presence of the MNCs affiliate in the host country strengthens competition and forces domestic firms to allocate their resources more efficiently, (iii) if the domestic suppliers and clients of the MNCs affiliate are forced to enhance productivity to maintain their contracts.

When MNCs affiliate and domestic firms operate in the same sector, they are in a situation of competition where the former has an incentive to minimize technology spillovers in order to preserve its advantage. Non-transfer policy can be achieved through payment of higher wages in order to prevent labor turnover, protection of intellectual property and/or locating their activities in places or sectors where domestic firms have limited capacity to absorb new technologies. These incentives tend to reduce the possible benefits of horizontal spillovers from FDI in domestic economies. Conversely, multinationals have incentives to accelerate technology diffusion to their upstream sectors as they surely benefit from the better performances of their suppliers. In this context, backward linkages should be the most likely channel through which spillovers occur.

Hence, as pointed by Javorcik (2004) the presence of the multinational may induce (i) a transfer of knowledge from foreign customers to local suppliers, (ii) higher quality product and better delivery services which force local suppliers to enhance their management and technologies and (iii) increased demand for intermediate inputs which could allow domestic suppliers to benefit from economies of scale.

Furthermore, the magnitude of vertical spillovers and their speed of diffusion depend on the types of FDI. Indeed, the effects on local suppliers depend to which extent the MNC affiliate is imports-oriented. So, since joint ventures and affiliates from mergers or acquisition are more likely to source locally than fully owned foreign affiliates, the former are expected to create more spillovers than the latter which is supposed to use more imported inputs and not to participate in the development of local suppliers.

Finally, note that even in case of technology diffusion, authors have mainly observed two possible causes of divergence between economies. Firstly, the standard models do not take into account that innovators develop technologies that suit their own economic and socio-politic environment. Since LDCs and developed economies differ in their economic and socio-politic characteristics, the new technologies developed in the north are not automatically profitable to LDCs. This problem is the so called appropriateness of technologies problem [see Barro and SalaiMartin (1998)]. Secondly, production factors vary across countries and it is thus well known that lagging economies cannot necessarily benefit as much as innovating economies from new products as they may not have the required skilled labor to innovate. This is the problem of mismatching technologies [see Acemoglu and Zilibotti (2001)].

Empirical works on backward linkages are numerous. Lall (1980) argues that MNCs may contribute to enhance productivity and efficiency of local firms in helping them to find suppliers, in giving them a technical assistance in order to increase product quality or to facilitate innovation, in assisting them in the purchases of raw materials or intermediate goods, in offering them training and help in management, organisation and in helping them to diversify and find new customers.

Lall (1980) and Behram and Wallender (1976) find these links respectively for logistics' firms in India and activities of General Motors and Pfizer in various host countries. Hill (1982) and Lindsey (1989) find a lower impact in Philippines. Katz (1969) shows that foreign firms in Argentina, improve pressure on their suppliers in order that the latter reach higher standards of quality, reliability and speed of delivery. He also shows that the foreign capital flows, in the Argentine shaper sector in the 1950s, has a significative impact on the level of technology used in other sectors because the multinational forces its local suppliers to modernize, imposing minimum quality in terms of standards and prices. Sjoholm (1998), in his study of foreign manufacturing, suggests that the multinational's presence could increase efficiency of local firms only if they are geographically close to the multinational. Kugler (2001) finds that the main spillovers in the Colombian shaper sector are at interindustrial level and not within the same industry. More recently, in the case of Lithuania, Javorcik (2004) shows that the impact of FDI on local suppliers is greater in the presence of vertical technology transfer from multinationals. Besides these papers, some other found a negative effect of FDI on local suppliers. In the analysis of the Venezuelian shaper sector by Aitken and Harisson (1991), foreign firms change local products demand into an imported products demand. Grether (1999) found similar negative effect of FDI on local suppliers for the Mexican case.

These studies suggest that FDI creates spillovers through its backward linkages. But, it is clear that these links will occur only if the activities of the MNC and the local firms are complementary and if local firms have the quality standard required.

If enormous empirical literature on backward linkages exists, only a few analytical studies are provided. To our knowledge, three main papers have been written on the subject. The first two models are the ones of Rodriguez-Clare (1996) and Markusen and Venables (1997). Both models study the relationship between multinationals and linkages. Markusen and Venables (1997) describe the effect that multinationals can have on backward linkages, development and welfare in the host country economy if its entry alter the imperfectly competitive hosts industries. In both models, the intermediate goods sector is monopolistically competitive and FDI alters the incentive to enter the local market. In these models, the concept of love-of-variety in the production function for final goods is the key element of the interaction between multinationals and local suppliers.

Lin and Saggi (2005) develop another kind of model that is motivated by the fact that the previous models omit strategic considerations that come from oligopolistic market structure. Since these considerations are overlooked, these models emphasize the demand-size effects of the multinational entry on the host economy even if Markusen and Venables (1997) allow for competition effect when multinational enters the host market. Conversely to the first two existing models, Lin and Saggi (2005) and Lin and Saggi (2004) consider how the mulinational's entry affect the supply side of the intermediate good sector. They analyze the relationship between vertical technological transfers from a multinational to its local suppliers and they find the equilibrium level of backward linkages. They also study how the contractual nature (exclusivity or not) affects the level of backward linkages. They develop a two-tier model in which the production of a final good requires a quantity of intermediate good and they use an oligopolistic market structure in both stages of production.

The model presented below is motivated by the South-Kivu example. However, its characteristics are general. It can hence describe many more situations than the specific case of South-Kivu. We define backward linkages as the quantity of intermediate goods produced by locals and used by foreign or multinational firms for the final good production. Without technology transfer to locals, a higher level of backward linkages means that more worker are employed in the intermediate goods sector. In LDCs and especially in South-Kivu, locals hence leave their subsitance economy to work in the intermediate good sector, earning higher wages. A higher level of backward linkages hence induces more value added in the economy. With technology transfer to locals, a sector with a higher level of backward linkages and more efficient workers is a sector which has improved its efficiency, since it can produce more with relatively less ressources. This more efficient sector could serve as an example and spillover other sectors, redirecting the economy away from a subsistance economy and towards higher efficiency. Contributions of the model are the following. First, it shows that, given strategic interaction à la Lin and Saggi (2005), when there is no exclusivity contracts [2], the multinational has an incentive to transfer its technology to its suppliers even if its competitors benefit from it. Second, we analyze how backward linkages and technology transfer react when multinationals become more competitive. We first describe two channels through which these multinationals become more competitive. The first channel is the possibility to produce the intermediate by itself and the second channel is the possibility to source locally on a different market (e.g. the local market) than its competitors. The latter channel is described in the Kivu example and has not been developed yet in the literature. The penetration of the multinational in the intermediate good sector allows it to transfer a higher technology than what was suggested in the previous models. We hence analyze how backward linkages react to these new incentives to engage in FDI and in vertical technology transfers. Hence, we derive the domestic market characteristics under which the multinationals increase the level of backward linlages when they enter LDCs markets. We also investigate the conditions under which vertical technology transfer leads to an increase in the level of backward

[2] LDCs often lack an efficient legal system and hence do not implement the law which makes exclusivity useless.

linkages in the local economy.

This paper is structured as followed: Section 2 gives an overview of the quinine case in South Kivu [see Simons (2007)]. The model is presented in section 3. After the general specifications of the model, we derive the equilibrium without multinationals. Then we compute the equlibrium with multinationals and compare it with the No-Multinational case. In section 4, we add technology transfer to local suppliers and derive the optimal technology transfer. We analyze its effects on the level of backward linkages. Finally, section 5 concludes.

1.2 Motivating example: Backward linkages in the quinine market in South Kivu, Dem.Rep.of Congo

In Simons (2007), we investigate the backward linkages induced by a former multinational in South-Kivu, Dem. Rep. of Congo (DRC). The case study is purely descriptive since economic data is not reliable or simply not available. We focus on some observations.

First, the vast majority of empirical literature on backward linkages in LDCs underestimate the exact level of linkages. Indeed, all studies are based on the formal sector and do not take into account informal sectors. This is directly due to the unavailability of official data on the informal sector. Moreover, the missing data are really hard to collect and may even be not really reliable since it depends on the goodwill of locals. Since the informal sector in LDCs and especially in DRC constitutes a large part of the economy (about 98 percents in South Kivu), classical mechanisms of technology diffusion are also likely to occur in the informal economy. So, the empirical level of backward linkages is undoubtfully underestimated in these countries.

In Simons (2007) we separate the suppliers of the ex-multinational in three groups. Each group corresponds to a level of technology. The first group is made up of the suppliers of raw materials, chinchona's bark. The extraction of the raw material does not need a day-by-day knowledge of advanced technology. The second group is made up of suppliers of intermediates goods that are produced and sourced locally. And the third is made up of foreign suppliers of intermediates since locals do not have the required technology to produce them. Here, we will have a look at the backward linkages on the first group which account for about 40 percents of local puchases of the firm. Typically, this sector wouldn't be taken into account since no official data is available outside the enterprise.

In concrete terms, the ex-multinational is a world producer of quinine with worldwide competitors, especially Indians. The multinational has its own cultivation of barks but must also purchase barks from local extractors in order to satisfy the demand. Although advanced technology is not required for the barks' extraction stricto sensu, we observe a high productivity differential due to two main reasons. The first cause of the difference in productivity is a day-by-day need of cash for local producers. In chinchona's barks, what matters is the optimal level of quinine that arises on a 6 year chinchona. But since locals need cash to live, they usually have to collect and sell the barks before the optimal harvesting time. Hence, the ex-multinational produces better barks than locals. The second difference in productivity comes from the contamination of the chinchona by a mushroom, the phytophtora. While locals cannot fight the mushroom, the ex-multinational has a research departement that has solved the problem in planting cloned germs which resist to the phytophtora.

These differences in productivity lead to a possible technology transfer. Two mechanisms of technology diffusion are set out. (i) The ex-multinational makes available its knowledge and easy supplier pre-financing terms to local suppliers. If most of crops take place in the first four year of the chinchona' growth, the ex-multinational offers the possibilty to let the barks ripen. The system is the following: The local supplier offers a quantity of barks that the ex-multinational buys at a price in function of the age of the barks but the supplier continue to let the bark ripen in his field. Once the barks have reached their optimal level of quinine, the firm buys all the crop at the price of the crop minus what it had already paid before. This mechanism is similar to an agricultural credit through which the firm let its ressources available to compensate for local inefficiency. We define this as a technology transfer since the multinational also gives advises to locals on what other plant to plant next to the chinchona to get a better bark's quality, on how to irrigate the plantation and when and how to cut the trees. (ii) Besides this spillover generated by the presence of the foreign firm into the local market, another mechanism of technology diffusion takes place. The ex-multinational diffuses its technology through a lease agreement of the fields of locals. In this case, the owner of the fields rents it to the firm for a given period. The ex-multinational plants its own germs that are of better quality. Note that you don't need to re-plant a chinchona after a bark's crop since it re-grows. Hence, once the rent is finished, locals benefit from the better plants. Moreover, during the leasing, if the management of the field is provided by the firm, the local owner participates to each activity of production. He is thus trained. Again, once the lease is finished, the local owner is able to enhance the productivity of his field compared to the pre-lease situation. Note that (ii) is a real technology transfer that takes place in two sequences. The first one is the training period of the local owner during the leasing and the second one is the imitation when the lease is over. Note that technology is likely to diffuse since it fits to the level of local human capital and so, is a matching technology.

1.3 Model

1.3.1 Modelling backward linkages in the quinine market

In order to model the quinine market,we begin by setting up a market configuration where there is no final good producer in the host economy. The final good is produced by foreign firms. These firms buy an intermediate good from a local monopolist who buys this intermediate good directly from the local market. This is the configuration of the Kivu example where extractors of raw materials (modeled as an intermediate good) sell it to a monopolist exporter who sells it to foreign firms. Typically, workers do not have sufficient resources to export on their own the raw materials nor do foreign firms have sufficient local market knowledge to buy raw materials from the local market. Hence, an intermediate agent is necessary and this intermediate agent is, here, a monopolist. What we study is the effect of the multinational's entry into the market. By becoming a multinational, a firm is, contrarily to the foreign firm, able to source its raw material directly from the local market and thus, does not need the exporter since it knows the local market through its contacts. In South Kivu, the multinational buys directly from the local barks cultivator since they both are in the same geographical area. We also assume that the multinational extracts a part of its needs in raw materials used in its final good production. This was observed in Kivu but again, it is not specific to it since governments of LDCs often allow multinationals to exploit a fixed amount of land. Hence, the multinational and local extractors coexist in the intermediate good sector while foreign firms and the multinational compete in the final good sector. These settings are based on the DRC-quinine example. However, the model can be applied to all situation where the previous characteristics are met. These are (i) atomistic producers of intermediate goods (or raw materials) do not have access to the international market, (ii) firms established outside the country are not in contact with these atomistic intermediate producers and (iii) multinationals can produce the intermediate good they need to produce the final good but may be constrained by the amount of land they can exploit.

1.3.2 General specifications

There are two goods, one intermediate good x and one final good y. Labor is the only factor of production and the world is divided into two regions: local and foreign. A foreign firm operating in local is called a multinational. The intermediate good can be of high or low quality. When it is produced by locals (subscript l), it is of low quality and when it is produced by the multinational (subscript m) it is of high quality. The final good is produced by foreign firms (subscript f) and by the multinational. To produce one unit of final good y each foreign firm requires λ_f units of labor and μ_f units of an intermediate good x. Foreign firms buy the intermediate good from a monopolist exporter who buys himself the good from locals in a perfectly competitive market. Locals need λ_l units of labor to produce one unit of intermediate good x_l. The competitive wage of locals is taken as the numeraire.

The multinational is able to produce the intermediate itself but faces a maximum production constraint on this good. The multinational hence produces at maximum $\overline{q_m}$ unit of final good y with its own maximum production of intermediate good x_m coming from its own extraction of raw materials. The intermediate good x_m produced by the multinational is of better quality (i.e:$x_m > x_l$). The multinational needs λ_o units of labor to produce one unit of its own intermediate good x_m. When it uses its own high quality intermediate good, the multinational needs λ_m units of labor and μ_m units of intermediate good x_m to produce one unit of final good y. Once the multinational has used all its own intermediate goods, it can buy the low quality intermediate good x_l from locals in a perfectly competitive market. In this case, the multinational needs λ_r units of labor and μ_r units of intermediate x_l to produce one unit of final good y. Hence, as in the South-Kivu example, we have that: (i) The multionational has access to raw materials (Chinchona tree) which allows it to produce part of the intermediate good (quinine) it needs for its final good production (medicine). (ii) The multinational intermediate good technology is superior to the one of local extractors in two ways: (a) since the multinational harvests barks at the optimal time, it needs less work to produce one unit of quinine, the intermediate good, i.e: $\lambda_o < \lambda_l$ and (b) since the multinational uses better germs, the intermediate good or quinine quality, is higher, i.e: $\mu_m < \mu_r$.(iii) The multinational has directly access to the local market while the foreign firm needs to pass throug an intermediate agent, the exporter. Multinational will then get the price of perfect competition and every foreign firm will have to pay the price of the monopolist exporter. Note that there may also be a technology differential between the multinational and the foreign firm that depends on the value of λ_r, λ_f, and μ_r, μ_f. If $\lambda_r/\lambda_f > \mu_r/\mu_f$ then the multinational is a less intensive user of intermediate good x than the foreign firm. This allows us to discuss how heterogeneity in final good producers affect backward linkages.

In the labor market, we set exogenous wages. In the intermediate good production, wages in the local market are fixed (they can be seen as reserve wages) while the multinational pays higher wages to locals. Here, the multinational wage can be seen as an efficiency wage and there is a lottery to elect the workers of the multinational. In the final good market, we allow for different wages between the multinational and the foreign firm since they are operating in distinct labor markets.

The foreign firm and the multinational both have Leontief production function for the final good. What differs is the quality of intermediate good and the technology they use. Given those, the marginal cost of production for the foreign firm f is given by

$$c_f = \lambda_f \omega_f + \mu_f P_x^M$$

Where P_x^M denotes the price of intermediate good x_l sold by the monopolist exporter and ω_f denotes the foreign wage per worker.

The marginal cost of production for the multinational that has not already used all its own intermediate good x_m is

$$c_m = \omega_m(\lambda_m + \mu_m \lambda_o)$$

The marginal cost of production for the multinational that has already used all its own intermediate good x_m is

$$c_r = \lambda_r \omega_m + \mu_r P_x^{PC}$$

Where P_x^{PC} denotes the price of intermediate good x_l sold by a perfectly competitive local extractor and ω_m denotes the multinational wage per worker.

Let $P(Q)$ be the inverse demand function for final good y where Q is the total consumption of final good y and P its price. Given the demand function, the profit of a foreign firm f is given by

$$\pi_f(q_f, q_{-f}) = (P(Q) - c_f)q_f - F$$

Where q_f is the amount of output produced by a foreign firm, Q is the total amount of good y produced in the world economy and F is the fixed cost faced by the foreign firm. We assume that fixed costs in the final good market are high which in turn yields Cournot competition with a low number of firms operating in the final good market. This is in line with the example where pharmaceutical firms need high investment in equipment to produce medicines and hence face few competitors. The profit of the multinational m is given by

$$\pi_m(q_m, q_f) = (P(Q) - c_m)\overline{q_m} + (P(Q) - c_r)(q_m - \overline{q_m}) - M$$

Where q_m is the amount of output produced by the multinational, $\overline{q_m}$ is the maximum amount of output that is produced with its own intermediate[3] and M is the fixed cost incurred by the multinational.
We simplify to a linear inverse demand function for the final good

$$P(Q) = \alpha - Q$$

Where α denotes world market size and Q the total output of final good y. We first study the market equilibrium when there is no multinational in the market, that is, when the intermediate is exported from the home country to be transformed abroad.

1.3.3 No multinational

In this configuration, there is no multinational and n foreign firms compete with each other buying the intermediate good x_l from a local monopolist exporter who buys it from locals extractors in a perfectly competitive market. The foreign firm takes the price of the monopolist P_x^M as given and chooses its output quantity q_f that maximizes its profit

$$Max(P(Q) - \lambda_f \omega_f - \mu_f P_x^M) q_f - F$$

Where $f = 1, .., n$. First order condition gives us the optimal output production of a foreign firm

$$q_f = \frac{\alpha - \lambda_f \omega_f - \mu_f P_x^M}{n+1}$$

Since a foreign firm needs μ_f units of intermediate good x_l to produce one unit of output y, each foreign firm demands $\mu_f q_f$ unit of intermediate good and the total demand is the horizontal sum of individual demand. Hence, inverse demand for intermediate x_l is given by

$$P_x^M(Q_x^M) = \frac{\alpha - \lambda_f \omega f}{\mu_f} - \frac{n+1}{n} \frac{Q_x^M}{\mu_f^2}$$

[3]Since the multinational buys the intermediate good from a competitive market and that its intermediate good production costs are constant, it will either buy or produce the better quality/price intermediate good but it will never do both.

Where Q_x^M is the total quantity of intermediate good x_l (i.e $Q_x^M = n\mu_f q_f$) and P_x^M its price. Given this demand for intermediate, the exporter maximizes his profits

$$Max(P_x^M(Q_x^M) - \lambda_l)Q_x^M$$

we find the equilibrium output of the local monopolist exporter (Q_x^M)

$$Q_x^M = \frac{n\mu_f^2}{2(n+1)}(\frac{\alpha - \lambda_f\omega_f}{\mu_f} - \lambda_l)$$

Where λ_l is the quantity of labor needed to produce one unit of intermediate good x. Since it is the sole production factor in a competitive market, it is also the price of the intermediate in the local market (we set the wages in the local economy equal to one). Hence, the price of the intermediate exported is

$$P_x^M = \frac{1}{2}(\frac{\alpha - \lambda_f\omega_f}{\mu_f} + \lambda_l)$$

We define the level of backward linkages (BL) as the equilibrium output of intermediate

$$BL^{NM} = Q_x^M$$

Hence, the degree of backward linkages when there is no multinational in the economy (BL^{NM})increases with the world market size (α) and decreases with the number of units of labor needed to transform raw materials into intermediate (λ_l) and in the number of units of labor needed by foreign firms to transform an intermediate good into a final good(λ_f). The degree of backward linkages also depends on the technology of the foreign firm (μ_f). If the technology is above a treshold ($\mu_f^{critical} = (\alpha - \lambda_f\omega_f)/2\lambda_l$), a better technology(that is a lower μ_f) reduces backward linkages and if technology is below this treshold, a better technology increases backward linkages. This is because when firms have a low technology, its improvment has two effects: firstly, it reduces the needs for intermediate and secondly it increases the quantity of good sold through a lowering in the cost of production. When technology is intially low the former effect dominates the latter and we have an increase in the needs of intermediate and backward linkages increase. When technology is initially high, the latter effect dominates and backward linkages drop.We will now consider the market equilibrium with a multinational.[4]

1.3.4 Multinational into the market

We want to study the impact of the multinational entry on the level of backward linkages in the local economy. In the final good market, a foreign firm has become a multinational. We do not model the choice of becoming a multinational. We simply consider that one foreign firm has been invited by the host governement to pursue its activities on its soil. Given the profit functions, the firm accepts. We now have $n-1$ foreign firms and one multinational that compete à la Cournot. Each firm maximizing profits, we find the reaction function of the multinational and each foreign firm, respectively

$$q_m = \frac{\alpha - (n-1)q_f - (\lambda_r \omega_m + \mu_r P_x^{PC})}{2}$$

$$q_f = \frac{\alpha - q_m - (\lambda_f \omega_f + \mu_f P_x^{M})}{n}$$

At equilibrium the multinational produces

$$q_m = \frac{\alpha + (n-1)(\lambda_f \omega_f + \mu_f P_x^{M}) - (n)(\lambda_r \omega_m + \mu_r P_x^{PC})}{n+1} \tag{1.-16}$$

and a foreign firm

$$q_f = \frac{\alpha + (\lambda_r \omega_m + \mu_r P_x^{PC}) - 2(\lambda_f \omega_f + \mu_f P_x^{M})}{n+1} \tag{1.-15}$$

We study now the effect of the multinational's entry on the degree of backward linkages induced by the foreign firm through the local monopolist exporter. The demand for intermediate good x_l supplied by the exporter (Q_x^M) is the sum of each individual foreign firm demand multiplied by the number of units needed by a foreign firm to produce one unit of

[4]We could endogenize n. However, since fixed costs are high, the number of firms is not sensitive to one firm becoming a multinational. As a result, endogenizing n would not add anything to the model.

final good ($(n-1)\mu_f q_f$). Hence the inverse demand of intermediate supplied by the exporter is given by

$$P_x^M(Q_x^M) = \frac{\alpha + (\lambda_r\omega_m + \mu_r P_x^{PC}) - 2\lambda_f\omega_f}{2\mu_f} - \frac{n+1}{2(n-1)\mu_f^2}Q_x^M \tag{1.-14}$$

When we compare this demand to the demand when the multinational is not into the market, we note that it is now flatter and that the intercept is lower [5]. We find the equilibrium output of the local monopolist exporter

$$Q_x^M = (\frac{\alpha + (\lambda_r\omega_m + \mu_r P_x^{PC}) - 2\lambda_f\omega_f}{2\mu_f} - \lambda_l)(\frac{(n-1)\mu_f^2}{n+1}) \tag{1.-13}$$

Hence, under some condition[6], the equilibrium output of the monopolist is lower in the presence of the multinational. The price of the monopolist for intermediate x_l is

$$P_x^M = \frac{1}{2}(\frac{\alpha + (\lambda_r\omega_m + \mu_r P_x^{PC}) - 2\lambda_f\omega_f}{2\mu_f} + \lambda_l) \tag{1.-12}$$

Hence, the multinational's entry reduces the equilibrium production of each foreign firm, the foreign firms demand for the intermediate good decreases which decreases the marginal revenue of the monopolist. Hence, the monopolist maximizes his profit by choosing a lower level of output which reduces the level of backward linkages. This is a negative competition effect of the multinational's entry.

We now look at the effect of the multinational's entry on the degree of backward linkages in the competitive market of local extractors. Since the marginal cost of production in the local market is constant, it is the demand for intermediate that determines the level of output and hence the level of backward linkages. Demand comes, on the one hand, from the local monopolist exporter and, on the other hand, from the direct demand of the multinational in the local competitive market. We expect two opposing effects: The competition effect caused by the multinational's entry lowers the backward linkages effect due to a lower demand by foreign firms and the local exporter (see supra), and a demand

[5] for $\alpha > c_r$ which always holds at equilibrium with multinationals.

[6] If the multinational does not have a cost disadvantage compared to the foreign firm $\lambda_r\omega_m + \mu_r\lambda_l < \lambda_f\omega_f + \mu_f\lambda_l$ or if the number of firms in the final good market is not too high $n < \frac{\alpha + c_r - 2(\lambda_f\omega_f + \mu_f\lambda_l)}{c_r - (\lambda_f\omega_f + \mu_f\lambda_l)}$.

effect that directly increases output in the local market. Let's analyze the demand for local intermediate x_l by the multinational (Q_x^{PC}).

At equilibrium, multinational production is given by (1). Hence, output in the local market induced by the multinational's demand is given by

$$Q_x^{PC} = \mu_r(q_m - \overline{q_m})$$

$$= \mu_r(\frac{\alpha + (n-1)(\lambda_f \omega_f + \mu_f P_x^M) - n(\lambda_r \omega_m + \mu_r P_x^{PC})}{n+1} - \overline{q_m}) \tag{1.-12}$$

where $\overline{q_m}$ is given, P_x^{PC} is equal to λ_l and P_x^M is given by (5). The degree of backward linkages when the multinational is into the market (BL^M) is

$$BL^M = Q_x^M + Q_x^{PC} \tag{1.-11}$$

Let's now compare the level of backward linkages without and with multinational market participation. We want to know under which conditions the multinational's entry into the market raises the level of backward linkages, that is when the following inequation holds

$$BL^M > BL^{NM} \tag{1.-10}$$

Which hold iff

$$\begin{aligned} &\frac{\mu_r}{n+1}(\alpha + (n-1)(\lambda_f \omega_f + \mu_f P_x^M) - n(\lambda_r \omega_m + \mu_r P_x^{PC})) - \mu_r \overline{q_m} \\ &> \\ &\frac{n\mu_f}{2(n+1)}(\alpha + (n-2)(\lambda_f \omega_f + \mu_f P_x^{PC}) - (n-1)(\lambda_r \omega_m + \mu_r P_x^{PC})) \end{aligned} \tag{1.-10}$$

The LHS of the inequality equation (1.-9) is the additional level of backward linkages coming from the multinational demand in the local market. First, since the multinational can source locally at a cheaper price ($P_x^{PC} < P_x^M$), it will increase its demand of intermediate good. That is, the cost advantage of the multinational stemming from the local market access ($(n-1)(\lambda_f \omega_f + \mu_f P_x^M) - n(\lambda_r \omega_m + \mu_r P_x^{PC})$) has a positive effect on backward linkages. Second, the maximum capacity of the multinational in the intermediate good production ($\overline{q_m}$) reduces the needs to source locally which drives backward linkages downwards. Third, the higher the technology of the multinational, the lower its needs in intermediate goods. As a result, for given output, if a multinational has a high technology, its intermediate good demand in the local market will be low. The RHS of the inequality equation (1.-9) is the decrease in backward linkages associated to the monopolist exporter. First, there is one firm less which demand to the monopolist exporter $((n-2)[.]-(n-1)[.])$, this decreases backward linkages. Second, if the multinational has an additional cost advantage, it will lower backward linkages of the exporter since the multinational will produce more locally $((.)(\lambda_f \omega_f + \mu_f P_x^{PC}) - (.)(\lambda_r \omega_m + \mu_r P_x^{PC}))$. Third, at given output, the higher the technology of the foreign firm, the lower its needs in intermediate good. As a result, the multinational's entry has two opposite effects. The first effect lowers backward linkages because of the competition effect, that is, foreign firms' demand to the local exporter disminishes because their equilibrium output is lower in the presence of the multinational. Hence, the exporter demand to the local competitive market decreases. The second effect is the demand effect, that is, the entry of the multinational raises the direct demand to the local competitive market of intermediate good. If the multinational does not have a large technology advantage on its final good competitors, and if it is not able to produce much of intermediate, then the demand effect dominates and the level of backward linkages in the economy increases when the multinational is into the market. This is what we expected since a technological avantage of the multinational over the foreign firm would mean a low increase in demand for intermediate in the local market since the multinational does not need much intermediate to produce one unit of final good. So changing from the foreign demand to multinational demand would lower demand for the intermediate. Similarly, a multinational with high capacity of production of the intermediate would lower the needs of intermediate locally sourced.

We now explore numerically how heterogeneity in technology of the foreign firm and the multinational affects backward linkages. We say that the heterogeneity or the technological differential between the multinational and the foreign firm is high when the multinational needs either relatively less unit of work to produce one unit of output from one unit of intermediate good or relatively less unit of intermediate good to produce one unit of output or both. We will only focus on the technological differential that comes from the need in intermediate good to produce one unit of output. Therefore, we consider that human capital is equal in both foreign firm and multinational and that they need the same level of labor to produce output, whatever the quality of the intermediate good.

In that case, a high technological differential induces that the intermediate good demand by the foreign firm decreases more than the additional demand of the multinational. Indeed, (i) the multinational needs less intermediate and (ii) it takes a part of the foreign firm market share thanks to its cost advantage which stems from its local market access. As a result, its entry lowers the overall demand for the intermediate. In the other case, when the technological differential is low, the demand effect dominates the competition effect.

We now provide a numerical simulation to illustrate the backward linkages effect of heterogenity in technology between the multinational and the foreign firm. We consider the case where there is only one foreign firm and one multinational ($n = 2$). We hence evaluate the effect of the entry of the multinational in the market for different values of μ_f and μ_r and other variables fixed. We set $\lambda_r = \lambda_f = \lambda_m = 3$ and $\omega_m = \omega_f = 10$ so that there is no heterogeneity in labor efficiency nor in labor costs. In these settings, wages paid by the multinational are ten times higher than the reserve wage which is an observed value in the Kivu example. We also set $\lambda_l = 3, \lambda_o = 0,5$ and $\mu_m = 0.7$ which reflects the fact that the multinational in South-Kivu was six times more productive than locals in the intermediate good production ($\lambda_l > \lambda_o$) and that this production was of better quality ($\mu_m > \mu_r$ where quality was measured by quinine content and was about 460% higher in the multinational barks). Finally we fix the size of the market ($\alpha = 50$) and the maximum quantity of intermediate produced by the multinational ($\overline{q_m}\lambda_o = 0.275$). We set no fixed cost and we only allow technologies of foreign firm and MNC to be different, that is $\mu_r \neq \mu_f$.

Figure 1 illustrates the link between the level of technology, the technology difference between the MNC and the foreign firm and the level of backward linkages. It shows us that the level of backward linkages is higher when the technological difference between the multinational and the foreign firm is not too high. As noted earlier, a better technology level does not necesarily higher the level of backward linkages. Indeed, we can see that a less efficient technology used by the foreign firm tends to higher the level of backward linkages when the

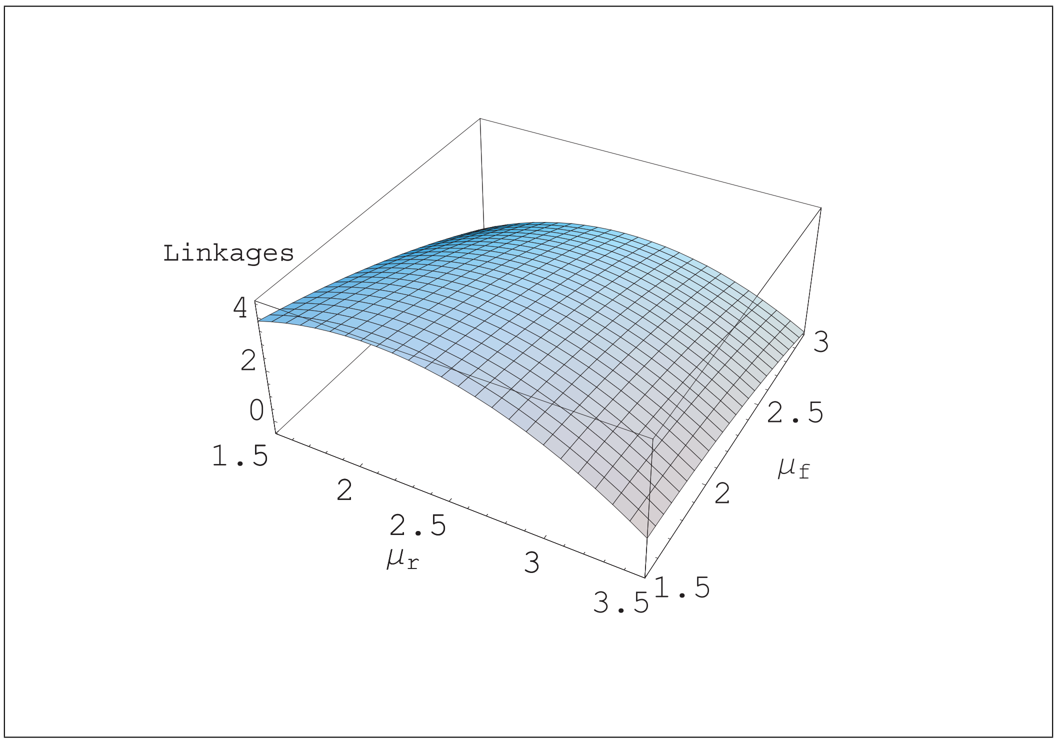


Figure 1.1: Level and difference in technology effects on backward linkages

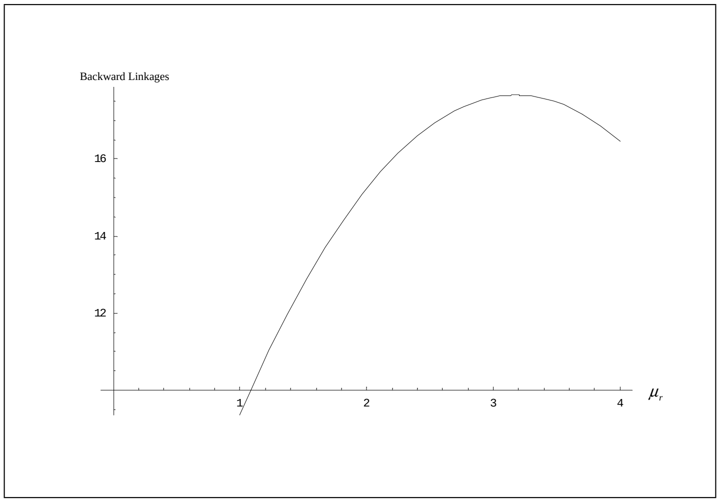


Figure 1.2: Level of backward linkages when $\mu_f = \mu_r$

technology differential with the multinational is not too high. Note that again, we have a treshold for the technology improvement to higher the level of backward linkages. Fixing equal technologies, i.e:$\mu_f = \mu_r$, Figure 2 shows under which critical level the level of backward linkages increases with the level of technology and over which level it decreases with technology. For the different levels of technology analyzed, an improvement in the level of technology increases more the needs of intermediate through the final good production than it decreases the needs of intermediate through the reduction in the amount of intermediate needed to create one output. This simulation perfectly illustrates our model findings.

Hence, when we have a higher level of backward linkages, since we assume high unemployment and few or no displacement in the labor market, this means that the number of workers in the local economy is higher. In that case, the only agent of the host economy that is worse off in the presence of the multinational is the monopolist exporter. As a result, the presence of the multinational influences positively the level of employment and it could also have a positive effect on GDP. However, even if GDP falls, there is a more equal distribution of revenues in the local economy since the monopolist transfers a part of its surplus to workers-consumers.

1.4 Optimal technology transfer by the multinational

Does the multinational has an incentive to transfer technology? To which agent? Since foreign firms are competitors of the multinational, the latter has no incentives to transfer technology to the formers since the multinational would loose its advantage in the market. So, the most plausible transfer is between the multinational and the local competitive extractor. On the one hand, since a better intermediate would lower the quantity of intermediate needed by the multinational to produce one unit of output since the intermediate is of better quality, multinational could transfer its knowledge to the local extractor. On the other hand, a better quality intermediate good produced by locals (because of the multinational technology transfer) would lower the quantity of labor needed to produce one unit of output. Hence, the technological level of the local extractor becomes a variable of choice of the multinational. The multinational can hence choose to enhance locals knowledge through technological transfers in order to increase its own profit. Note that we will only study the effect of a technology transfer on the number of intermediate needed to produce one unit of output. So, the transfer has no effect on the quantity of labor needed to transform the intermediate (even if it is of better quality). We also consider that foreign firm cannot transfer their technology since they don't have any contact with local producers while the multinational does.

We begin by studying the optimal level of transfer by the multinational and then check how it affects local extractors. Throughout this section, we assume that the market configuration does not change, that is, the multinational, the exporter and the foreign firms make positive profits in producing positive quantities of goods at strictly positive price. That is, we do not allow that the multinational forces out the foreign firm.

With technology transfer, the profit of the multinational becomes

$$\pi_m(q_m, q_f, t) = (P(Q) - c_m)\overline{q_m} + (P(Q) - c_r^{tt}(t))(q_m - \overline{q_m}) - f(t)(q_m - \overline{q_m})$$

where $f(t)$ is the transfer cost per unit of output produced with the locally sourced intermediate good, and $c_r^{tt}(t)$ is the marginal cost of producing the final good with technological transfer (index tt) when the multinational has already used all its own intermediate good, it is given by

$$c_r^{tt}(t) = \lambda_r \omega_m + (\mu_r - g(t))P_x^{PC}$$

Where $g(t)$ is the reduction in the number of intermediate needed by the multinational to produce a unit of final good due to a transfer t. So, g(t) can be seen as the technology progress adequacy to the multinational, or in other word, the technology progress adequacy to the downstream sectors of local producers. So, has seen before, the multinational now chooses its output quantity and its technological transfer in order to maximize profit while the foreign firm only chooses its output production. Note that the technology transfer lowers the quantity of the intermediate needed by the foreign firm to produce one unit of output. Hence, the multinational surely looses at least a part of its competitive advantage that depend on its own more efficient production of intermediate. Indeed, a part of the multinational advantage comes from its own extraction which is more productive than that of locals. Since it transfers technology, the difference is less important [$(\lambda_l - \lambda_o)$ shrinks]. This creates a trade off for the multinational.

The profit of the foreign firm is now given by

$$\pi_f(q_f, q_m, t) = (P(Q) - c_f)q_f - F$$

where

$$c_f = \lambda_f \omega_f + (\mu_f - k(t))P_x^M$$

Where $k(t)$ is the reduction in the number of intermediate needed by the foreign firm to produce a unit of final good due to a transfer t. So, k(t) can be seen as the technology progress adequacy to the foreign firm, that is again, the technology progress adequacy to the downstream sectors of local producers. Note that we allow here for g(t) and k(t) to be different, that is, we allow that the transfer fits more the multinational technology than that of the foreign firm. This is reasonable since the transfer comes from the multinational and so, we expect technology adjustment costs to arise for the foreign firm, hence we suppose that $g(t) \geq k(t)$.

Hence, the multinational maximizes its profit with respect to the transfer and to its output quantity while the foreign firm maximizes profit with respect to its output. The game à la Cournot gives us the following reaction functions of the multinational and the foreign firm, respectively

$$q_m = \frac{\alpha - (n-1)q_f - (\lambda_r\omega_m + (\mu_r - g(t))P_x^{PC}) - f(t)}{2}$$
$$q_f = \frac{\alpha - q_m - (\lambda_f\omega_f + (\mu_f - k(t))P_x^{M})}{n}$$

Furthermore, First Order Condition for an optimal transfer is given by

$$\frac{\delta\pi_m(\overline{q_m} = 0, t)}{\delta t} + \frac{\delta c_r^{tt}(t)}{\delta t}\overline{q_m} = 0 \qquad (1.\text{-}17)$$

Proposition 1 gives us one type of corner solution of non transfer that occurs for any possible transfer, that is for any $t \in [0, \lambda_l - \lambda_0]$.

Proposition 1: The multinational has no incentive to transfer any of its technology when the gain of the transfer, for a fully locally sourced intermediate, less than compensate the transfer driven relative loss of profitability in the own production of intermediate, that is when

$$\frac{\delta\pi_m(\overline{q_m} = 0, t)}{\delta t} + \frac{\delta c_r^{tt}(t)}{\delta t}\overline{q_m} < 0 \qquad (1.\text{-}17)$$

Conversely, Proposition 2 gives us a corner solution of total transfer when $\forall t \in [0, \lambda_l - \lambda_0]$.

Proposition 2: The multinational has an incentive to transfer all its technology when the gain of the transfer, for a fully locally sourced intermediate, more than compensate the relative loss of profitability in the own production of intermediate, that is when

$$\frac{\delta\pi_m(\overline{q_m} = 0, t)}{\delta t} + \frac{\delta c_r^{tt}(t)}{\delta t}\overline{q_m} > 0 \qquad (1.\text{-}17)$$

Note that the reduction of the marginal cost of production comes from two reinforcing effects: (i)The multinational needs less intermediate goods to produce one unit of output thanks to its technology transfer and (ii) this technology transfer reduces the price of the intermediate in the local competitive market.

From (1.4), if the multinational locally sources all of its intermediate and if the transfer cost is not to high, it will transfer all its technology. It is also implied in (1.4) that if the multinational is able to fully produce its needs of intermediate, it won't transfer technology. These two propositions give us sufficient condition for non-transfer and total transfer.

Proposition 3: It is optimal for the multinational to transfer only a part t_{opt} of its technology if

(i) $\forall t \in [0, \lambda_l - \lambda_0]$, t_{opt} is s.t. $\frac{\delta \pi_m(\overline{q_m}=0,t)}{\delta t} + \frac{\delta c_r^{tt}(t)}{\delta t}\overline{q_m} = 0$

(ii)$\pi_m(t = t_{opt}) > \pi_m(t = 0)$

(iii) $\pi_m(t = t_{opt}) > \pi_m(t = \lambda_l - \lambda_0)$

Where when only (ii) does not hold we have a no-transfer solution, when only (iii) does not hold we have a total transfer solution and when both do not hold, we have a no-transfer solution when $\pi_m(t = 0) > \pi_m(t = \lambda_l - \lambda_o)$ and total transfer when $\pi_m(t = 0) < \pi_m(t = \lambda_l - \lambda_o)$. Hence, propositions 1 to 3 give us necessary and sufficient conditions for zero, partial and total technology transfer. As we can see in proposition (3), for the multinational, the transfer is (i) decreasing in its final good technology, that is the better its technology the lower the transfer, (ii) decreasing in the level of technology of locals, that is when locals are already technologically advanced, the transfer needs not to be high, (iii) decreasing in the level of output produced with its own intermediate, (iv) implicitly decreasing in the cost of transferring technology, (v) ambiguously affected by its absorption rate since a high rate would mean that transferring is profitable while a low rate would encourage more transfer. We now comment how equilibria quantities and prices are affected by a transfer.

At equilibrium we know that output produce by the multinational and the foreign firm respectively are

$$q_m = \frac{\alpha + (n-1)(\lambda_f \omega_f + (\mu_f - k(t))P_x^M) - n(\lambda_r \omega_m + (\mu_r - g(t))P_x^{PC} + f(t))}{n+1}$$

$$q_f = \frac{\alpha + (\lambda_r \omega_m + (\mu_r - g(t))P_x^{PC} + f(t)) - 2(\lambda_f \omega_f + (\mu_f - k(t))P_x^M)}{n+1}$$

Therefrom, we derive the price of the monopolist exporter

$$P_x^M = \frac{1}{2}(\frac{\alpha + (\lambda_r \omega_m + (\mu_r - g(t))P_x^{PC} + f(t)) - 2\lambda_f \omega_f}{2(\mu_f - k(t))} + \lambda_l - t)$$

Hence we have various channels through which the transfer influences the monopolist price. On the one hand, the transfer lowers this price since (i) the multinational needs less intermediate which reduce the quantity of output produce by the foreign firm and reduce demand to the monopolist, (ii) the multinational pay less on the local market to get an intermediate which once more reduce demand of the foreign firm to the monopolist and (iii) the competitive market price disminishes what reduces the cost of the monoplist. On the other hand, the transfer increases the price of the monoplist since (iv) there is a transfer cost for the multinational what reduces its output production and increases the foreign firm production and hence the demand to the monoplist and (v) demand to the monopolist increases since output by the foreign firm increases because it needs less intermediate to produce one unit of output.

We also have various channels through which the transfer affects the output quantity of the multinational. On the one hand, the transfer lowers the production since (i) the foreign firm needs less intermediate to produce output and (ii) there is a cost of transfering technology. On the other hand, output increases since (iii) the multinational needs less intermediate to produce output and (iv) local market price shrinks thanks to the transfer. The effect of the quantity output varies also in the same direction as the monopolist price. Note also that if the local market price disminishes more than the monopolist price, then if the cost of transfer is sufficiently low, the output produce by the multinational increases since the technology absorption rate of the foreign firm will always be lower or equal to that of the multinational. Hence, the effects on the profits through these channels are still ambiguous. Let's now move to how the optimal transfer affect backward linkages.

1.4.1 Backward linkages effect of the technology transfer

The effect of technology transfer on the degree of backward linkages in the local economy depends on how locally sourced intermediate are affected by the transfer. We still have the two different channels of linkage: (i) the intermediate good locally sourced by the multinational and (ii) the exported quantities of the monopolist exporter.

The first observation is that the technology transfer creates a trade-off for the multinational. On the one hand, the multinational benefits from the transfer since it lowers the price of the intermediate good in the competitive market. On the other hand, the transfer lowers the cost of production of the foreign firms. Hence, as we already mentioned, the transfer lowers the multinational's advantage on its competitors. Note that the transfer also depends on the maximum capacity of own intermediates that the multinational produces. If this maximum is low, then the multinational clearly benefits from transfering technology, if it is high, then the multinational has no incentive to diffuse its technology since its rent comes from its technology advantage. We already saw how the transfer affects the output quantities of the multinational. Backward linkages that comes from the multinational in the locally competitive market are affected in the same way and the magnitude of the total variation correspond to that of output production multiplied by the number of intermediate to produce one unit of output, as seen before.

We study now how the transfer affects the equilibrium quantities of intermediate goods sold by the exporter. On the one hand, the transfer lowers these quantities since (i) the multinational needs less intermediate, (ii) the purchasing price of the intermediate good is lower for the multinational, these two effects make the multinational more competitive and thus hurt the foreign firm and the exporter and (iii) the foreign firm needs less intermediate to produce one unit of output, which lowers its demand to the exporter. On the other hand, the transfer increases the output quantities of the exporter since (iv) the price of the intermediate good in the local market is lower which reduces the cost of the exporter, (v) the foreign firm needs less intermediate to produce the same amount of output which allows it to produce more and demand more of the intermediate and (vi) there is a transfer cost for the multinational. We now present some simulations that illustrate what could be the effect of a transfer on the difference in backward linkages, that is the difference in backward linkage when there is or there is not a transfer.

Comparative statics

Note that we study the effect of the transfer on the level of backward linkages (BL^t) where backward linkages to the local economy are now given by

$$BL^t = Q_x^M + Q_x^{PC} \tag{1.-19}$$

We illustrate two cases: 1)the multinational maximizes its profit in transfering all its technology and 2)the multinational has an incentive to transfer a part of its technology and this transfer leads to a higher level of backward linkages.
The effect of a technology transfer on backward linkages depends on two effects discussed earlier. (i) It depends on the quantity of intermediate demanded by the foreign firms. If the transfer is too important, it will reduce backward linkages through the exporter. (ii)It also depends on the quantity of intermediate good demanded by the multinational into the local competitive market. Since the transfer lowers the cost of production of the multinational, output produced by the multinational increases, but since it needs less intermediate to produce a unit of output, the expected effect should be an increase in the quantity if the transfer is small and conversely. Hence, we expect a high technology transfer to lower backward linkages and a low transfer to increase it. We now move to our 2 cases.

subcase (1)
We keep numerical values as in section 3.4 so that these values fit the South-Kivu example. We set the different absorption rates equal and fix it at $g(t) = k(t) = 0.7t$. We also fix $\mu_f = \mu_r = 3.2$ and finally we set the transfer cost $f(t) = t$.
Since the transfer is a choice of the multinational, we want to find the optimal transfer that maximizes the profit. Figure 3 illustrates how the profit of the multinational is affected by

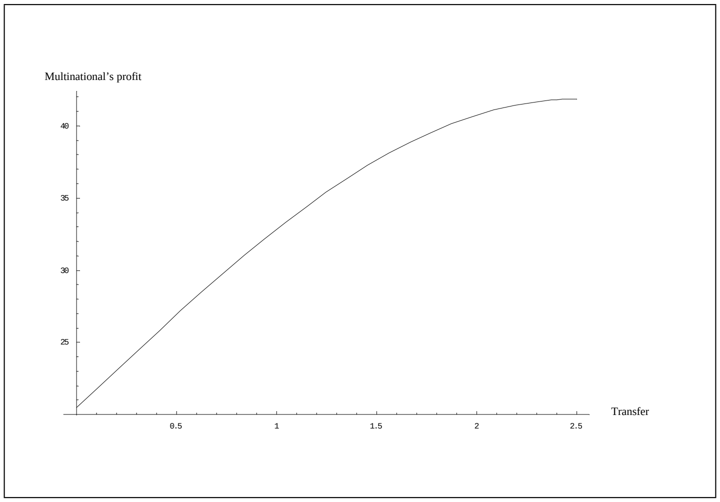


Figure 1.3: Effect of the transfer on the multinational's profit

the technology transfer. We find that the optimal transfer is a total transfer ($t_{optimal} = 2.5$). The transfer is maximum since: (i) The multinational cannot extract sufficient raw materials itself and (ii) the cost of transfer is not too high. Figure 4 now illustrates how the difference in backward linkages is affected by the technology transfer. Since we found that the optimal transfer is a total transfer ($t_{optimal} = 2.5$), we can now find the level of backward linkages with transfer and compare it to the case where there is no transfer. We find that the total transfer lowers the level of backward linkages, what was expected.

From this optimal total transfer, if we increase the technology of both the multinational and the foreign firm by 10 percents, we see that the optimal transfer decreases by 7 percents[7] what decreases the level of backward linkages by 14 percents. That is, the level of backward linkages is lower with lower transfer and higher technology in the final good sector. This doesn't contradict or previous intuitions. Indeed, we have two opposite effects (i) the lower transfer increases the level of backward linkages while (ii) the technological improvement lowers it. In this case the latter dominate the former what leads to a lower level of backward linkages. This becomes clearer when we compare the technology improvment by 10 percents

[7] We consider that there is a 10 percents transfer when a multinational has a technology of 1 and transfers .1.

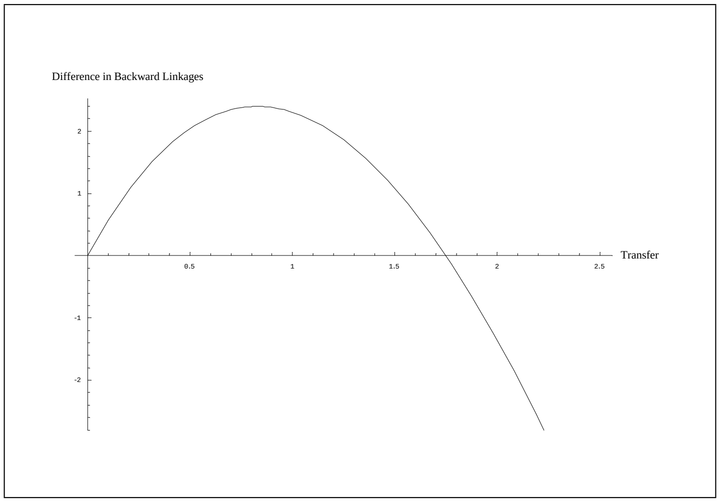


Figure 1.4: Difference in backward linkages with technology transfer

of both the multinational and the foreign firm with an improvment by 10 percents of the technology of the multinational only. In this case, when only the multinational improved its technology, the transfer is 3,5 percents lower-than when both improved technology and the level of backward linkages is 10 percents higher. This is because this time the two effects go in the same way. The lower transfer increases the level of backward linkages and as the technology of the multinational is the same and that of the foreign firm is less efficient, the number of intermediate needed increases and so do backward linkages.

subcase (2)

We keep simplifications of subcase (1) but we now we set $f(t) = 2t$ and we show an example where we have an optimal transfer that increases the level of backward linkages. Figure 5 depicts the profit of the MNC with respect to the transfer and Figure 6 depicts the difference in backward linkages with respect to the transfer. We clearly see that the optimal transfer ($t = 1.57$) increases the degree of backward linkages. We study here how variables affect the degree of backward linkages. We already know how maximal extraction of the multinational, how a technology gap and a variation of technology affect the optimal transfer. So, we will now check how does the market size and the level of technology of locals affect the level of

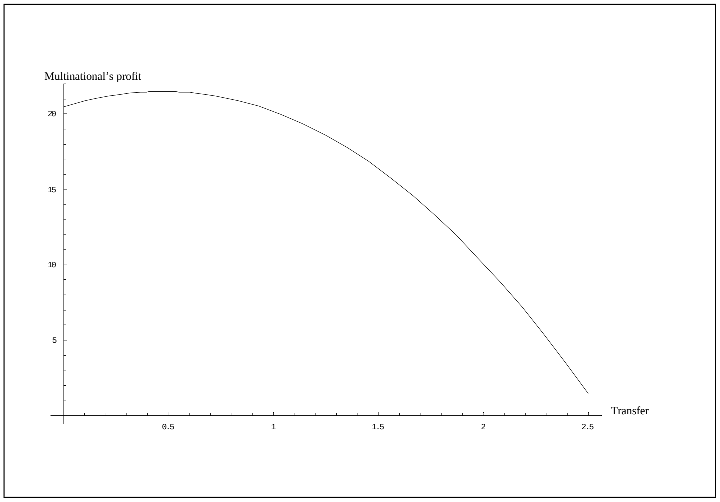


Figure 1.5: Effect of the transfer on the multinational's profit

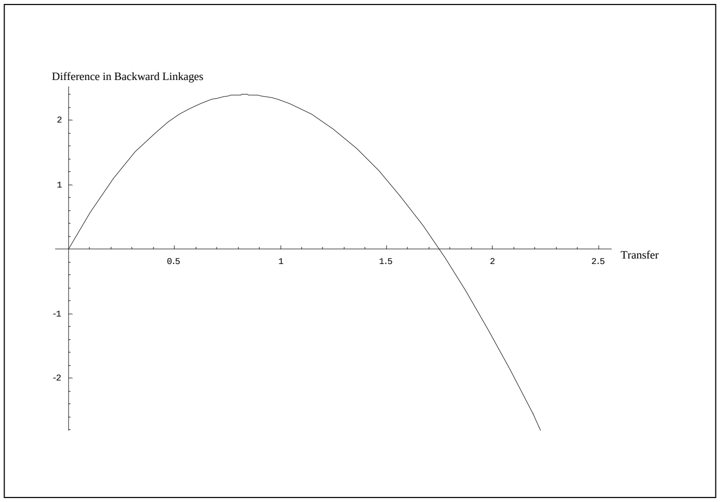


Figure 1.6: Effect of the transfer on the difference in backward linkages

backward linkages.

Results on how the market size affects the level of backward linkages are not surprising. For our values, an increase by 10 percents of the market size leads to an increase of the level of backward linkages by 30 percents.We also note that the difference in backward linkages (that is when we compare it to the case of zero transfer) shrinks. This is because the level of backward linkages comes mostly from the market size and hence when the market size is higher the share of backward linkages due to the transfer is lower.

Finally, when the technology level of the local firm increases, the multinational has a lower impact on the local market. This is why our simulations show that an increase by 10 percents of local technology reduces the effect of the multinational entry on the difference in backward linkages by 25 percents.

Hence, our simulations showed that under some characteristics, the entry of the multinational increases the level of backward linkages. Unfortunately, these characteristic are exogenous to the firm's choice. Hence, if in some cases, the entry of the multinational may increase the level of backward linkages, it is not necessarily so and it depends on the sector.

1.5 Conclusion

In contrast to earlier literature, this model provides a more realistic approach of market's interaction in the raw materials sector in LDCs. Our model depicts a situation where a multinational has two advantages to establish itself into a host country that produces the intermediate needed to produce its final good. Establishment in host countries allows the multinational (i) to buy its intermediate from the local market rather than from an exporter and (ii) to produce its own intermediate of better quality thanks to its knowledge. In these settings, transfering technology to its local supplier can be profitable in two ways: (i) it lowers the price of the intermediate, (ii) it improves the quality of its intermediate. Conversely, transfering technology can also be harmful since (i) it reduces the technology advantage of the multinational on its competitors and (ii) it may reduce the price of the intermediate for its competitors. Our market configuration is an ologipolistic final good market made up of a multinational and worldwide competitors, the former sourcing its intermediate in a competitive local market and the latter buying its intermediates from a monopolist exporter, where the exporter buys its sales from the competitive local market. In this configuration we depicts the impact of the presence of the multinational in the host country. The effect depends on which of the competition effect or the demand effect dominates the other one. The competition effect reduces the final good production of foreign firms and hence the need for intermediates, and the demand effect increases the demand in the local competitive market through the needs of intermediate of the multinational. We also emphasized that the degree of backward linkages also depends on the level of technology used by the multinational. Finally, we showed that a multinational that has an interest to transfer technology may enhance the level of backward linkages in the local economy if the initial technology advantage of the multinational and its possibility of intermediate production are not too high. Hence, our model and simulations seem to be consistent with previous empirical works on backward linkages and may, when market possesses similar features to our model and simulations, support the attempt of many LDCs to attract foreign direct investment hoping that spillovers to domestic industries in knowledge and technology will be brought by multinationals. Further research on this topic should focus on the welfare effects of transfer and linkages. This model could also be extended to a general equilibrium one where labour market should be developed.

Chapter 2

Delocation, home wages and welfare

Abstract

I present a general equilibrium model of delocation where firms move from the North to the South to benefit from low wages. As suggested by the large empirical litterature, welfare in the North increases when the host country is not technologically too lagged. Moreover, I show that vertical technology transfer to the South plays a major role in enhancing welfare of workers-consumers in the North and in the South. This analysis helps explaining the differences in empirical findings on production delocation.

2.1 Introduction

Differences in wages across the Globe, disminishing trade costs and development of communication technologies give the opportunity to entrepreneurs to relocate their activities towards low wages regions. One phenomenon is called delocation, that is, doing abroad what was so far done at home but at a cheaper price. That is, there is a change in the location of the production plant which moves from the high wage North to the low wage South. Part of the production which has moved to the low wages South is hence exported to satisfy northern demand while part of the production which has stayed in the North is still exported to satisfy southern demand. The remaining production is sold in its country of production. According to this definition, we distinguish delocation from Foreign Direct Investment (FDI) and offshoring. Delocation implies that a firm is closed at home to be re-opened abroad, ruling out any pure investment as it can be the case when engaging in FDI. Delocation is also different from offshoring since outsourcing abroad (or offshoring) can be an initial decision, that is, the outsourced production has always been located abroad and has not moved from home to abroad as it is the case when firms delocate. Delocation also implies re-importing part of the production which is not necessarily so when offshoring activities or when engaging in FDI. As a result FDI or offshoring do not systematically imply delocation.

Delocation has been a matter of concern of rich countries for many years and the phenomenon is increasing with more and more firms delocating towards low wages countries (Ebenstein, Harrison, McMillan, and Phillips, 2011). Salient examples mentioned by mainstream media include among others Salomon delocating its production of boots from France to Romania; Molex, the car equipment producer, delocating from France to Slovakia or finally General motors, delocating part of its production from the US to China, Korea and Mexico. Empirical studies of the economic impact of delocation show mixed results. The effects on home wages are, depending on the cases, positive (Desai, Foley, and Hines, 2009; Borga, 2005), negative (Brainard and Riker, 2001; Hanson, Mataloni, and Slaugher, 2003; Hijzen, Gorg, and Hine, 2005)) and sometimes neutral (Falk and Koebel, 2002; Riker and Brainard, 1997).

The purpose of this paper is to provide a new theoretical framework to analyze the wages and welfare effects of delocation. When firms move for cost saving incentives, workers hired in these firms increase labor supply for other jobs in the home country but these workers also have the possibility to consume the low priced goods now produced abroad through delocation. This paper hence models in details how these workers-consumers are affected by delocation. (i) It fully analyzes the various general equilibrium effects of pure delocation on workers-consumers when firms are moving to benefit from low wages; (ii) It uses the technology level of the host country to explain how differences across destination of delocation and how differences in the short (direct effects: No technology transfer to the host economy) to long run (indirect effects: technology transfer) affect home welfare of the worker-consumer. The analytical framework presented gives an additional rationale so as to explain the mixed results obtained by empirical investigations so far[1] and describes clear mechanisms of delocation on wages and welfare in the North.

I develop a model where firms from the North produce a final good with the resources from the South and the South cannot produce the final good without technology from the North. You can think of any product or service using labor from low wage regions and technology initially not available in those regions such as cars, hi-fi, chemicals and refined products. You can also think of production that needs raw materials present in some location and technology present in other locations. Among others, mobile phones need coltan and technology to be produced, and these two input are not available in the same Region; medication such as malaria fighters need quinine and technology not available in the same country.

I use a standard general equilibrium model of North-South trade to asses the welfare effects of firms relocation where firms move from the North to the South to benefit from low wages. In a Dixit-Stiglitz model of trade with a two stage level of production, I show that when firms relocate from the North to the South, northern labor demand decreases, which yields lower wages in the North. Since the prices of the goods produced by relocated firms are lower, northern consumers consume relatively more of these goods. Moreover, the host technology level affects positively the production capacity and wages in the South which in turn impacts

[1]This new rationale is complementary to other explanations of the effects of delocation on wages such as the period under study, the type of delocation, the exposure to offshoring.

positively demand for final goods and hence wages and prices in the North. Because in this kind of model, wages react more than prices to a variation in the host technology, moving to a lower technology region will result in a drop in northern wages and in a relatively lower drop in northern and southern prices. Hence, welfare of a workers-consumers in the North increases if the region of destination of the delocation is not relatively technologically too lagged. On the other hand, since delocated firms pay higher wages than locals and that southern consumers have access to cheaper goods, the welfare in the South increases.
I then allow for exogenous vertical technology transfer (VTT) [2] to analyze welfare effects in both the North and the South when relocated firms boost technology of their local suppliers because they are situated closer to them. In presence of VTT, southern wages increase, which leads to less incentives to delocate and to a higher southern demand for final goods. These effects boost labor demand in the North and northern wages increase. The evolution of prices is ambiguous since wages and technology increase. However, the wage effect dominates and welfare of the worker-consumer increases with technology transfer.

Related litterature

First, we enlarge North-South general equilibrium models of trade to study welfare effects of delocation while existing models (e.g Segerstrom and Dinopoulos, 2007; Gustafsson and Segerstrom, 2011) focus on the effects of trade openess or IP protection on welfare. Second, we contribute to the litterature studying the relationship between Foreign Direct Investment, VTT (i.e. vertical technology transfer) under exclusivity and welfare (Lin and Saggi, 2007). In Lin and Saggi (2007), the model is a partial equilibrium one. Using a general equilibrium framework and relaxing the hypothesis of exclusivity, we contrast the previous findings by shedding light on the potential gains from the North resulting from having access to cheaper goods. Morever, technology transfer is welfare-enhancing for both regions since an increase in the technology of the South affects the capacity of production of the North because the

[2] We don't study IPR effects or innovation/imitation incentives. For endogenous technology transfer and IPR questions see Jakobsson and Segerstrom (2013).

production chain may be multi-regions. Third, we contrast the findings of the outsourcing litterature on welfare (see Keuschnigg and Ribi, 2007). We add technology transfer to upstream suppliers and we characterize the results conditioned by the technology level of the destination of delocated firms. We show that without technology transfer, welfare decreases only when the destination is technologically too lagged, and we also show that VTT is welfare increasing in both regions. In this line, it is also close to the litterature in trade-in-tasks ((Grossman and Rossi-Hansberg, 2006, 2008; Baldwin and Robert-Nicoud, 2010). While they also analyze the effects of relocation on wages, they find ambiguous effects in general.[3] By focusing implicitly on low skilled workers-consumers and hence dropping the traditional distinction between low and high skilled workers and by introducing the technological gap between home and host economies, we are able to clearly predict wages and welfare effects of delocation.

The model is reduced to its highest simplicity to study the price and wages effects on consumers-workers. It does not account for the chosen type of production process (see Antras and Chor (2012); Schwarz and Suedekum (2011)) and omits the traditional discussion on transportation costs (see e.g Eicher and Kang (2005)). Transition from one occupation to another is automatic in a full-employment context and is reflected in the increase in labor supply in alternative jobs. However, the model's results provide a potential explanation regarding the mixed evidence obtained by empirical studies about the effects of delocation. As other authors, Feenstra (2010) suggests that the offshoring destination plays a significant role in the home effects of offshoring. Strauss-Kahn (2003) shows that there is a negative effect on the northern labor market only with relocation towards very low wages regions and Harrison and McMillan (2009) show that affiliate employment in low-income countries substitutes for domestic employment and find that lower host wages are associated to lower labor demand in the home country. Moreover, Ebenstein, Harrison, McMillan, and Phillips (2011) shows that offshoring put downward pressure on wages through reallocation of workers. Rama (2003) finds negative short run effects and positive long run effects of relocation on northern wages. Hence, these studies suggests that the technology level of the destination and the time hori-

[3]Except for a special positive case in Grossman and Rossi-Hansberg (2006).

zon of the study (Short/long run are of major importance when we analyze the effects of production relocation. This paper formalizes theoretically these ideas. Finally, as pointed out by Ebenstein, Harrison, McMillan, and Phillips (2011), the limit of the empirical studies is that they are not able to characterize the counterfactual of how wages would have evolved in absence of offshoring. The model overcomes this limit.

The rest of the paper is organized as follows: In Section 2, the basis of the general model are presented. I analyze the effects when there is no delocation in Section 3 and do the same when allowing for delocation in Section 4. I then compare both situations in Section 5 before concluding.

2.2 The Model

We assume there are 2 regions, North and South, respectively denoted N and S. Labor is perfectly mobile within each region but immobile across regions. Its measure in each region is L_r with $r = N, S$. We consider that there is full employment in both regions. The whole economy is made of two sectors. A competitive intermediate good sector and a final good sector where firms in the South compete monopolistically with firms from the North . The intermediate good is taken as the numeraire. It is only produced in the South which is the low technology region. There are N differenciated final goods and each variety needs labor and intermediate goods to be produced. Hence the North can be seen as a high technology region asembling a final good from an intermediate that is produced only in the South.

We consider two types of firms in the final good sector. The northern firm (Type n)that buys the intermediate from the South and asembles it in the North and the delocated firm (Type d) that buys and asembles in the South. Hence, the northern firm uses labor and technology from the North while the delocated firm (infra DLF) uses labor from the South and technology from the North.

2.2.1 Demand

We consider that all individuals have the same utility function across regions and the utility function is featured by Dixit-Stiglitz preferences

$$U = (\sum_{j=1}^{N} c_j^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}} \qquad j = 1, ..., N \tag{2.1}$$

Where c_j is the consumption of a variety j, N is the worlwide number of available differenciated varieties. Among these N varieties N_N varieties are produced in the North and N_D varieties are produced in the South by DLFs. The elasticity of substitution between two varieties is measured by σ. Wages in the North are ω_N and in the South wages in the intermediate good sector ($s = I$) are $\omega_{S,I}$ [4] while the DLF ($s = D$) pays wages $\omega_{S,D}$. Hence, individual demand for a final good variety j in Region r and sector s is the solution of:

$$Max_{c_j} U(c_1, ..., c_N) \tag{2.2}$$

$$s.t. \sum_{j=1}^{N} p_j c_{j,r,s} \leq \omega_{r,s} \tag{2.3}$$

Where p_j is the price of variety j and $\omega_{r,s}$ is the wage in country r and sector s.[5] Optimal demand for variety j, by a consumer in Region r and sector s is given by:

$$c_{j,r,s} = (\frac{p_j}{P_M})^{-\sigma} \frac{\omega_{r,s}}{P_M} \tag{2.4}$$

Where P_M is the price index

$$P_M = (\sum_{j=1}^{N} p_j^{1-\sigma})^{\frac{1}{1-\sigma}} \tag{2.5}$$

and the indirect utility of a consumer in Region r and sector s is given by

$$V_{r,s} = \frac{\omega_{r,s}}{P_M} \tag{2.6}$$

[4] To simplify the notation we use ω_S in place of $\omega_{S,I}$.

[5] Note that in Region N, there is only one sector. Hence we omit the subindex s. Note also that we allow the DLF to pay higher wages than its suppliers ($\omega_{S,d} > \omega_{S,f}$).

2.2.2 Production

Final good production

Each symmetric variety j of the final good is produced with a Cobb-Douglas production function. Each firm uses technology of its type, labor from its Region $L_{r,j}$ and an intermediate good X_j. Hence, a Northern firm ($j = n$) has the following production function

$$y_n = A_N L_{N,n}^{\alpha} X_n^{1-\alpha} \tag{2.7}$$

while the production function of the delocated firm ($j = d$) is given by

$$y_d = A_D L_{S,d}^{\alpha} X_d^{1-\alpha} \tag{2.8}$$

Where α is the labor share and A_D the total factor productivity of the DLF. We assume that the productivity of DLFs is lower than the productivity of Northern firms (i.e. $A_D < A_N$) as suggested by the large literature on technology transfer from home to host country(e.g. Acemoglu and Zilbotti (1999)).

Intermediate good production

The production of each intermediate good requires L units of labor for each unit of the intermediate. Hence the production function is given by

$$X(L_S) = A_S L_{S,I} \tag{2.9}$$

Where A_S is total factor productivity in Region S (with $A_S < A_D$) and $L_{S,I}$ is the total amount of labor hired in the intermediate good sector.

2.3 No Delocation

We begin by analyzing the case in which there is no delocation, that is when the production of the final good comes only from the North. Then, we study the case in which we allow for delocation and finally, we compare both situations.

2.3.1 Final good production

We consider N producers of the final good in the North. Each minimizing its costs to maximize profit

$$min_{L_{N,j},X_j} \quad \omega_N L_{N,j} + X_j \quad s.t. \quad y_j = A_N L_{N,j}^{\alpha} X_j^{1-\alpha} \quad j = 1, ..., N \tag{2.10}$$

Which gives conditional input demand for each firm j

$$L_{N,j} = \frac{1}{A_N}(\frac{1-\alpha}{\alpha})^{\alpha-1}\omega_N^{\alpha-1}y_j \tag{2.11}$$

$$X_j = \frac{1}{A_N}(\frac{1-\alpha}{\alpha})^{\alpha}\omega_N^{\alpha}y_j \tag{2.12}$$

Since each firm produces a symmetric variety subject to homothetic cost function, the price of each variety, p_j, is

$$p_j = \frac{\sigma}{\sigma - 1}a_j \tag{2.13}$$

where unit cost $a_j = \frac{1}{A_N}(1-\alpha)^{\alpha-1}\alpha^{-\alpha}\omega_N^{\alpha}$. From zero profit condition in the final good sector

$$\pi_j = (p_j - a_j)y_j - H\omega_N = 0 \tag{2.14}$$

Where fixed cost is the same across firms and has the form of H workers hired at wage ω_N, we derive the quantity of output for each variety

$$y_j = \frac{H\omega_N}{a_j}(\sigma - 1) \tag{2.15}$$

which is a traditional ratio of fixed on marginal costs.
Equilibrium in the final good market ($c_j = y_j$) gives the equilibrium number of firms in the North

$$N = \frac{E}{\sigma H \omega_N} \tag{2.16}$$

which depends positively on world income E and negatively on the fixed cost. Hence, a higher fixed cost lowers the number of firms and increases production by firm.

2.3.2 Intermediate good production

Each firm in the South produces the intermediate good and faces perfect competition. Demand for intermediate comes from final good producers in the North. Combining (2.12) and (2.15) gives the firm intermediate demand

$$\sum_j X_j = X^* = NH\omega_N(1-\alpha)(\sigma-1) \tag{2.17}$$

Its profit is thus given by

$$\pi_S = X - \omega_S L_{S,I} \tag{2.18}$$

and free entry induces competitive wages

$$\omega_S = A_S \tag{2.19}$$

which is also GDP per capita in the South. Note that the wage bill or total GDP is given by $X = \omega_S L_{S,I} = NH\omega_N(1-\alpha)(\sigma-1)$.

2.3.3 Equilibrium

Since the level of prices (P_M) is already computed, we look a (i) the number of firms or varieties in the final good sector and at (ii) wages in both Region.

(i) Note that combining (2.11), (2.15) and the fixed labor cost requirement yields the labor input per firm

$$L_{N,j} = H(\alpha(\sigma-1)+1) \tag{2.20}$$

combining this with full employment condition $L_N = \sum_{j=1}^{N}(L_{N,j}+H)$ yields the number of firms in the North

$$N = \frac{L_N}{H(\alpha(\sigma-1)+1)} \tag{2.21}$$

Which is the population in the North divided by the number of workers per firm. It depends negatively on (i) the labor share, (ii) the fixed costs and (iii) the elasticity of substitution.

Since the love for variety is inversely reflected in the elasticity of substitution, the number of firms depends positively on the love for variety.
(ii) Wages in the South are competitive

$$\omega_{S,I} = A_S \tag{2.22}$$

while in the North, combining (2.17) and (2.21) gives wages in the North

$$\omega_N = A_S \frac{L_{S,I}}{L_N} \frac{(\alpha(\sigma-1)+1)}{(1-\alpha)(\sigma-1)} \tag{2.23}$$

Wages in the North are expressed in terms of the intermediate good, the numeraire, and can hence be easily transformed into relative wage.[6] However, given our considerations and for the sake of clarity in the following sections we keep this exposition method. We see that wages in the North (i) depend positively on the level of production in the South. A higher level of production in the South means more demand for the final good, higher labor demand in the North and higher wages in the North, (ii) are increasing in the final good love for variety. A higher love for variety increases the number of firms. At given output by firm, there are more spendings in fixed labor cost and labor demand increases, (iii) is increasing in the labor share of the final good production function since a higher labor share increases labor demand and (iv) does not depend on northern technology since the higher labor demand coming from a higher output production is perfectly offset by the lower labor demand per unit of output coming from a higher technology. Note that the wage bill or GDP in the North is $E_N = A_S L_{S,I} \frac{(\alpha(\sigma-1)+1)}{(1-\alpha)(\sigma-1)}$, and in the South $E_S = A_S L_{S,I}$. Hence, whatever the level of σ, when $\alpha \geq 0.5$, that is when the labor share is not too low, the northern region has a higher GDP than the southern region. Moreover, wages in the North are higher than wages in the South for $\frac{L_S}{L_N} > \frac{(1-\alpha)(\sigma-1)}{\alpha(\sigma-1)+1}$, that is the northern population is not too large with respect to the southern population, what we assume from now on. Since the production of the final good requires the intermediate good produced in the South, labor demand in the North depends on labor supply in the South. Labor demand in the North is hence higher

[6]In these settings, any change in population size, labor share, elasticity of substitution is capitalized into wages in the North.

when there are more intermediate goods to be transformed into final goods. That is, when L_S is sufficiently high.

2.4 Delocation

The equilibrium wages in each region just derived supra implies that northern firms have an incentive to move their production plant from the North to the South to benefit from lower wages. On the other hand, DLFs are less productive than northern firms ($A_D < A_N$) which lowers the incentive to delocate. However, since the choice of one single firm affects the overall incentives to delocate, only a part of the firms delocates at equilibrium.
In this model, since each firm was already selling in both regions, there is no market penetration incentive for firms.[7] We can thus study the effect of firms moving only for lower wages advantage.

2.4.1 Final good production

We now have two types of firms in the final good sector. The delocated firm (type d) and the northern firm (type n). DLF minimizes costs to maximize profit

$$min_{L_d,X_d} \;\; \omega_D L_d + X_d \;\; s.t. \;\; y_d = A_D L_d^{\alpha} X_d^{1-\alpha} \tag{2.24}$$

[7]We set no transportation cost. We hence avoid any market size effect. Adding transportation costs would mean, on the one hand, that a northern firm would pay transportation costs when importing the intermediate to the North and also when exporting the final good to te South. On the other hand, a delocated firm would face transportation costs only when exporting the final good to northern consumers. Indeed, since this firm is now located in the South, it does not import anymore the intermediate good produced in the South. As a result, adding transportation costs could limit (resp. favour) the incentives to delocate if the cost of exporting the final good to all northern consumers is higher (resp. lower) than the imports and exports costs for intermediate goods and southern consumers. The results of the model would only change in terms of magnitude with higher or lower delocation depending on the structure of transportation costs but the highlighted mechanisms would stay the same.

Which gives conditional input demand

$$L_d = \frac{1}{A_D}(\frac{1-\alpha}{\alpha})^{\alpha-1}\omega_D^{\alpha-1}y_d \tag{2.25}$$

$$X_d = \frac{1}{A_D}(\frac{1-\alpha}{\alpha})^{\alpha}\omega_D^{\alpha}y_d \tag{2.26}$$

Since we consider firms' price setting under Dixit-Stiglitz preferences in the case of monopolistic competition, optimal price is a constant mark up over marginal costs and does not depend on other firms decisions. Hence, price, profit and optimal quantities of the DLF are given by:

$$p_d = \frac{\sigma}{\sigma-1}a_d \tag{2.27}$$

$$\pi_d = (p_d - a_d)y_d - M\omega_D \tag{2.28}$$

$$y_d = \frac{M\omega_D}{a_d}(\sigma-1) \tag{2.29}$$

Where a_d is the marginal cost equal to $\frac{1}{A_D}(1-\alpha)^{\alpha-1}\alpha^{-\alpha}\omega_D^{\alpha}$. M is the fixed cost faced by the DLF wich is hiring M workers from the South. We allow fixed costs in the South and in the North to be different since it can take more time to settle a business in one region or another, or infrastructure costs may also differ etc.

Price and quantities of each northern firm take the same general expression as in the previous section (resp. 2.13 and 2.15) but wages in the North may have changed. We denote the total number of firms or varieties by N. Where there are N_N northern firms and N_D delocated firms and $N = N_N + N_D$.

Equilibrium in the final good market requires $c_d = y_d$, from (2.29) and world demand derived from (2.4) we find the link between the number of northern and DLF firms

$$N_D = \frac{E}{\sigma M\omega_D} - N_N[\frac{A_N}{A_D}(\frac{\omega_D}{\omega_N})^{\alpha}]^{\sigma-1} \tag{2.30}$$

This suggests that the equilibrium number of DLFs depends (i) positively on World GDP, (ii) negatively on the fixed cost and the wage level of the DLF, (iii) negatively on the number of northern firms and (iv) negatively on the cost advantage of the northern firm on the DLF respresented by the term between brakets.

2.4.2 Intermediate good production

Demand of intermediate comes from DLFs and northern firms. Each DLF demand is given by

$$X_d = M\omega_D(1-\alpha)(\sigma-1) \tag{2.31}$$

and each northern firm demand is

$$X_n = H\omega_N(1-\alpha)(\sigma-1) \tag{2.32}$$

Which makes total demand ($X = N_N X_i + N_D X_d$)

$$X = (H\omega_N N_N + M\omega_D N_D)(1-\alpha)(\sigma-1) \tag{2.33}$$

and free entry induces competitive wages $\omega_S = A_S$.

2.4.3 Labor market

In the South, there is full employment but the market is dual. Workers in the intermediate good sector are paid the competitive wage while the DLF fixes efficiency wages à la Shapiro and Stiglitz (1985). That is, they attract workers and avoid shirking. This is in line with the literature in which Multinationals pay higher wages than locals. [8] Hence, the DLF fixes its wages on the wages in the intermediate sector. Under these settings, Shapiro and Stiglitz (1985) showed that the firm pays a constant premium over the competitive wages. We denote it c and we have $\omega_D = \omega_{S,I} + c$. We hence have an excess labor supply for the DLFs and applicants who are not hired work in the intermediate good sector at the competitve wage. We denote by $L_{S,D}$ the total number of workers employed by DLFs and by $L_{S,I}$ the total number of workers in the intermediate good sector. Full employment condition ensures $L_S = L_{S,I} + L_{S,D}$. Given this, after delocation, the wage bill in the South increases since there is full employment and the only possible movement of labor takes place from the intermediate

[8]See for example Aitken, Harrison, and Lipsey (1997) and Brown, Deardorff, and Stern (2003)

good sector to the final good sector that pays higher wages.
In the North, since firms are moving from the North to the South, we expect relocation of firms to lower labor demand and wages in the North. Moreover, a lower intermediate production from the South (since some southern workers work now for the DLF) makes less intermediate available what lowers total output in the North. This lowers again labor demand and wages. Conversely, higher wages in the South should boost final good demand, what increases labor demand and wages in the North. Hence, these effects on wages in the North go the opposite way. This makes the net effect ambiguous.

2.4.4 Existence and uniqueness of the equilibrium

Variables of major importance here are (i) wages in the North ω_N which is also GDP per capita since there is full employment and free entry conditions greeding zero profit, (ii) the number of firms in the North N_N, to analyse whether firm realocation affect the mass and structure of the home country economy and (iii) the number of southern workers in DLFs $L_{S,D}$, which will give the number of workers in the South that benefit from higher wages paid by the DLFs.
Combining (2.11) and (2.15) gives the number of firms in the North: $N_N = \frac{L_N}{(\alpha(\sigma-1)+1)H}$ which depends only on fixed parameters. Similarily the number of workers $L_{S,D}$ is proportional to the number of DLFs, $L_{S,D} = N_D(\alpha(\sigma-1)+1)M$. Hence, we focus here on 2 equations that describe the relationship existing between wages in the North and the number of DLFs. Since all other variables are proportional to these variables, these equations describe the equilibrium.
Rewriting zero profit condition in the intermediate sector combining $L_{S,D} = N_D(\alpha(\sigma-1)+1)M$ with (2.33) and the full employment condition in the South yields what we now call the Intermediate sector equation

$$N_D = Max[\frac{\omega_{S,I}L_S - H\omega_N N_N(1-\alpha)(\sigma-1)}{M\omega_D(1-\alpha)(\sigma-1) + M\omega_{S,I}(\alpha(\sigma-1)+1)}; 0] \tag{2.34}$$

and rewriting the final good market equilibrium using $L_{S,D} = N_D(\alpha(\sigma-1)+1)M$ yields what we now call the final good market equation

$$N_D = Max[\frac{\omega_N L_N + \omega_{S,I} L_S - \sigma M \omega_D N_N [\frac{A_N}{A_D}(\frac{\omega_D}{\omega_N})^{\alpha}]^{\sigma-1}}{M\omega_D(1-\alpha)(\sigma-1) + M\omega_{S,I}(\alpha(\sigma-1)+1)}; 0] \tag{2.35}$$

Intermediate sector equation (2.34) is decreasing in the northern wage ω_N and its horizontal intercept is $\omega_N = A_S \frac{L_S}{L_N} \frac{\alpha(\sigma-1)+1}{(1-\alpha)(\sigma-1)} > 0$. Since final good market equation (2.35) is increasing in the northern wage ω_N, a sufficient condition that ensures the existence and uniqueness of the equilibrium with a positive number of DLF is for the Market equilibrium condition evaluated at $\omega_N = A_S \frac{L_S}{L_N} \frac{\alpha(\sigma-1)+1}{(1-\alpha)(\sigma-1)}$ to be positive. Market equilibrium is positive if

$$\omega_N L_N + \omega_{S,I} L_S \geq \sigma M \omega_D N_N [\frac{A_N}{A_D}(\frac{\omega_D}{\omega_N})^{\alpha}]^{\sigma-1} \tag{2.36}$$

which is the sufficient condition for the existence and uniqueness of the equilibrium.[9] When the world demand in the no delocation case, LHS of inequality (2.36), is larger, there is more room for final good firms. Moreover, firms coexist if the DLF has costs which are sufficiently low and if firms do not differ to much in terms of costs, RHS of inequality (2.36). In other words, we have coexistence of both types of firms when (i) world demand is sufficiently high, (ii) costs are sufficiently low and (iii) when costs differences between DLF and northern firms are not too high.

Hence solving (2.34) and (2.35) yields the equilibrium northern wages and the number of DLFs, respectively

$$\omega_N = (c + A_S)[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{\alpha(\sigma-1)+1}} \tag{2.37}$$

$$N_D = \frac{A_S L_S - (c + A_S)[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{\alpha(\sigma-1)+1}} \frac{(1-\alpha)(\sigma-1)}{\alpha(\sigma-1)+1} L_N}{M(A_S + c)(1-\alpha)(\sigma-1) + M A_S(\alpha(\sigma-1)+1)} \tag{2.38}$$

2.5 Direct effects of Delocation

In this section we assess the effects of delocation on the North. Beginning with wages, we then move to purchasing power and welfare effects of delocation.

[9] Where ω_N, $\omega_{S,I}$ are described by equations (2.23)and (2.22), and $N_N = \frac{L_N}{(\alpha(\sigma-1)+1)H}$ and $\omega_D = A_S + c$.

Proposition 1: When firms relocate from the North to the South, wages in the North unambiguously decrease.

Proof: See Appendix A.1

Wages in the North unambiguously decrease when firms move to the South. In the intermediate sector equation (2.34), when a firm moves to the South, demand for intermediate goods from the North decreases, which yields to less output produced by the northern firms and a decrease in wages. Conversely, in the final good market equation (2.35), when firms move to the South they hire labor from the South and since they pay higher wages, South becomes richer and demand for final goods increases which tends to boost labor demand in the North. However, the former effect dominates the latter and wages in the North unambiguously decrease. When wages in the North are lower than their equilibrium value, the cost advantage of a DLF over a northern firm is low and DLFs have an incentive to relocate their plant in the North. This increases labor demand in the North and so do wages.

Proposition 2: For the sufficient conditions c and x[10] not too high and σ not too low, when firms relocate from the North to the South, welfare in the North (i) is increasing in the southern technology (ii) increases when the technology gap G is not too high, i.e when $G > \underline{G}$.

Proof: See Appendix A.2

From proposition (1), wages in the North decrease when firms relocate to the South. In terms of prices, since (i) delocation decreases northern wages and (ii) wages in the South are lower than in the North, then the unit cost of producing the final good drops. Moreover, there are

[10]x is the cost advantage of the northern firm $[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{\alpha(\sigma-1)+1}}$.

more varieties available. These effects go in the same way and the price index unambiguously decreases.

Since wages and prices in the North decrease, the effect of delocation on northern welfare of workers-consumers is not straightforward. Let denote R_u, the ratio of utilities in the North prior and post delocation

$$R_u = \frac{\frac{\omega_{N,D}}{\omega_N}}{\frac{P_{M,D}}{P_M}} \tag{2.39}$$

Where the subscript D describes the situation with delocation. This ratio can also be interpreted as the variation in purchasing power. It is increasing in southern technology A_S (See Appendix A.2). Consider the level of southern technology $\underline{A_S}$ such that utility does not change after delocation, i.e. $R_u = 1$. This mean that even if wages unconditionnaly drop following delocation, utility or purchasing power increase if delocation occurs in a country where technology is not too lagged that is where $A_S > \underline{A_S}$. In other words, welfare in the North increases when the technology gap G between North and South is not too high, i.e. when $G < \underline{G}$[11]. In figure 2.1, purchasing power or welfare in the North is plotted as a function of the level of southern technology. Two effects are at work. On the one hand, the access to cheaper goods and a higher number of varieties under delocation increase utility and redirect expenses toward low prices goods produced in the South. On the other hand, delocation decreases northern wages. In other words, consumers are better off and workers are worse off. When firms delocate to very low wages regions, the latter effect dominates the former. That is, the decrease in prices and the additional number of varities does not compensate the decrease in wages. Conversely when firms move to relatively higher wages regions the decrease in northern wages is more than compensated by the decrease in prices and the larger number of varieties. The intuition is the following. After a decrease in wages, prices drop but they drop less than wages. Hence, when a firm moves to a relatively lower wages region (i) wages in the North drop relatively more (ii) prices in the North and in the South drop less than the decrease in wages. These effects lower the purchasing power of workers-consumers

[11] where the technology gap $\underline{G}$ is given by $A_N - \underline{A_S}$ and $G = A_N - A_S$.

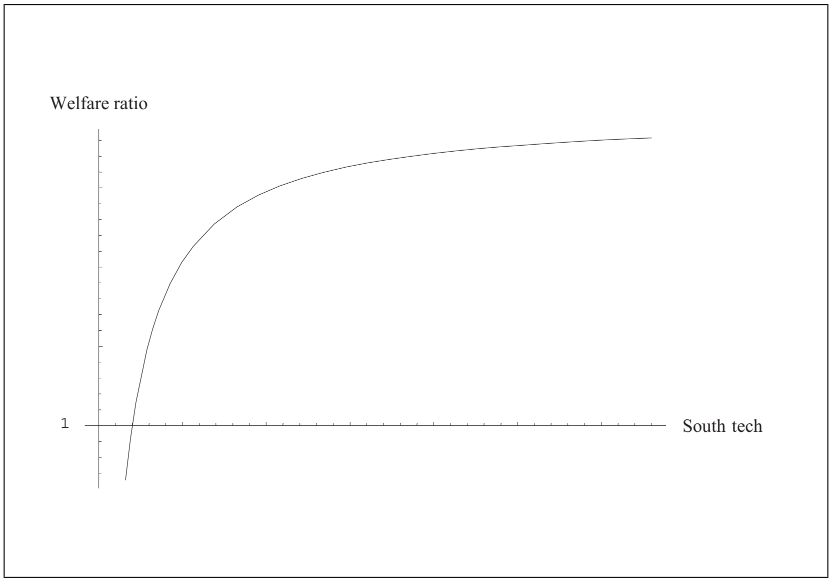


Figure 2.1: Welfare ratio and southern technology

in the North when firms relocate to relatively lower wages regions. [12]

This analysis supports the skeptical view that delocation reduces the wages in the North and hence hurts workers but it also shows that following delocation, consumers have access to more varieties and to low prices goods. This may increase welfare of workers-consumers in the North. Moreover, when firms delocate to lower wages regions, the welfare effect is relatively more detrimental to the home economy. This result is in line with lots of empirical studies (Strauss-Kahn (2003), Rama (2003), Feenstra (2010)).

We have analyzed the direct effects of delocation. Nevertheless, once delocation has occured, it may have various indirect effects on the host economy. Among others, there could be a

[12] Note that the love for variety is not determinant for the results. It plays a limited role since consumers already benefit from trade when there is no delocation possibility. These results hence do not depend on the CES form of the utility function. The gain in utility would be still valid but in a lower extend with a CES augmented or a quadratic utility function. With the former, if love for variety is null, utility gains come only from lower prices which would reduce the number of delocated firms at the equilibrium w.r.t the CES. With the former, consumers would spread more equally their consumptions between varieties leading to less delocation. As a result, the same mechanisms would occur with these other preferences - but their magnitude would be lower - and we would still have utility gains stemming from consuming lower priced goods.

technology transfer from the DLF to its local suppliers. We analyze this indirect effect in the next section.

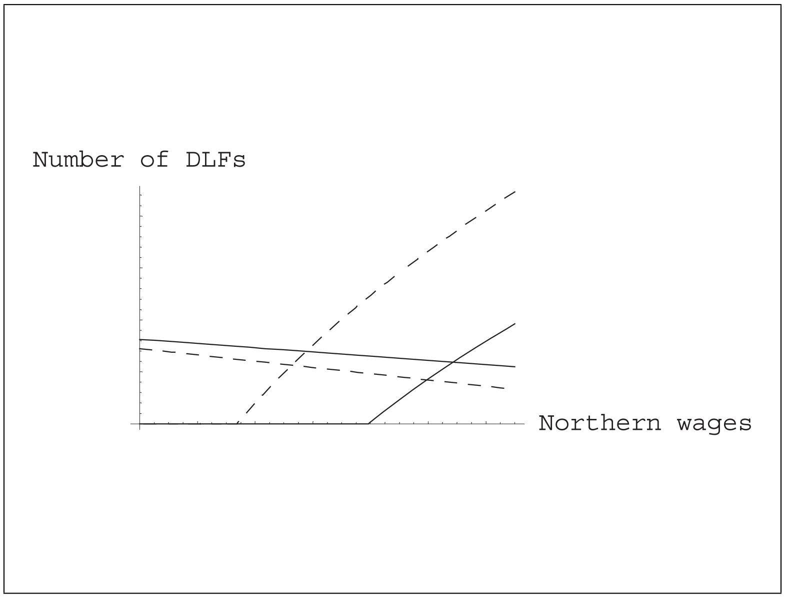
2.6 Indirect effects of Delocation

As emphasized previously, the domestic effects of delocation are expected to be different depending on the destination of DLF. Moreover, indirect effects of delocation such as technology transfer to upstream suppliers may also affect the effects of delocation. In other words, when firms delocates, they affect their new environment and these changes lead to indirect effects. This section studies the effects of a technolgy transfer from the DLF to its local suppliers. We model it as an exogenous increase in the southern technology A_S (As in Lin and Saggi (2005)). That is, we study how markets, delocated firms, wages and welfare adjust when firms start transfering technology when they have already delocated.

Proposition 3: When delocated firms start transfering technology to the South, wages in the North unambiguously increase.

Proof: See Appendix A.3

This effect is illustrated in figure 2.2. On the one hand, the effect of a better southern technology on the Intermediate sector equation (2.34) results in a higher horizontal intercept. That is, when there is no delocation, there are more intermediate goods produced which increases labor demand and wages in the North. The effect on the vertical intercept is similar. For any value of the northern wage, there is room for more delocation since there are more intermediate goods produced. Finally, the slope is flatter since when a DLF leaves the South, the increase in intermediate goods demand is higher than prior to delocation because of the technology transfer. Hence, for given wages in the North, there is room for more delocation.



- - - No Transfer — Transfer

Figure 2.2: Effect of a technology transfer

This supposes that once the transfer has taken place, the technology stays, even if the DLF moves back to the North. On the other hand, the final good market equation (2.35) moves downwards and is flatter as A_S increases. That is, firms have less incentives to delocate since wages in the South are higher. Hence, the increase in the southern technology following a transfer has a positive impact on northern wages. Moreover, the number of DLFs increases since the effect of a higher capacity of production in the intermediate sector which yields to more place for delocation always dominates the effect of a lower incentive to delocate. The increase in the number of DLFs hence induces a higher overall number of workers for DLFs. So, under vertical technology transfer (VTT) the South is richer, demand for final good increases which in turn boosts labor demand and wages in the North and final good demand in the South. Hence, VTT leads to higher wages in both the North and the South and to more varieties.

Hence, compared to the situation in which there is no delocation, when firms move from the North to the South and transfer technology to their suppliers, wages in the South are unambiguously higher and if the transfer is large enough wages in the North increase.We now move to welfare effects of the transfer.

Proposition 4: When delocated firms start transfering technology to the South, welfare in the North unambiguously increase.

Proof: See Appendix A.5

In terms of prices, when DLFs start transfering their technologies to the South, from proposition (4) both wages in the North and in the South increase, this results in an increase in the price of the varieties sold in the two regions. At the same time, the number of varieties increases. Hence, the effect of the transfer on the price index is unsigned. Therefore, the effect of a technology transfer on welfare is not straightforward since wages increase and the sign of the variation in the price index is ambiguous. However, the positive wages effect always dominates and welfare in the North increases with the transfer as depicted in Figure 2.3.

Hence, from the previous propositions, we can describe the effects of delocation when it involves technology transfer. When firms move to the South, wages in the North and prices drop. When the DLF starts transfering its technology, it increases productivity and wages in the South. This induces a higher demand for final goods by southern consumers which leads to an increase in wages in the North while the price index is still dependent on the lower unit cost of production in the South. There are two effects at work (i) delocation decreases prices and northern wages and (ii) technology transfer increases southern productivity and southern demand for final goods. As a result, if northern wages increase only for a sufficient technology transfer, welfare in the North increases if the host country has a sufficient initial level of technology or if it acquires a higher technology through the transfer. Note also that the higher the transfer, the higher the relative welfare gain. Hence, moving to a lower wages region and transfering more technology will lead to a relatively higher increase in welfare

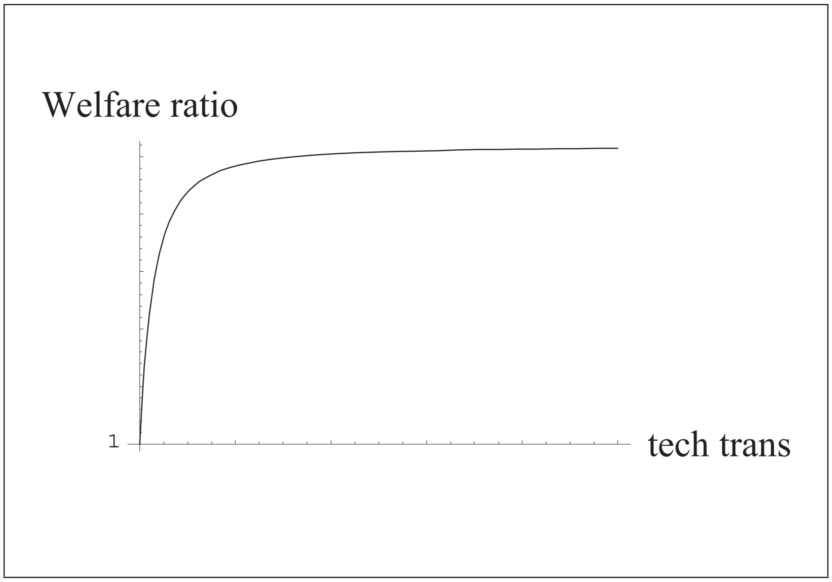


Figure 2.3: Welfare effect of a technology transfer

in the North. Moreover, northern consumers consume more final good produced from the South relative to those produced in the North since their price is lower. This increases their consumption and they consume more varities which increases welfare. When the transfer is larger, the ratio of northern to southern prices decreases and consumers spread more equally their consumption over the goods. That is, they consume relatively more northern goods. Hence, contrarily to the skeptical view on delocation, this analysis shows that delocation to low wages regions may increase wages and purchasing power and welfare in the North.

2.7 Conclusion

The model presented in this paper contrast the general skepticism on delocation of northern activities to the South. When there is no vertical technology transfer from the North to the South, northern wages unambiguously decrease. Indeed when firms move to the South, demand for northern goods shrinks because prices of southern goods are lower. This lowers wages in the North. Still, welfare in the North may increase when consumers redirect their expenses toward cheaper goods available from the South after delocation occured.

When transfer occurs, I have shown that northern wages, purchase power and welfare may increase. The mechanism is quite simple. A delocated firm transfers technology to its suppliers what increases wages in the southern economy and boosts southern demand for final goods, including northern ones. This increase in demand as a positive impact on northern wages. Moreover, since southern goods are still cheaper the purchase power increases. So does welfare. But with transfer, consumers spread more equally their consumption across northern and southern goods.

This enlarges the classical view that the level of technology and the absorption capacity of the host country affect the effect of delocation on the host but also on the home economy. This model presents an additional explanation of why empirical studies produce different results about the effect of delocation on home wages, that is, why delocation to lower wages region is relatively more detrimental for the home economy in terms of welfare and why long run effects may be different than short run effects.

Chapter 3

Income distribution, multi-quality firms and patterns of trade

Abstract[1]

We provide a North-South Schumpeterian growth model endogenously generating demand-driven patterns of vertical intra-industrial trade. More precisely, we build a model featuring non-homothetic preferences and income differences, and show that such conditions guarantee the endogenous emergence of multi-location, multi-quality firms. The existence of such firms and wealth heterogeneity among consumers both across and within countries then generate and shape rich patterns of *intra-industrial* vertical trade and FDI, with the extent of income disparities also conditioning the incentives to invest in R&D of both incumbents and challengers, and by extension the long-run growth rate. We then investigate the impact of within regions inequalities and trade integration on the endogenous wage gap across regions, on the length of the quality-life cycle and on long-run growth. We particularly find that a larger income gap *within* regions contributes to lowering growth and increasing inter-regional inequalities. We also find that trade integration boosts long run growth but increases inter-regional inequalities.

[1]This chapter was cowritten with Hélène Latzer

3.1 Introduction

In 2004, the French car manufacturer Renault started to manufacture the "Logan" car in its Romanian branch Dacia. The Logan was designed for the lower budget consumers living in Eastern European countries, which were integrating the European Union in the same year: it only offered basic technologies having already been used in some former Renault models (Clio), and was sold at a much lower price than the other cars present on the same market segment. However, even though this car was explicitly targeting Eastern European demand and was produced in that market, it met a rapid and unexpected success in Western Europe. By 2006, the car was exported back towards the French, Italian, Spanish and German markets. This example illustrates: (i) how brand diversification can give a second life to features having moved down the quality ladder, and how this extended profitability might have an impact on the R&D investment of multi-quality, multinational firms; (ii) the existing relationship between the local demand structure in growing and non-growing economies and patterns of trade in quality.

Models of North-South trade studying the growth implications of innovation, imitation and the resulting patterns of trade have already been provided (Grossman and Helpmann, 1991; Dinopoulos and Segerstrom, 2010).The main focus of this literature has been so far to identify the impact of trade openness and intellectual property rights on northern innovation and southern imitation patterns, and on the resulting product life-cycle and long-run growth. However, existing models usually focus on supply-driven determinants of R&D investment and trade patterns, leaving out any impact of the aggregate demand structure; also, they feature the traditional Schumpeterian creative destruction effect ("Arrow effect"), with only the highest quality being consumed and traded in each sector (inter-industrial trade patterns). Those two key features make the existing models unable to account for and investigate the growth and wealth distribution implications of *demand-driven, intra-industrial* vertical trade patterns such as the Renault-Dacia one, where income inequalities across and within regions result in the existence of multi-quality firms as well as in more than one quality of the same good being consumed and traded at equilibrium. The present paper builds on these considerations, and aims at providing a general equilibrium dynamic framework featuring the previously identified characteristics.

We develop a North-South Schumpeterian model of endogenous growth displaying non-homothetic preferences as well as both within- and across- countries inequality. Firms invest in R&D so as to invent higher qualities of existing products, and as in Latzer (2013), the presence of unit consumption and inequality among consumers ensures both the consumption of more than one quality at the equilibrium *and* innovation by incumbents, allowing for the endogenous emergence of multi-quality firms. Indeed, differences in the willingness to pay among heterogenous consumers make it profitable for firms to offer several distinct price/quality bundles, so as to efficiently price-discriminate across different income groups. The North is assumed to be the only region where innovation and the production of the highest available quality can take place; on the other hand, we identify and focus on parametric conditions ensuring that the production of the second-best quality locates itself in the South. Under such conditions, we then demonstrate that the model features rich patterns of *intra-industrial* vertical trade and FDI, with disparities in purchasing power within *and* across regions ensuring the co-existence of mono-quality, mono-location firms and multi-quality, multi-location firms. More precisely, we focus on the parametric cases for which the new quality leader chooses to capture only the upper part of both the northern and southern markets, abandoning the poor consumers to the former leader. In this case, quality leaders having innovated only once produce their single quality in their northern home region and export part of their production towards the southern foreign market (mono-product local firms), while former leaders having been leapfrogged and now selling the second-best quality engage in FDI to serve locally the southern host market and export back part of their production to their northern home region (mono-product delocalized firms). On the other hand, successful incumbents having at their disposal two successive qualities then locate the production of the highest quality in the North, and optimally choose to locate the production of their lowest quality in the South, where demand for this quality is relatively high and where labor costs are lower (multi-quality, multi-localization firm). Beyond those vertical trade patterns, the extent of income inequality also influences the incentives to invest in R&D of both incumbents and challengers, and hence conditions the long-run growth rate and inequalities across regions.

We then investigate the impact of trade integration as well as intra-regional redistribution policies on the endogenous wage gap (inter-regional inequalities) and on the innovation rate per type of firms (i.e. challengers or incumbents). In the absence of closed-from analytical solutions, we proceed to simulations so as to determine the comparative statics following a shock on the transport costs τ, the wealth gap d or the degree of wealth concentration β. We find in particular that long-run growth unambiguously decreases following an increase in the intra-country wealth gap: such a result is at odds with what had been exemplified so far in closed-country growth frameworks (Foellmi and Zweimuller, 2006; Latzer, 2013), and points to the necessity of taking into account trade patterns when analyzing the impact of redistribution policies. Another salient result pertains to the long-run growth impact of trade liberalization, which is found to be positive in our model: such an impact had not been exemplified so far by existing North-South Schumpeterian models (Borota, 2012).

Our main contribution to the literature consists in providing a Schumpeterian growth model where demand-based determinants both generate and shape patterns of intra-industrial vertical trade, hence being able to account for so far overlooked inequality-driven trade patterns such as the Renault-Dacia one. We are then also able to emphasize so far overlooked impacts of within-country redistribution and trade liberalization policies.

Relation to literature.

Our work is related to several strands of literature. Recent contributions in the international trade literature have investigated the specific role and importance of multi-product firms (Bernard, Redding, and Schott, 2010), especially considering the influence of trade patterns on their portfolio composition and resulting R&D investments (Eckel and Neary, 2010; Dhingra, 2013). However, our model is the first one to investigate this question in a *vertical differentiation* quality-ladder framework, where the impact of the aggregate demand structure on a firm's portfolio does not operate through cannibalization effects but rather through price discrimination opportunities (Mussa and Rosen, 1978). Another recent strand of literature has been exemplifying the existence and importance of demand-driven patterns of vertical intra-industrial trade and FDI (Fajgelbaum, Grossman, and Helpman, 2011; Grossman, Helpman, and Fajgelbaum, 2012). However, the models provided so far have been developed in a static framework, leaving the modeling of the R&D investment and the subsequent impact of demand structure on the design of new qualities out of the model's reach: our model on the other hand explicitly accounts for innovation dynamics. Finally, dynamic North-South Schumpeterian models have been investigating the long-run growth impact of vertical trade (Grossman and Helpmann, 1991; Segerstrom and Dinopoulos, 2006; Dinopoulos and Segerstrom, 2010); however, as already mentioned above, those models have so far only taken into account inter-industry trade (*product* life cycle). Indeed, the Arrow effect traditionally present in quality-ladder models leaves room for the consumption of only the highest quality within each sector, whose production either in the North or the South generates supply-based inter-industrial patterns of trade. Our model, on the other hand, provides demand-driven, vertical intra-industrial trade patterns (*quality* life cycle). Finally, while Borota (2012) offered in a recent contribution a dynamic North-South model accounting for empirically identified patterns of intra-industrial trade, the determinants of regional quality specialization as well as the resulting growth and trade patterns are solely driven by supply characteristics in her model.

The rest of the paper is organized as follows. Section 2 presents the model, while Section 3 derives equilibrium conditions and characteristics. Section 4 then investigates the impact of a redistribution shock on relative wages, long-run growth and welfare, while Section 5 sheds light on the distribution distortions arising from trade openness.

3.2 The model

The model uses the framework developed by Latzer (2013), but assumes the existence of two regions (North and South), and includes both intra- and inter-country inequalities.

3.2.1 Consumers

Wealth distribution across the world

Across the globe, we model a fixed number L of consumers that live infinitely and inelastically supply one unit of labor each period. There are two regions, respectively denoted as North and South ($r = N, S$), with labor being immobile across regions. All consumers have the same preferences, but are assumed to differ in terms of income. More precisely, the world population is heterogenous in terms of (1) asset ownership and (2) labor income.

(1) Regarding asset ownership, the world population is split into two groups: the poor (P) and the rich (R). The share of "poor" consumers within the world population is denoted by β. The ratio of asset endowments $\omega_P(t)$ of a poor consumer *relative* to the average per-capita amount of assets is denoted by d: we have $d = \frac{\omega_P(t)}{\Omega(t)/L}$, with $\Omega(t)$ being the aggregate amount of assets. Given d, the assets owned by a rich consumer can be computed as $\omega_R(t) = \frac{1-\beta d}{1-\beta}\frac{\Omega(t)}{L}$. Hence, the extent of inequality in terms of asset ownership is fully described by the two parameters β and d. Finally, we assume that a fraction ξ of the poor population and a fraction σ of the rich population live in the North.

(2) Regarding labor income, we restrict ourselves to parametric cases where wages in the South $w_S(t)$ are endogenously lower than wages in the North, which are equal to the numeraire (see infra $w_N = 1$). That is $w_S(t) < w_N(t) = 1$. From then on, we will hence consider the southern wage as the *relative* wage between the two regions, and simply label it $w(t)$. Note that this relative wage can also serve as a measure of the wage gap between the two regions (the lower $w(t)$, the wider the gap).

Heterogeneity in wages entails income inequalities *across* regions, while the heterogeneity in asset endowments induces income inequalities *within* regions. We can hence distinguish four groups of consumers in the world: the rich living in the North (NR), the rich living in the South (SR), the poor living in the North (NP), and finally the poor living in the South (SP).

The respective size of those different groups can be inferred from the previously introduced parameters describing income distribution across the world:

$$L_{NR} = \sigma(1-\beta)L, \quad L_{NP} = \xi\beta L, \quad L_{SR} = (1-\sigma)(1-\beta)L, \quad L_{SP} = (1-\xi)\beta L$$

We have the following expressions for the four possible levels of income:

$$y_{NR}(t) = 1 + r(t)\omega_R(t) \tag{3.0}$$

$$y_{NP}(t) = 1 + r(t)\omega_P(t) \tag{3.1}$$

$$y_{SR}(t) = w(t) + r(t)\omega_R(t) \tag{3.2}$$

$$y_{SP}(t) = w(t) + r(t)\omega_P(t) \tag{3.3}$$

with $r(t)$ being the interest rate.

Preferences

Current income is spent for the consumption of two types of final goods: a homogenous commodity and a continuum of differentiated goods.

The homogenous good is produced under perfect competition with labor alone, requires a unit labor input and is nontradable across regions. We choose the northern standardized good as the numeraire, and hence have as stated above $w_N(t) = 1$.

The other group of products, indexed by $s \in [0, 1]$, is subject to quality innovation over time. At any date t, we assume that a sequence of qualities $q_j(s,t)$, $j = 0, -1, -2, ...$ exist and can be produced within each industry s, with $q_0(s,t)$ being the best quality, $q_{-1}(s,t)$ the second-best, etc. Two successive qualities differ by a fixed factor $k > 1$: $q_j(s,t) = kq_{j-1}(s,t)$. By assumption, **consumers value only one unit of each differentiated good**. As in Zweimuller and Brunner (2005), this unit consumption feature is the key assumption guaranteeing the non-homotheticity of the preference structure in this model. Indeed, for each industry s at each period t, an individual belonging to group i living in region r then chooses to consume the quality level $q_j(s,t)$ that offers him the highest utility, considering its price $p_r(s,t,q_j(s,t))$. We denote this quality $q_{rij}(s,t)$, and the index of consumed qualities over industries $Q_{ri}(t) = \int_0^1 q_{rij}(s,t)ds$. He then spends the rest of his income over the consumption of $c_{ri}(t)$ units of the locally produced homogenous good.

Using the unit consumption property, the log-linear instantaneous utility $u_{ri}(t)$ of a type i consumer living in region r can hence be expressed the following way:

$$u_{ri}(t) = \ln c_{ri}(t) + \ln Q_{ri}(t) = \ln\left(y_{ri}(t) - P_{ri}(t, Q_{ri}(t))\right) + \ln Q_{ri}(t) \tag{3.4}$$

with $P_{ri}(t, Q_{ri}(t)) = \int_0^1 p(s,t,q_{rij}(s,t))ds$ being the price index associated to the quality good consumption index $Q_{ri}(t)$. Please note that for the sake of notation simplicity, we will from now on refer to this price index as $P_{ri}(t)$, and to the price being charged for quality j in sector s in country r as $p_j(r,s,t)$.

At time τ, the intertemporal decision problem of a type i consumer living in region r is to maximize:

$$\int_\tau^\infty \left(\ln c_{ri}(t) + \ln Q_{ri}(t)\right) e^{-\rho(t-\tau)}dt$$
$$\text{s.t.} \qquad \omega_i(\tau) + \int_\tau^\infty w_r e^{-r(t)(t-\tau)}dt \geq \int_\tau^\infty w_r c_{ri}(t)e^{-r(t)(t-\tau)}dt + \int_\tau^\infty P_{ri}(t)e^{-r(t)(t-\tau)}dt$$

with ρ being the rate of time preference. Given an expected time path for both the interest rate $r(t)$ and the relationship between quality and price indices, it is then possible to determine the optimal time path of $c_{ri}(t)$ (i.e. the consumption devoted to the standardized commodity) and of $Q_{ri}(t)$ (i.e. the chosen quality for each quality-differentiated good) for a consumer of type i living in region r.

Separability of utility (both over time and across goods) guarantees that for any given foreseen time path $P_{ri}(t)$ of expenditures devoted to the continuum of quality goods that does not exhaust life-time resources, the optimal path of consumption expenditures on the homogenous good has to fulfill the standard first-order condition of such a maximization problem:

$$\frac{\dot{c}_{ri}(t)}{c_{ri}(t)} = r(t) - \rho \tag{3.3}$$

The optimal time path of $Q_{ri}(t)$, on the other hand, cannot be characterized by a differential equation, since the quality choices are discrete. It is possible to notice however that within each industry s, the choice of the quality $q_{rij}(s,t)$ being consumed by a type i individual living in region r depends on the pricing decisions $p(s,t,q_{rij}(s,t))$ made by profit-maximizing firms. We hence set aside the discrete quality choices on the part of consumers until having defined the market and price structure for each of the quality sectors.

The focus of this article is on the balanced growth path (BGP) properties of such a model, along which all variables remain constant or grow at a constant rate. Even though the equilibrium as well as the BGP will only be formally defined in section 3.3, from now on we will omit the functional dependance of the different variables on time, so as to simplify notations. Also, we will immediately focus on "multi-quality, multi-location firms" equilibria, i.e. balanced growth paths in which (i) incumbents invest a positive amount in R&D, and (ii) former producers survive in the case the new leader detains only monopoly rights on the highest quality. We take the existence of such equilibria for granted in the rest of this section, but will clearly discuss the parameter conditions guaranteeing their existence and uniqueness in section 3.3.

3.2.2 Producers

The market for quality goods is non-competitive. Labor is the only input, with constant unit labor requirement $a < 1$.[2] We assume that firms who own the blueprint for a given quality in a given sector also have the capacity to costlessly adapt the design of the product to each of the market they intend serving, so as to make it impossible for a third party to resell it on another market; in other words, we preclude the possibility of international arbitrage.[3] The

[2]Given the model assumes unit consumption of the quality goods, a necessarily has to be inferior to 1.

[3]International arbitrage (or carry-along trade) designates the practice of exploiting differences in the pricing of the same good on different markets. An arbitrageur can then purchase the good cheaply on the market where the price is the lowest, ship it to the high-price market, and re-sell it with profits. As Follmi, Hepenstrick, and Zweimuller (2011) demonstrate, such arbitrage opportunities significantly impact patterns

quality goods being characterized by unit consumption and fixed quality increments, firms use prices as strategic variables. Firms know the shares of groups P and R in the world population, the respective incomes y_{rR} and y_{rP} as well as the preferences of the consumers within each region r, but *cannot distinguish individuals by income*. Also, as it will be further commented below, firms within each sector only consider their strategic interactions with other firms of the same sector, and do not internalize the impact of their pricing decisions on consumption allocation across sectors, aggregate wealth Ω, relative wages w and aggregate R&D efforts.

Market structure and sector-specific pricing strategies

The detailed demonstrations regarding the market structure and pricing can be found in Latzer (2013). We will here only reproduce the main propositions and intuitions, adapting them to an open economy framework.

First, in order to comment the strategic decisions operated by firms within a given industry, it is necessary to define the "threshold" price $p^T_{\{j-m,j\}}(i,r,s)$ for which a consumer belonging to group i living in region r is indifferent between quality j and quality $j-m$ in industry s, given the price $p_{j-m}(r,s)$ charged for quality $j-m$ in country r. Determining such a threshold price amounts to solving the following equality:

$$\ln(q_j(s)) - \ln(q_{j-m}(s)) = \lambda_{ri}[p^T_{\{j-m,j\}}(i,r,s) - p_{j-m}(r,s)] \qquad (3.3)$$

The left-hand side of equality (3.2.2) is the utility gain when consuming quality $q_j(s)$ rather than quality $q_{j-m}(s)$; the right-hand side on the other hand captures the costs associated to choosing $q_j(s)$ over $q_{j-m}(s)$, expressed as the price difference $p^T_{\{j-m,j\}}(i,r,s) - p_{j-m}(r,s)$ times the marginal utility of income λ_{ri} of a consumer belonging to group i living in country r. It is important to notice that while λ_{ri} depends on the overall price index P_{ri}, firms within a particular sector take it as given in their decision-making. Indeed, because of the existence

of trade, and more precisely account for "export zeros" between rich and poor countries; however, for the sake of simplicity we abstract from such considerations in our benchmark model.

of a *continuum* of quality good industries, firms within a given sector are "small in the big, but big in the small" (Neary, 2009): even though they resort to strategic pricing within their own industry, they do not take into account the impact of their pricing decisions on economy-wide variables.[4] Considering the fact that $q_j(s) = k^m q_{j-m}(s)$ and defining $\mu_{ri} = \frac{1}{\lambda_{ri}}$ as the willingness to pay of a consumer belonging to group i living in country r, solving for $p^T_{\{j-m,j\}}(i,r,s)$ in the above equality yields:

$$p^T_{\{j-m,j\}}(i,r,s) = \mu_{ri} \ln k^m + p_{j-m}(r,s) \tag{3.3}$$

The price $p^T_{\{j-m,j\}}(i,r,s)$ is the maximum price that the firm selling the quality j in industry s can charge to a type i consumer living in country r in order to have a positive market share, when competing against the firm selling the quality $j-m$. As one can see, this threshold price positively depends on the willingness to pay of type i consumers $\mu_{ri} = \frac{1}{\lambda_i}$ (with $\mu_R > \mu_P$), as well as on the price charged by the competitor $p_{j-m}(r,s)$.

For a world economy characterized by two distinct groups of consumers (R and P) living in two distinct regions/markets (N and S) in which the possibility of international arbitrage is excluded, it is then possible to establish:

Lemma 1 *Within each sector $s \in [0,1]$, we have that at equilibrium,*
(1) The highest quality is produced,
(2) At most the two highest qualities q_0 and q_{-1} are actually produced.

Proof: The detailed proof can be found in Zweimuller and Brunner (2005) for a closed economy composed of two consumer groups. It can immediately be applied to our framework with 4 groups of consumers spread in two different regions because of our exclusion of the possibility of carry-along trade. Indeed, precluding international arbitrage guarantees that the producer of a given quality (whether it is the highest or the second-best) can treat the North and the South as two hermetic markets, in which they can carry out two pricing strategies totally independent from each other. □

[4]For a similar pricing decision problem in the case of successful innovators in a R&D-driven growth model, see Foellmi, Wuergler, and Zweimuller (2009).

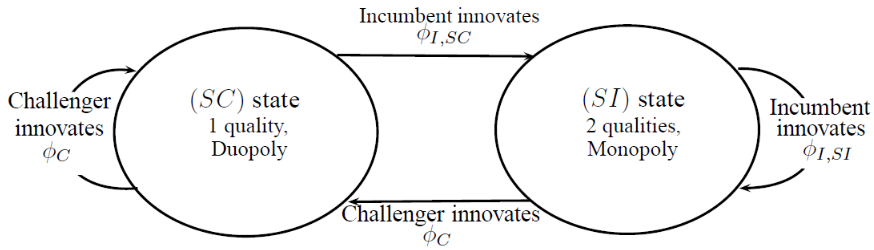


Figure 3.1: Two possible states

In our model, the incumbent is investing in R&D, and can hence innovate twice in a row. Each industry s then fluctuates between two states over time, depending on the winner of the last innovation race (see Figure 3.1 for an illustration). In our two-country set-up, the two possible states (SC) and (SI) can be characterized in the following way:

- **"Successful Challenger" (SC) state**: a challenger is the winner of the last R&D race, i.e. the new quality leader is different from the former quality leader. The new quality leader then only retains exclusive monopoly rights for the highest quality q_0, and depending on its pricing strategy, the producer of the quality q_{-1} might remain active (duopoly market structure) or be driven out of the market (monopoly market structure).

- **"Successful Incumbent" (SI) state**: the current quality leader, still carrying out R&D, is the winner of the next R&D race, and hence retains exclusive monopoly rights for *both* the highest quality $q_0(s)$ and the second-best quality $q_{-1}(s)$. According to lemma 1, the market structure is then a monopoly, with the quality leader offering two different price/quality bundles in order to discriminate between the groups P and R in each market.

In the following analysis, we will restrict ourselves to discussing at length the resolution of the case where the market structure is a duopoly in the (SC) state, i.e. the case where the income distribution makes it optimal for the new quality leader to sell the highest quality q_0 to the rich consumers only, abandoning the poor consumers to the producer of quality q_{-1}. Two reasons justify this exposition choice. First, since the objective of this paper is to reproduce and analyze the implications of "quality-life cycle" trade patterns such as the "Renault-Dacia" one, the case where two distinct qualities are sold and traded in every industry (and not only in (SI)-state industries) is the most relevant one. Second, as it will become clear in the following sections, the duopoly case is (perhaps unexpectedly) the one guaranteeing the simplest expressions for the main endogenous variables, enabling us to analytically guarantee its existence and robustness under clearly identified parametric conditions.

Equilibrium prices and profits

In the duopoly case, the prices being charged to each consumer type ri are similar across industries: only the identity of the firm producing quality q_{-1} differs. Indeed, quality q_0 is systematically sold by the winner of the latest innovation race at the threshold price $p^T_{\{-1,0\}}(R,r,s)$, given the price $p_{-1}(r,s)$ being charged for quality q_{-1} in the region r. In industries being in the (SC) state, the former quality leader then remains active, and charges the highest possible price enabling him to capture the poor group of consumers $p^T_{\{-2,-1\}}(P,r,s)$, given that the producer of quality q_{-2} engages in marginal cost pricing ($p_{-2}(r,s) = c_r$ with c_r being the unit production cost of q_{-2} for the region r). In industries being in the (SI) state on the other hand, the new quality leader also chooses to sell the second-best quality (over which it retains exclusive monopoly rights, since it has innovated twice in a row) at the price $p^T_{\{-2,-1\}}(P,r,s)$. Defining $\kappa = \ln k$ and dropping the industry indices from then on, the prices paid by the four groups of consumers in every in industry s are then of the form:

$$p_{NP} = \kappa\mu_{NP} + c_N, \qquad p_{NR} = \kappa\mu_{NR} + p_{NP} \tag{3.4}$$

$$p_{SP} = \kappa\mu_{SP} + c_S, \qquad p_{SR} = \kappa\mu_{SR} + p_{SP} \tag{3.5}$$

Finally, the first-order condition governing the amount of divisible homogenous good c_{ri} being consumed by a type ri consumer yields the following expression for the marginal utility of income λ_{ri}:

$$\frac{1}{c_{ri}} = \frac{1}{y_{ri} - P_{ri}} = \lambda_{ri} \tag{3.5}$$

The computation of the willingness to pay $\mu_{ri} = \frac{1}{\lambda_{ri}}$ hence depends on the price index for the quality goods P_{ri} each type of consumer is facing. Since we just established that in the duopoly case, every industry enters symmetrically in the price index, we simply have $\mu_{ri} = y_{ri} - p_{ri}$. Plugging this expression back in (3.4) – (3.5), we finally obtain the following equilibrium values for p_{NP}, p_{NR}, p_{SP} and p_{SR}:

$$\begin{aligned} p_{NP} &= \frac{\kappa y_{NP} + c_N}{\kappa + 1} && (3.6)\\ p_{NR} &= \frac{\kappa}{\kappa+1} y_{NR} + \frac{\kappa y_{NP} + c_N}{(\kappa+1)^2} && (3.7)\\ p_{SP} &= \frac{\kappa y_{SP} + c_S}{\kappa + 1} && (3.8)\\ p_{SR} &= \frac{\kappa}{\kappa+1} y_{SR} + \frac{\kappa y_{SP} + c_S}{(\kappa+1)^2} && (3.9) \end{aligned}$$

Let π_L be the profits associated to selling the highest quality available, and π_F the profits reaped from selling the second-best quality. We assume the existence of "iceberg" trade costs: in order to export to country r ($r \in \{N, S\}$) one unit of quality good manufactured in country v ($v \in \{N, S\}$, $v \neq r$), a firm must ship $\tau \geq 1$ units. We then have:

$$\pi_L = L_{NR}(p_{NR} - a) + L_{SR}(p_{SR} - \tau a), \qquad \pi_F = L_{NP}(p_{NP} - c_N) + L_{SP}(p_{SP} - c_S) \qquad (3.9)$$

In industries being in the (SC) state, those two profits are reaped by two distinct firms: π_L accrues to the winner of the latest innovation race, while π_F is won by the former quality leader (now producer of the second-best quality). In industries being in the (SI) state, the successful incumbent sells the two available qualities, and earns profits $\pi_{SI} = \pi_L + \pi_F$.

Localization choice for the producer of the second-best quality

While we assume that the highest technology can be used by the North only, we have so far left the localization of the second-best producer uncharacterized. In each state, we let the producer of the second-best quality choose bewteen continuing production in the North or costlessly moving it to the South.[5] Let π_F^r be the instantaneous profits associated to the

[5]Introducing relocation costs would lower the incentives to move to the South, creating an arbitrage between lower marginal costs and the existence of fixed costs in the case of FDI; however, it wouldn't change

production of the second best quality when locating in region r. Considering that a single firm does not internalize the effects of its location choice on aggregate variables, we can establish that:

Proposition 2 *For $\xi < \frac{1}{2}$ we necessarily have $\pi_F^S > \pi_F^N$, guaranteeing that the production of the second-best quality is located in the South for every sector s.*

Proof: In the case the producer of the second-best quality is located in the South, we have $c_S = wa$ and $c_N = \tau aw$; in the case the producer of the second-best quality is located in the North, we have $c_S = \tau a$ and $c_N = a$. Plugging those values into p_{NP} and p_{SP}, we have $\pi_N^S - \pi_F^N = \beta a L \frac{\kappa}{\kappa+1}(\xi(1-\tau w) + (1-\xi)(\tau - w))$. Firms consider the sign of this difference when choosing where to locate. Since we restrict ourselves to parametric cases where $w < 1$ and we have $\tau > 1$, for values of w such that $\tau w < 1$ we necessarily have $\pi_F^S - \pi_F^N > 0$. For values of w such that $\tau w > 1$, we need to have $\frac{1-\xi}{\xi}(\tau - w) > \tau w - 1$ to ensure that producers of q_{-1} locate in the South. If $\xi < 1/2$, we have $\frac{1-\xi}{\xi}(\tau - w) > \tau - w > \tau w - 1$ (the second part of the expression is systematically true since $\tau - w - (\tau w - 1) = \tau + 1 - w(\tau + 1) > 0$). Hence, for values of $\xi < 1/2$, we have $\pi_F^S - \pi_F^N > 0$ for any value of the endogenous relative wage $w < 1$. This ends the proof. □

Profits of firms diminish along both transport and wage costs, while unit consumption ensures that the size of demand in a given region is uniquely pinned down by the size of its population L_r. Hence, provided $\xi < 1/2$, there necessarily is a larger demand in the South for the second-best quality, and firms will choose to locate so as to serve this demand locally while avoiding transport costs and benefitting from lower wages. This choice is independant of the state each industry finds itself in, since the profits generated by selling the second-best quality are the same, whether it is produced by the follower (SC state) or by the differentiated monopolist (SI state).

the main intuition, which is that a given firm will locate itself so as to locally serve the biggest market.

From then on, since we want to be able to investigate the growth implications of vertical patterns of trade such as the "Renault-Dacia" one (i.e. including positive export flows from the South to the North for the lowest qualities), we focus on such parametric cases, and impose $\xi < 1/2$. That is, there are more poors in the South than in the North.

3.2.3 R&D sector

Firms engage in R&D to discover the next quality level, with R&D activities being located in the North only. We assume free entry, with every firm having access to the same R&D technology. Innovations occur for a given firm i according to a Poisson process of hazard rate ϕ_i. Labor is the only input, and we assume constant returns to R&D at the firm level. To have an immediate probability of innovating of ϕ_f, a firm f needs to hire $F\phi_f$ northern labor units, F being a positive constant inversely related to the efficiency of the R&D technology. We define the following expected present values: v_C for the value of a challenger firm, v_{SC} and v_{SI} for the values of a quality leader having respectively innovated once and twice, and v_F as the value of a leapfrogged leader (follower). Free entry and constant returns to scale imply that R&D challengers have no market value, whatever state the economy finds itself in: $v_C = 0$. Free entry of challengers in the successive R&D races also yields the traditional equality constraint between expected profits of innovating for the first time $\phi_C v_{SC}$ and engaged costs $\phi_C F$:

$$v_{SC} = F \tag{3.10}$$

The incumbent participates to the race while having already innovated at least once, and hence being the current producer of the leading quality in case (SC)/of the two highest qualities in case (SI). In industries being currently in the (SC) state, the incumbent faces the following Hamilton-Jacobi-Bellman (HJB) equation:

$$rv_{SC} = \max_{\phi_{I,SC} \geq 0} \{\pi_L - F\phi_{I,SC} + \phi_{I,SC}(v_{SI} - v_{SC}) + \phi_C(v_F - v_{SC})\} \tag{3.11}$$

The incumbent in the (SC) state earns the profits π_L , and incurs the R&D costs $F\phi_{I,SC}$. With instantaneous probability $\phi_{I,SC}$, the leader innovates once more, the industry jumps to the state (SI), and the value of the leader (now producing and selling two distinct qualities) climbs to v_{SI}. However, with overall instantaneous probability ϕ_C, some R&D challenger innovates, and the quality leader then becomes a follower: its value drops to v_F. The industry then remains in the state (SC).

In the (SI) state on the other hand, the incumbent faces the following HJB equation:

$$rv_{SI} = \max_{\phi_{I,SI}\geq 0}\{\pi_{SI} - F\phi_{I,SI} + \phi_{I,SI}(v_{SI} - v_{SI}) + \phi_C(v_F - v_{SI})\} \tag{3.12}$$

The incumbent in the (SI) state earns the profits $\pi_{SI} = \pi_L + \pi_F$ of a monopolist being able to discriminate between rich and poor consumers by offering two distinct price/quantity bundles. He incurs the R&D costs $F\phi_{I,SI}$. With instantaneous probability $\phi_{I,SI}$, the incumbent innovates once more, in which case its value remains v_{SI} (cf lemma 1): the incumbent is then still the producer of the two qualities being sold, *but* he has driven himself out of the market for the former quality q_{-1}, that has become quality q_{-2} with the latest quality jump. With instantaneous probability ϕ_C,[6] some R&D follower innovates, and the quality leader then becomes a follower: its value falls to v_F.

Finally, we have a last actor with non-null profits, i.e. the producer of the quality q_{-1} in the industries being in the (SC) state. This former leader (and now follower) faces the following HJB equation:

$$rv_F = \max_{\phi_F\geq 0}\{\pi_F - wF\phi_F + \phi_F(v_{SC} - v_F) + (\phi_C + \phi_I)(v_C - v_F)\} \tag{3.13}$$

The follower in the (SC) state earns the profits π_F, and incurs the R&D costs $F\phi_F$. With instantaneous probability ϕ_F, the follower innovates, in which case its value becomes v_{SC}. With instantaneous probability ϕ_C on the other hand, some R&D challenger innovates, and the follower's value falls back to $v_C = 0$.

[6] The challengers invest the same amount in the R&D sector ϕ_C in both states (SC) and (SI), since they face the same expected reward v_{SC} in both cases: a successful innovation by a challenger indeed always brings the industry back to state (SC).

The three corresponding first-order conditions are of the following form:

$$(-F + v_{SI} - v_{SC})\phi_{I,SC} = 0, \quad \phi_{I,SC} \geq 0 \tag{3.14}$$

$$(-F + v_{SC} - v_F)\phi_F = 0, \quad \phi_F \geq 0 \tag{3.15}$$

$$-F\phi_{I,SI} = 0, \quad \phi_{I,SI} \geq 0 \tag{3.16}$$

(3.16) immediately implies $\phi_{I,SI} = 0$. From then on, we hence refer to the investment in R&D of the incumbent firm in the (SC) state as simply ϕ_I. Combined with (3.10), (3.15) entails either $\phi_F = 0$ or $v_F = 0$. The second possibility cannot be true, since the follower's profits π_F are strictly positive: we hence necessarily have that $\phi_F = 0$. Plugging this value back into (3.13), we obtain that $v_F = \frac{\pi_F}{r+\phi_C+\phi_I}$. Finally, plugging the free-entry condition (3.10) and the first-order condition (3.15) in the HJB equations (3.11) and (3.12), it is possible to obtain the 2 following expressions, equating incurred R&D costs and expected profits in both possible states:

$$F = \frac{\pi_L + \phi_C\left(\frac{\pi_F}{r+\phi_C+\phi_I}\right)}{r+\phi_C} \tag{3.17}$$

$$2F = \frac{\pi_{SI} + \phi_C\left(\frac{\pi_F}{r+\phi_C+\phi_I}\right)}{r+\phi_C} \tag{3.18}$$

3.3 Balanced growth path analysis

3.3.1 Labor market equilibrium

We denote by θ_{SC} the fraction of all industries for which the latest innovator is a challenger (i.e. being in the (SC) state), and θ_{SI} the fraction of all industries for which the last innovation race has been won by an incumbent (i.e. being in the (SI) state). While challengers invest an equal amount in R&D in every industry, incumbents only invest in R&D in industries being in the (SC) state; the total northern labor demand in the R&D sector is hence equal to $F(\phi_C + \int_{\theta_{SC}} \phi_I(s)ds)$. Since we imposed unit consumption of the quality good, $a(L_{NR}+\tau L_{SR})$ units of northern labor are devoted to the production of the highest quality good.[7] Similarly, since the second-best quality is sold to poor consumers in both regions and produced in the South, we have $a(\tau L_{NP} + L_{SP})$ units of labor devoted to the production of the quality q_{-1} in the South. Finally, $L_{NR}(y_{NR} - p_{NR}) + L_{NP}(y_{NP} - p_{NP})$ units of labor are devoted to the production of the standardized good in the North, and $L_{SR}(1/w)(y_{SR} - p_{SR}) + L_{SP}(1/w)(y_{SP} - p_{SP})$ units of labor are devoted to the production of the standardized good in the South.

We hence have the following equation characterizing the equilibrium on the labor market in each region:

$$L_N = F\phi_C + \theta_{SC}F\phi_I + a(L_{NR} + \tau L_{SR}) + L_{NR}(y_{NR} - p_{NR}) + L_{NP}(y_{NP} - p_{NP}) \quad (3.19)$$

$$L_S = a(\tau L_{NP} + L_{SP}) + L_{SR}(1/w)(y_{SR} - p_{SR}) + L_{SP}(1/w)(y_{SP} - p_{SP}) \quad (3.20)$$

It is then possible to transform those two labor equilibrium conditions so as to obtain a relationship between profit flows and the overall wealth within the economy Ω. Summing up (3.19) and (3.20), replacing y_P and y_R by their respective values, keeping in mind that $\pi_L + \pi_F = \pi_{SI}$ and rearranging terms, we get:

$$F(\phi_C + \theta_{SC}\phi_I) - \pi_{SI} + r\Omega = 0 \quad (3.20)$$

Using (3.17) so as to substitute for F, we finally obtain the expected identity between overall wealth of the consumers Ω and the present discounted value of firms' profits within the economy as a whole:

$$\Omega = \theta_{SC}\frac{\pi_L + \pi_F}{r + \phi_C} + \theta_{SI}\frac{\pi_{SI}}{r + \phi_C} \quad (3.20)$$

3.3.2 Balanced growth path analysis

Definition 1 *In the case we have a duopoly market structure in the (SC) state, an equilibrium is defined by a time path for consumption of the homogenous good for the four consumer types* $\{c_{ri}(t)\}_{t=0}^{\infty}$ *that satisfies* (3.2.2)*, time paths for R&D expenditures by incumbents and*

[7]Indeed, as previously mentioned, the highest quality is sold to rich in both regions, and we impose for its production to take place in the North.

challengers $\{\phi_C(s,t), \phi_I(s,t)\}_{s\in(0,1),t=0}^{\infty}$ *that satisfy* (3.10), (3.11) *and* (3.12), *time paths of prices and present discounted value of firms' profits* $\{p_{ri}, \Omega(t)\}_{t=0}^{\infty}$ *given by* (3.6), (3.7), (3.8), (3.9), (3.2.2), *and* (3.3.1), *a time path for southern wages* $\{w(t)\}_{t=0}^{\infty}$ *given by* (3.20), *and a time path of the interest rate* $\{r(t)\}_{t=0}^{\infty}$ *which satisfies* (3.3).

In addition, we define a balanced growth path (BGP) as an equilibrium path along which every variable grows at a constant rate, either null or positive. In such a *product*-innovation model (i.e. precluding any productivity improvement) with a fixed population level L, the BGP is characterized by constant levels of innovation ϕ_C and ϕ_I, overall wealth Ω and consumption c_{ri} ($i = R, P$; $r = N, S$).[8] Consumers however still become better-off over time due to the quality improvements of the differentiated goods and the resulting growth of individual utility. As already stated in the previous section, we focus in this paper on such a BGP, and we now proceed to describing its properties.

Along such a BGP, it is possible to express θ_{SC} and θ_{SI} as functions of the innovation rates ϕ_C and ϕ_I. Indeed, along the BGP we have that the flows in must equal the flows out of each state: we then have the condition $\phi_C\theta_{SI} = \phi_I\theta_{SC}$ that has to be respected.[9] Combining it with the fact that the two shares sum up to 1 (i.e. $\theta_{SC} + \theta_{SI} = 1$), we obtain:

$$\theta_{SC} = \frac{\phi_C}{\phi_I + \phi_C}, \qquad \theta_{SI} = \frac{\phi_I}{\phi_C + \phi_I} \tag{3.20}$$

Proposition 3 (Existence and uniqueness of the BGP equilibrium) *For* τ, a, d *sufficiently low and* β, L *sufficiently high, there exists a unique BGP along which (i) we have a duopoly in the (SC) state, (ii) both incumbents and challengers invest strictly positive amounts in R&D* ϕ_I *and* ϕ_C, *and (iii) the consumers' utility grows at the constant rate* $\gamma = \kappa\phi_C(1 + \frac{\phi_I}{\phi_I+\phi_C})$.

[8] The consumption of the continuum of quality-differentiated goods is anyway always constant, since we impose unit consumption in this model.

[9] Indeed, for each industry being in the (SC) state, the probability to exit this state is equal to the probability $\phi_I(s)$ of an incumbent innovating; for each industry being in the (SI) state, the probability to enter the (SC) state corresponds to the probability $\phi_C(s)$ of a challenger innovating.

Proof: cf Appendix B.

Existence and uniqueness of the BGP hence occurs under the following parameter conditions:[10] (i) τ and a sufficiently low and L sufficiently high, i.e. sufficiently low marginal production costs and a sufficiently large overall market size so as to ensure positive profits in every market segment; (ii) d sufficiently low, i.e the wealthy groups in both the North and the South are rich enough to entice the successful challenger to choose the "duopoly" pricing strategy enabling him to fully exploit their higher willingness to pay; β sufficiently high, i.e. the size of the poor consumers groups is big enough to ensure that the follower's profits are positive, despite the rather large size of the within-country wealth gap. These conditions hence yield the coexistence of positive R&D investments by firms willing to become a successful challenger (ϕ_C) or a successful incumbent (ϕ_I).
We have hence designed a North-South model where disparities in purchasing power within and across regions ensure the co-existence of 2 types of firms:

- *Mono-product, mono-location firms.* Within this type, we distinguish two cases: (i) firms producing in their home region and exporting part of their production towards the foreign market (mono-product local firms), and (ii) firms engaging in FDI to serve the host market while exporting back part of their production to serve their home region (mono-product delocated firms).

  (i) The mono-product local firms are successful challengers who only have at their disposal the highest available quality, which cannot be produced in the South. They hence locate their production in the North, and serve the upper part of the southern market through exports.

  (ii) The mono-product delocated firms, on the other hand, are former leaders who have been leapfrogged, and whose quality has become second-best. Those firms choose to locate in the South, where the relative demand for the second-best quality is higher

[10] For a full exposition and discussion of the parameter conditions, see Appendix B.2

and where the production costs are lower. Hence, while they avoid transport costs for the main share of their sales, they serve consumers in their country of origin through exports.

- *Multi-quality, multi-location firms.* These firms are the successful incumbents, who have at their disposal two successive qualities and can then efficiently discriminate between consumers by offering various price/quality bundles, reaping maximum surplus from all the consumer segments across the globe. They locate the production of the highest quality in the North, and optimally choose to locate the production of their lowest quality in the South, where demand for this quality is relatively high and where labor costs are lower. Because the two qualities are consumed in the two regions, those firms simultaneously resort to both FDI and exports, serving the upper part of the southern market and the lower part of the northern market through exports.

Beyond the existence of multi-quality firms already identified in Latzer (2013), we have hence demonstrated that under non-homotheticity of preferences, income disparities also generate rich inequality-driven intra-industrial trade patterns. A full investigation of the impact of income distribution (and hence of redistribution policies) on long-run growth and other macroeconomic outcomes hence benefits from being carried out in an international trade framework. Similarly, predictions regarding the long-run macroeconomic impact of trade openness shocks might be influenced by the existing interactions existing between income inequality (across- and within regions), R&D investment and trade patterns. We now move to investigating those questions in the next section.

3.4 Income distribution, trade integration and innovation

In this section, we study the implications of such a model of intra-industrial trade regarding the existing interactions between (i) income distribution and innovation of multi-quality, multinational firms; (ii) within- and across country inequality levels; (iii) trade integration, the long-run growth rate and the inter-regional wage gap. In the following analysis, we consider two types of variations in the extent of wealth disparities: (a) a greater wealth *concentration* (i.e. an increase in β for a given d) and (b) a larger income gap (i.e. a decrease in d for a fixed level of β). We also analyze the effect of trade integration (i.e. a decrease in τ). The results can be summarized in the following numerical findings:

Numerical finding 1: effects of a greater wealth concentration.
Under the parametric conditions identified in Proposition 1, a greater wealth concentration (corresponding to an increase in β) leads to: an unambiguous increase in the challengers' innovation rate ϕ_C and a decrease in the incumbent's innovation rate ϕ_I; an increase of the southern wage rate w in most parametric cases; an ambiguous effect on the overall growth rate γ.

It should first be signaled that a rise in the share of the population being poor β while keeping d constant corresponds to a higher concentration of wealth among a smaller group of rich people. Indeed, it implies an increase in the *relative* wealth of rich consumers ($\frac{\partial d_R}{\partial \beta} = \frac{1-d}{(1-\beta)^2} > 0$): there are more poor (both in the North and the South) with the same income, and fewer rich with more income.

We first comment on the variation of the southern wage rate w, which can be interpreted as a reverse measure of the interregional wage gap: the lower w, the higher the northern relative wage $\frac{1}{w}$, and the wider the inequality level *across* regions. As one can see considering (3.20), the value of w is pinned down by the equilibrium condition on the southern labor market. In the case of a positive shock on β, the size of the poor population in the world βL has increased: because of our unit consumption requirement of the quality good and considering the fact that the second-best quality sold to the poor is produced in the South, labor demand for the production of the quality good $a(\tau L_{NP} + L_{SP})$ increases following a positive shock on β.[11] A greater wealth concentration on the other hand negatively impacts the labor demand

[11]Because of our assumption that $\xi < 1/2$, we also have that the labor *supply* L_S has augmented; however,

for the production of the homogenous good. Indeed, the rich become wealthier but are also charged a higher price for the quality good, while the poor become more numerous and are still charged the same price than before: in total, the amount of standardized good being consumed (and hence produced) ends up diminishing. In most parametric cases, the positive effect of a higher labor demand for the quality good seems however to dominate, and w increases.

So as to rationalize the variations of the incumbents' and challengers' innovation rates ϕ_I and ϕ_C, we consider the impact of a wealth concentration shock on the expected profits following a successful innovation. It should first be noted that such a shock generates variations in the expected profits through market-size, price and marginal costs (through the resulting variation in w) effects. We then consider the expected profits of a successful challenger, i.e. $\pi_L + \phi_C \frac{\pi_F}{\phi_C+\phi_I+\rho}$. Those profits are composed of two distinct parts: (i) the "first-round", immediate profits π_L stemming from having successfully innovated, and (ii) the actualized, "second-round" profits $\phi_C \frac{\pi_F}{\phi_C+\phi_I+\rho}$ accruing from becoming a follower in the case leapfrogging occurs. The first-round profits π_L are impacted by a negative market-size effect and a positive price effect: monopolists in the (SC) state indeed sell their new leading quality to a smaller group of consumers, but at a higher price. On the other hand, the second-round profits π_F benefit from a positive market-size effect (the size of the poor consumers group has increased), but are negatively impacted by the increase in the southern unit production costs resulting from a higher w. The conjugated positive first-round price and second-round market-size effects finally seem to dominate, since ϕ_C increases in every considered parametric case. On the other hand, the decrease in the incumbent's innovation rate ϕ_I stems from the decrease in the incremental profits π_F of a firm successfully innovating for the second time following the increase in its production costs w (the second-best quality being systematically produced in the South under the parametric condition $\xi < \frac{1}{2}$).

Finally, the opposite directions of the variations of ϕ_C and ϕ_I leave the impact on the overall growth rate $\gamma = \phi_C \left(1 + \frac{\phi_I}{\phi_C+\phi_I}\right)$ undetermined: the effect of a greater wealth concentration

the increase in the labor demand for the quality good is stronger, since part of the production is also exported back to the northern poor, whose number increased as well following a positive shock on β.

on the long-run growth rate is ambiguous.

Numerical findings 2: effects of a larger income gap.

Under the parametric conditions identified in Proposition 1, a larger income gap (corresponding to a decrease in d) leads to: an unambiguous decrease in the challengers' innovation rate ϕ_C, the southern wage rate w and the overall growth rate γ; an unambiguous increase in the incumbent's innovation rate ϕ_I.

We first consider the impact of a larger income gap on relative wages. Following a negative shock on d, the quantity of labor hired in the quality good production sector is left unchanged under our unit consumption assumption: indeed, variations in d leave the size of the poor and rich groups unchanged. On the other hand, a larger wealth gap and the resulting more unequal income distribution diminishes the overall expenses devoted to the homogenous good: indeed, price discrimination is more effective in the case of the rich group, and their residual expenses devoted to the consumption of the standardized good decrease; this negative variation ends up dominating the increase in the homogenous good consumption of the poor group. Labor demand for the production of the homogenous good in the South hence decreases; as a consequence, w moves downwards following a decrease in d. We hence have that a greater within-country inequality level also contributes to a greater North-South wage gap.

So as to understand the variations of ϕ_I and ϕ_C, we again consider the impact of a decrease in d on the expected profits of both types of firms operating in the R&D sector. The first-round profits π_L are impacted by a positive price effect (the rich have become wealthier, and their willingness to pay for quality has hence increased), but suffer from an increase in the production costs: indeed, the southern wage has diminished, which hints at an increase of the relative northern wage $\frac{1}{w}$. On the other hand, the second-round profits π_F are impacted by a negative price effect (the poor have become poorer), but are boosted by a decrease in the unit production costs of the second-best quality. The fact that ϕ_C unambiguously decreases hints at the fact that the combined impact of the two negative effects (first-round increase in the production costs and second-round price effect) dominates. On the other hand, the variation of ϕ_I following such a redistribution shock is ambiguous. Finally, we find that in every carried out simulation, the growth rate γ diminishes following an increase in the within country wealth gap: a greater inequality level is hence detrimental for long-run growth.

Numerical findings 3: effects of trade integration.

Under the parametric conditions identified in Proposition 1, trade integration (corresponding to a decrease in the iceberg transport costs τ) leads to: an unambiguous increase in the incumbent's innovation rate ϕ_I and the overall growth rate γ, and a decrease in the southern wage rate w.

A decrease in the iceberg transportation costs τ leads to a lower labor demand for the production of the quality good in the South $a(\tau L_{NP} + L_{SP})$: indeed, part of this production is reexported to northern poor consumers L_{NP}, and since firms are the ones incurring the trade-related extra costs, they benefit from a decrease in the latter. On the other hand, the prices charged for quality to the different southern consumer groups are not impacted by an openness shock (again, firms are the ones bearing all the burden, and consumers don't see any impact of variations in τ on the price they pay for a given quality), and labor demand devoted to the homogeneous good sector is left unchanged. A decrease in τ hence necessarily leads to a decrease in w: trade integration increases the interregional wage gap.

Considering the expected profits in the case of a successful innovation, π_L is positively impacted by a positive price effect (export costs have decreased regarding the southern rich consumers), but suffers from increased production costs (the relative northern wage $\frac{1}{w}$ has increased). The "second-round" profits π_F are on the other hand impacted by a positive price effect (export costs have decreased regarding the northern poor consumers), and also positively by a decrease in its production costs aw. While the overall impact on π_L (and the resulting variation of ϕ_C) is ambiguous, π_F necessarily increases, leading to an increase in both the incumbent's innovation rate ϕ_I and the overall growth rate γ. Trade liberalization is hence beneficial for the long-run growth rate in our framework.

Those different results can be compared to two separate strands of literature: (i) the literature studying the existing interactions between income distribution and long-run growth in a closed-economy framework (Foellmi and Zweimuller, 2006; Latzer, 2013); (ii) the literature investigating the impact of trade liberalization on the long-run growth rate in a North-South Schumpeterian framework (Dinopoulos and Segerstrom, 2010; Borota, 2012).

First, the literature investigating the impact of income distribution on long-run growth operating through the product market has done so in the case of expanding-variety (Foellmi and Zweimuller, 2006; Foellmi, Wuergler, and Zweimuller, 2009) as well as quality-ladder models (Latzer, 2013), but has systematically tackled the question in a closed economy framework. While the predictions regarding the impact of a greater wealth concentration differ across modeling frameworks,[12] existing closed-economy models all predicted a positive impact of a greater wealth gap (i.e. of a lower value of d).

In Latzer (2013) in particular, the positive impact of a lower value of d operates through the stronger price discrimination opportunities for existing quality leaders innovating for a second time, and the resulting increase in ϕ_I. This positive variation of the incumbent's R&D investment systematically dominates the observed decrease in ϕ_C in the absence of trade. In our open economy framework, ϕ_C similarly decreases, but this negative variation dominates the sometimes positive impact on ϕ_I: when intra-industrial trade occurs, a wider wealth gap between rich and poor is systematically detrimental for the long-run growth rate. The further effect operates through the variations in the southern relative wage, which is found to be negatively impacted by negative within-country redistribution shocks.

Second, papers that had so far considered the impact of trade liberalization on the long-

[12]In the existing expanding-variety models featuring non-homothetic preferences (see, among others, Foellmi and Zweimuller, 2006), a greater wealth concentration is found to positively impact the long-run growth rate through a positive price effect and despite a negative price effect; on the other hand, Zweimuller and Brunner (2005) as well as Latzer (2013) predict a negative impact of a higher value of β an economy's rate of growth.

run growth rate and the North-South relative wage had done so in models featuring either inter-industrial trade (Dinopoulos and Segerstrom, 2010), or supply-driven intra-industrial trade (Borota, 2012). In those two types of frameworks, lower levels of τ have no impact on the long-run growth rate: indeed, in models featuring quality-augmented Dixit-Stiglitz preferences, the constant elasticity of substitution guarantees that gains from exporting at lower costs are exactly offset by the stronger market penetration of competing firms, leaving the expected profits in the case of a successful innovation unchanged. In our model featuring non-homothetic preferences on the other hand, the profits are positively impacted by a stronger trade liberalization, which results in a positive impact on γ of a decrease in transport costs τ. To the best of our knowledge, our model is the first to exemplify such a positive demand-driven impact of trade integration on a country's long-run growth rate. Our model furthermore predicts an increase in the relative northern wage $\frac{1}{w}$, which is at odds with the predictions of Borota (2012) in a similar intra-industrial trade framework: hence, the nature of the trade determinants (either supply- or demand-based) matter when considering the welfare impact of a greater degree of trade openness.

3.5 Conclusion

We have hence provided a North-South Schumpeterian model of endogenous growth being able to account for demand-driven patterns of vertical intra-industrial trade such as the "Renault-Dacia" case. Disparities in purchasing power within *and* across regions ensure the co-existence of mono-quality, mono-location firms and multi-quality, multi-location firms generating rich patterns of trade and FDI, and also influence the incentives to invest in R&D of both incumbents and challengers. In the case of a wider intra-country wealth gap, our model then predicts a negative impact on the long-run growth rate, as well as an increase in the interregional wage gap. We are also able to demonstrate that liberalization policies are beneficial for a country's long-run growth, but widen the North-South wage gap.

Appendix A

1

The existence of the equilibrium with a positive number of DLFs requires $N_D \geq 0$. From (2.34) we have $N_D \geq 0$ when $\omega_N \leq A_S \frac{L_S}{L_N} \frac{\alpha(\sigma-1)}{(1-\alpha)(\sigma-1)}$ where the RHS term is equal to wages in the North when there is no delocation. We hence have lower wages after delocation. This ends the proof.$\square$

2

First we show that under the conditions

$$c \leq A_S \frac{L_S - L_N}{L_N} \tag{21}$$

$$\sigma > \frac{(b(bc^2(\alpha-1) + c(a\alpha + 2b(\alpha-1)A_S + b(\alpha-1) + a\alpha)A_S^2)L_N + aA_S(bc(2-\alpha) + (a + b(2-\alpha) - a\alpha)A_S)L_S)}{(b(bc^2(\alpha-1) + c(a(\alpha-1) + 2b(\alpha-1)A_S + (a+b)(\alpha-1)A_S^2)L_N + aA_S(bc(1-\alpha) + (a + b - a\alpha - 1b\alpha)A_S)L_S))} \tag{22}$$

$$x < \frac{(aA_S(bc(2 + \alpha(\sigma-1) - \sigma) + (a(1 + \alpha(\sigma-1) - \sigma) + b(2 + \alpha(\sigma-1) - \sigma))A_S)L_S)}{(b(bc^2(1 + \alpha(\sigma-1) - \sigma) + c(a(\alpha(\sigma-1) - \sigma) + 2b(1 - \sigma + \alpha(\sigma-1)))A_S + (a(\alpha(\sigma-1) - \sigma) + b(1 + \alpha(\sigma-1) - \sigma))A_S^2)L_N)} \tag{23}$$

the ratio of utilities prior and post delocation $R_u = \frac{U_{N,D}}{U_N}$ is increasing in A_S where subscript D describes the situation with delocation. We have

$$\frac{U_{N,D}}{U_N} = \frac{\frac{\omega_{N,D}}{P_{M,D}}}{\frac{\omega_N}{P_M}} = \frac{\omega_{N,D}}{\omega_N} \left(\frac{N_N p_{j,d}}{N_N p_j^{1-\sigma} + N_D p_d^{1-\sigma}}\right)^{\frac{1}{1-\sigma}} \tag{24}$$

Note that $\frac{p_{j,d}}{p_j} = (\frac{\omega_N}{\omega_{N,D}})^{-\alpha}$ and $\frac{p_d}{p_j} = \frac{A_N}{A_D}(\frac{\omega_N}{\omega_{N,D}})^{\alpha}$.
Dividing (2.34) by (2.21), using (2.22) and (2.37) and rearranging yields

$$\frac{N_D}{N_N} = \frac{H}{L_N}\frac{A_S L_S(\alpha(\sigma-1)+1) - \omega_N L_N(1-\alpha)(\sigma-1)}{M\omega_D(1-\alpha)(\sigma-1) + M\omega_{S,I}(\alpha(\sigma-1)+1)} \tag{25}$$

Substituting (25),(2.37), (2.22) and $\omega_D = A_S + c$ in (24) gives

$$\begin{aligned} \frac{U_{N,D}}{U_N} &= (\frac{A_S \frac{L_{S,I}}{L_N}\frac{a}{b}}{(c+A_S)[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{a}}})^{\alpha-1} \\ [1 &+ \frac{H}{L_N}\frac{A_S L_S a - (c+A_S)[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{a}} L_N b}{M(A_S+c)b + MA_S a}(\frac{A_N}{A_D}(\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1})^{\frac{1}{a}})^{a-1}]^{\frac{1}{\sigma-1}} \end{aligned} \tag{26}$$

where $a = \alpha(\sigma-1)+1$ and $b = (1-\alpha)(\sigma-1)$.
Deriving (26) w.r.t A_S yields

$$\begin{aligned} &\underbrace{\frac{1}{A_S(c+A_S)}}_{>0}\underbrace{[ac(\frac{aA_S L_S}{xb(A_S+C)L_N})^{\alpha-1}(1-\frac{H(\frac{A_N}{A_D}x)^{\alpha-1}(bx(c+A_S)L_N - aA_S L_S)}{M(bc+(A+b)A_S)L_N})^{\frac{1}{\sigma-1}}}_{>0 \text{from equation (2.38)}} \\ &\underbrace{[\frac{\alpha-1}{a} - (\frac{(bHA_D(\frac{A_N}{A_D}x)^{a}A_S(c+A_S)(xL_N+L_S))}{((\sigma-1)(bc+(a+b)A_S)(-MA_N x(bc+(a+b)A_S)L_N + HA_D(\frac{A_N}{A_D}x)^{a}(bx(c+A_S)L_N - aA_S L_S)))})]]}_{\Omega} \end{aligned} \tag{26}$$

where $x = [\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{a}}$.
The term Ω determines the sign of the derivative. It is strictly positive under the conditions (21),(22) and (23).
I now show that we can have $R_u = 1$. Since R_u is increasing in A_S, It is sufficient to show that $lim_{A_S \to 0} R_u = 0$.
We have $R_u = Max\,[\frac{U_D}{U}, 0]$. We have $lim_{A_S\to 0}\omega_{N,D} = cx$ and $lim_{A_S\to 0}P_{M,D} = -\frac{xL_N}{MA}\frac{\sigma}{\sigma-1}\frac{1}{A_D}(1-\alpha)^{\alpha-1}\alpha^{-\alpha c^{\alpha}}$. Applying Hospital rule for the limit of U, we get $lim_{A_S\to 0}\omega_N = \frac{aL_S}{bL_N}$ and $lim_{A_S\to 0}P_M = 0$. Hence, since $lim_{A_S\to 0}R_u = lim_{A_S\to 0}\frac{\omega_{N,D}}{P_{M,D}}\frac{P_M}{\omega_N} = \frac{(+)(0)}{(+)(-)} = 0$. This ends the proof. $\square$

3

Rewriting (2.37) with transfer yields

$$\omega_N = (c + A_S + t)[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{\alpha(\sigma-1)+1}}$$

Which is increasing in the transfer t.

4

I show that N_D and L_D are increasing in the transfer.

Let t be transfer such that the technology of the South is $A_S + t$ after a transfer t. Introducing the transfer in (2.38) yields

$$L_D = \frac{(\alpha(\sigma-1)+1)(A_S+t)L_S - (A_S+t+c)[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{\alpha(\sigma-1)+1}}(1-\alpha)(\sigma-1)L_N}{(A_S+t+c)(1-\alpha)(\sigma-1)+(A_S+t)(\alpha(\sigma-1)+1)}$$

let

$$\begin{aligned} a &= \alpha(\sigma-1)+1 \\ b &= (1-\alpha)(\sigma-1) \\ d &= L_N\frac{b}{a}[\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1}]^{\frac{1}{\alpha(\sigma-1)+1}} \end{aligned}$$

we have

$$\frac{(A_S+t)-d}{M(A_S+c+t)b+(A_S+t)aM}$$

Deriving w.r.t. the transfer t yields

$$\frac{(a+b)d+bcL_S}{M(at+b(c+t)+(a+b)A_S)^2}$$

Which is positive. Hence N_D is increasing in t. And since $L_D = N_D(\alpha(\sigma-1)+1)M$, we have that L_D is increasing in t.

5

I show that the welfare in the North ratio is increasing in the transfer t.

we have

$$\frac{U_{N,t}}{U_N} = \frac{\omega_{N,t}}{\omega_N}\frac{P_M}{P_{M,t}}$$

where subindex t describes the situation with transfer. Rearranging using equilibrium expressions of the variables yields

$$\frac{U_{N,t}}{U_N} = (\frac{\omega_{N,t}}{\omega_N})^{1-\alpha}(\frac{1+\frac{N_D}{N_N}(\frac{P_d}{P_j})^{1-\sigma}}{1+\frac{N_{D,t}}{N_{N,t}}(\frac{P_{d,t}}{P_{j,t}})^{1-\sigma}})^{\frac{1}{1-\sigma}}$$

Note that $1+\frac{N_D}{N_N}(\frac{P_d}{P_j})^{1-\sigma}$ and $N_{N,t}$ do not depend on t and that

$$\frac{P_{d,t}}{P_{j,t}} = \frac{A_N}{A_D}(\frac{1}{(\frac{M}{H}(\frac{A_N}{A_D})^{\sigma-1})^{\frac{1}{\alpha(1-\sigma)+1}}})^{\alpha}$$

is also independent on t.

let

$$x = 1+\frac{N_D}{N_N}(\frac{P_d}{P_j})^{1-\sigma}$$
$$y = (\frac{P_{d,t}}{P_{j,t}})^{1-\sigma}\frac{1}{N_{N,t}}$$

we have

$$\frac{U_{N,t}}{U_N} = (\frac{A_S+t+c}{A_S+c})^{1-\alpha}(\frac{x}{1+yN_{D,t}})^{\frac{1}{1-\sigma}}$$

let

$$f[t] = (\frac{A_S+t+c}{A_S+c})^{1-\alpha}$$
$$h[t] = 1+yN_{D,t}$$
$$g[t] = (\frac{x}{h[t]})^{\frac{1}{1-\sigma}}$$

we have

$$\frac{U_{N,t}}{U_N} = f[t]g[t] = f[t](\frac{x}{h[t]})^{\frac{1}{1-\sigma}}$$

With $f[t] > 0$ and $g[t] > 0$ it sufficient to prove that $f'[t] > 0$ and $g'[t] > 0$ to have that $\frac{U_{N,t}}{U_N}$ is increasing in t. It is straightforward to show that $f'[t] > 0$ and we proved in Appendix A.4 that $N_{D,t}$ is increasing in t. Hence, $h'[t] > 0$ and $g'[t] > 0$. This ends the proof. $\square$

Appendix B

1

The southern labor equilibrium condition yields a linear relationship between overall wealth Ω and the relative wage w. More precisely, we have $w = A_0\Omega$, with:

$$A_0 = \frac{r(-1+d\beta(\xi-\sigma)+\sigma+\kappa(-1+d(1+\beta(\xi-1)-\sigma)+\sigma))}{L(\kappa((2+\kappa)(\sigma-1)+\beta(1+(1+\kappa)\xi-(2+\kappa)\sigma))+a(-1+\sigma+\beta(1-\sigma+(1+\kappa)(\kappa(1-\xi)+\xi\tau(1+\kappa)))))}$$

We can then express profits $\pi_F[\Omega]$ and $\pi_L[\Omega]$ as

$$\pi_F = A_F\Omega + E_F \tag{8}$$

$$\pi_L = A_L\Omega + E_L \tag{9}$$

with

$$A_F = \frac{\beta\kappa(dr - A_0L(-1+\xi+a(1+\xi(-1+\tau))))}{1+\kappa}$$

$$E_F = \frac{L\beta\kappa\xi}{1+\kappa} > 0$$

$$A_L = \frac{r\kappa(1+\kappa-d(-1+\beta(2+\kappa))) + A_0L(1-\beta)((a+\kappa(2+\kappa))(1-\sigma)+a\sigma\tau)}{(1+\kappa)^2}$$

$$E_L = \frac{L(1-\beta)(\kappa(2+\kappa)\sigma + a(1+\kappa)^2(\sigma(\tau-1)-\tau))}{(1+\kappa)^2}$$

We show that under the conditions

$$0 < A_L < A_F < r \tag{5}$$

$$E_F > E_L > Fr > 0 \tag{6}$$

the system formed by equations (3.17) (3.18) (3.19) (3.20) admits a unique equilibrium. To show that, it is sufficient to prove that the following two equations cross once on $\Omega \in [0;\infty[$.

$$\phi_I = f(\Omega) = \frac{\pi_F(\pi_L - Fr)}{F(\pi_F - \pi_L)} \tag{7}$$

$$\phi_I = g(\Omega) = \frac{(\pi_F - Fr)(\pi_L + Fr - r\Omega)}{F(\pi_F - \pi_L - 2Fr + r\Omega)} \tag{8}$$

First, $f(\Omega)$ is continuous in Ω^+ since its only discontinuity is in $\frac{E_F - E_L}{A_L - A_F}$ which is negative under conditions (5) and (6) . We also have

(i)$\lim_{\Omega\to 0} f(\Omega) = \frac{E_F(E_L - Fr)}{F(E_F - E_L)}$ which is positive under condition (6);

(ii) $\lim_{\Omega\to\infty} f(\Omega) = \infty$ under condition (5) ;

(iii) The derivative of $f(\Omega)$ w.r.t Ω has two potential roots in $\Omega \in \Re$. These are $\frac{\overbrace{A_F A_L(E_L - E_F)}^{*} +/- \sqrt{\Delta}}{A_F A_L(A_F - A_L)}$ where $\Delta = A_F A_L(A_L E_F - A_F E_L)(A_L E_F - A_F E_L + (A_F - A_L)Fr)$. Since $*$ is negative under condition (6) and the denominator positive under (5), at least one of these potential roots, if any, is negative. Hence there is at maximum one extremum in $\Re^+$, if any.

Combining (iii) with (i) and (ii) ensures that $f(\Omega)$ is positive and increasing in $\Re+$.

Second, $g(\Omega)$ is continuous except in $\Omega = \Omega_A = \frac{-E_F + E_L + 2Fr}{A_F - A_L + r}$ where it admits a vertical asymptot. We also have

(i) The function $g(\Omega)$ has at maximum one potential extremum candidate because the potential roots of its derivatives are $\frac{A_F(A_L - r)(2Fr - E_F + E_L) +/- \sqrt{\Delta}}{A_F(A_L - r)(A_F - A_L + r)}$ with $\Delta = A_F(A_L - r)[A_L E_F - A_F E_L - (E_F + (A_F + A_L)F)r + Fr^2] \leq 0$ under condition (5);

(ii) $\lim_{\Omega\to-\infty} = \infty$; $\lim_{\Omega\to\Omega_A^-} g(\Omega) = -\infty$; $\lim_{\Omega\to\Omega_A^+} g(\Omega) = +\infty$; $\lim_{\Omega\to\infty} g(\Omega) = -\infty$ under conditions (5) and (6).

Combining (i) and (ii), $g(\Omega)$ is monotonously decreasing on $\Omega \in]-\infty;\Omega_A[\cup]\Omega_A;\infty[$.

(iii) $g(\Omega)$ admits two roots in $\frac{Fr - E_F}{A_F}$ and $\frac{E_F + Fr}{r - A_L}$. Note that under condition (6) and (5) the first root is negative and the second is positive. Given $\lim_{\Omega\to\Omega_A^-} g(\Omega) = -\infty$ and monotony we hence have that for $\Omega_A > 0$ $g(\Omega)$ is negative on $\Omega \in [0;\Omega_2[$.

Combining (iii) with (i) and (ii) we have that $g(\Omega) < 0$ for $0 < \Omega < \Omega_A$. For $\Omega > \Omega_A$, $g(\Omega) > 0$, it is infinite for values of Ω very close to Ω_A and decreases toward minus infinity as Ω increases.

As a result, for $\Omega_A > 0$, since $\lim_{\Omega \to \Omega_2^+} g(\Omega) - f(\Omega) = +\infty$ under conditions (5), the functions $f(\Omega)$ and $g(\Omega)$ cross once on $\Omega \in [0; \infty[$ under conditions (5) and (6). For $\Omega_A < 0$ we also need that the function crosses in $\Re+$, that is $\lim_{\Omega \to 0} g(\Omega) - f(\Omega) > 0$ which is always satisfied for $\Omega_A < 0$. Finally, the set of conditions is non empty as provided by numerical simulations. An illustration is provided in Figure B.1. Intuitions on the value of parameters for which we have existence and uniqueness is given in part 2. This ends the proof. □

2

We discuss conditions on the parameters in order to satisfy the general conditions for the existence and uniqueness of the equilibrium.

(i) For $0 < A_L < A_F < r$. First, note that since $w = A_0 \Omega$ we must have $A_0 > 0$. The numerator of (9) is always negative. The denominator must hence be negative which arises for a τ and a sufficiently low. Second, $A_L > 0$. We can write π_L as $\pi_L = a_{\pi_L}\Omega + b_{\pi_L}w + c_{\pi_L}$ where $A_L = a_{\pi_L} + b_{\pi_L}A_0$. It is straightforward to show that $a_{\pi_L}, b_{\pi_L} > 0$. With $A_0 > 0$ this ensures $A_L > 0$. Third, for non-extreme values of the parameters we have (a) with a and τ low we have $A_F > 0$; (b) β affects A_F and A_L through A_0 and directly. The effect of β through A_0 is positive but dominated by the direct effect, especially when d, a and τ are low enough. The direct effect of β on A_F is positive while it is negative on A_L. As a result, for non extreme values of the vector of parameters we have $A_F > A_L$ for β high enough (reinforced by d, a and τ sufficiently low). Forth, we have $r > A_F$ for τ and a low. Hence, we have (5) satisfied for a and τ sufficiently low and β sufficiently high.

(ii) For $E_F > E_L > Fr > 0$. First, $E_F > 0$ and $Fr > 0$. Second, $E_L > 0$ for a and τ sufficiently low. Indeed the denominator of E_L is positive and its numerator is positive for a and τ sufficiently low. Third, we have that β has a positive effect on E_F and a negative one on E_L. Also, since $E_L > 0$, we have $E_F > E_L$ for β sufficiently high. Fourth, we have $E_L > Fr$ for L large enough.

As a result the conditions (5) and (6) are satified for (i) τ and a sufficiently low, i.e. the

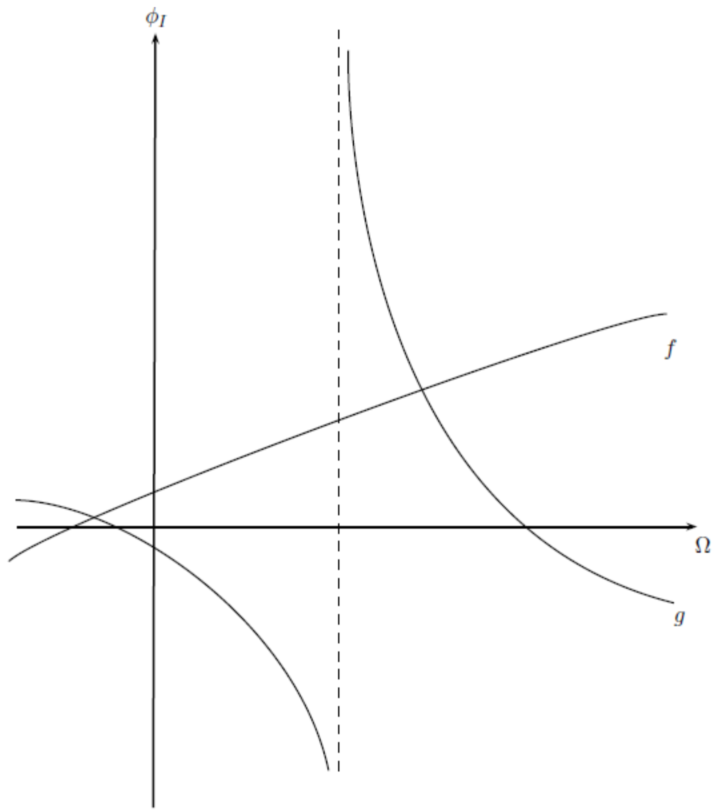


Figure 2: Steady state equilibrium

cost of the firms are not too high wich ensures their presence; (ii) L sufficiently high i.e. the market is sufficiently large; (iii) d sufficiently low and β sufficiently high i.e, the rich are rich enough to ensure the presence of the leader and the group of poors is large enough to ensure the presence of the follower. These conditions hence yield the coexistence of $R\&D$ undertaken by firms to become a Successful challenger or a Successful Incumbent.

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