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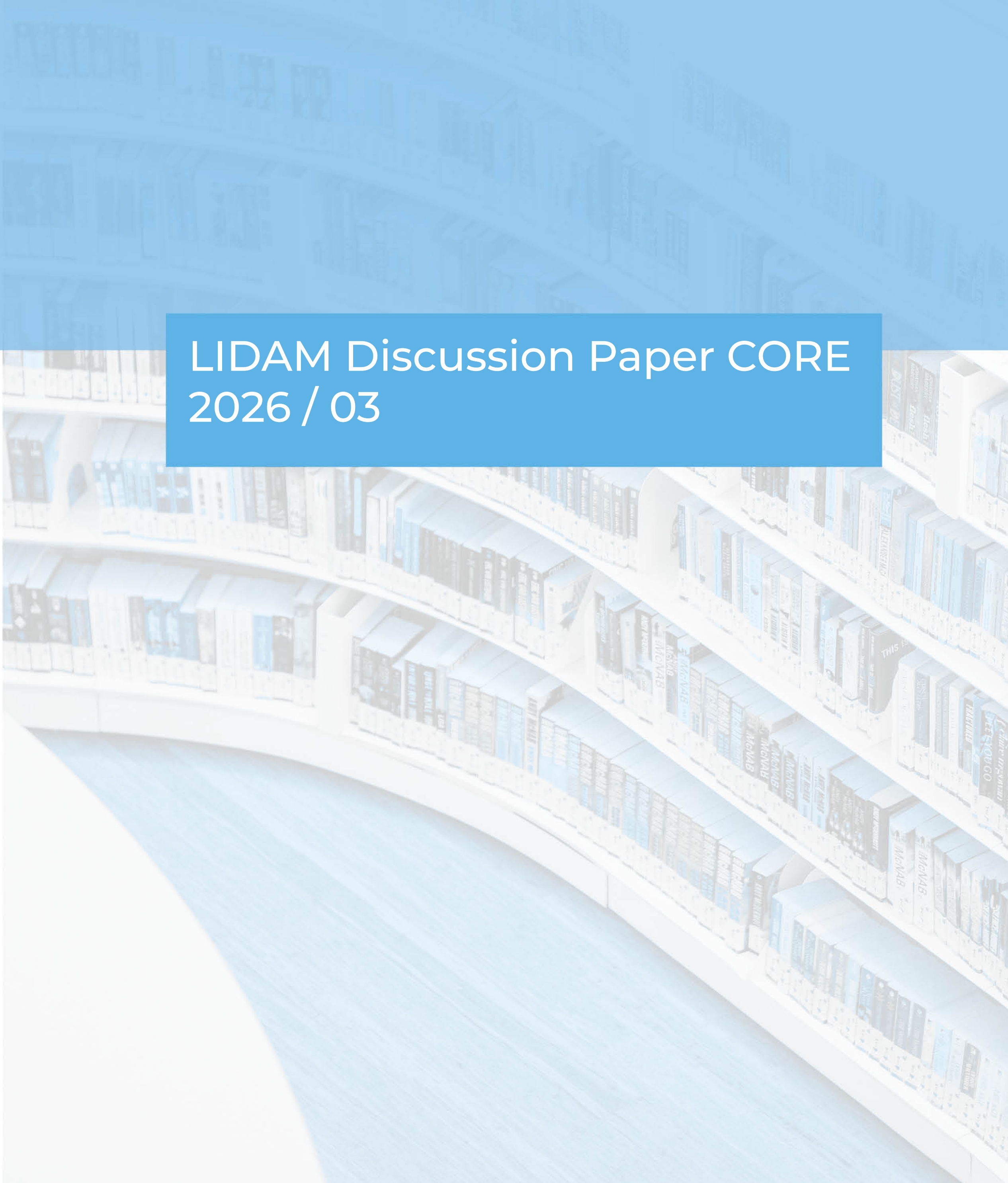
LIDAM Discussion Paper CORE
2026 / 03



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Oligopolistic output markets

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November 11, 2025

The overwhelming majority of macroeconomic models uses the assumption that output markets are perfectly competitive or else monopolistically competitive, in either case that output is supplied by insignificant firms, producing at a scale that is negligible when compared to the size of their respective markets. This view contrasts with the one prevailing in the 1930s, the period of formation of macroeconomic theory as an autonomous field (section 1). It is also in discrepancy with the simple observation of economies nowadays populated by large firms, some of them "superstars" (section 2). So, this view exhibits a problematic resilience that cannot be fully explained by the conceptual and analytic simplicity it allows. Indeed, the Dixit and Stiglitz (1977) general equilibrium model at the basis of New Keynesian macroeconomics can be straightforwardly adapted to a context of large firms while keeping much of its tractability (section 3). And it is easy to show that moving to such context of oligopolistic industries has serious implications for the analysis of major macroeconomic phenomena, like unemployment, or fluctuations and growth (section 4).

1 Guidelines from the Late Thirties

Contrary to a largely diffused belief, Keynes did not assume perfectly competitive output markets in the *General Theory*, but just a "given degree of competition" (Keynes 1936, p.245). The two fundamental postulates he attributed to the classical economics were formulated in terms which explicitly cover the case where "competition and markets are imperfect" (1936, p.5), a case concerning output markets for the first postulate and labour markets for the second. Admittedly however, imperfect competition in the output markets does not play a decisive role in the corpus of the *General Theory*. It was only after the Dunlop (1938) and Tarshis (1939) statistical observation that real wages and money wages *do not* move in opposite directions, in contradiction to what was stated in the *General Theory*, that Keynes came to take seriously the role of imperfect competition along the cycle, and not only inasmuch as the degree of competition is smaller than its upper limit, but also and principally inasmuch as "the degree of the imperfection of competition" may "fluctuate in the short period with the

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level of output" (Keynes 1939, p.50), "in the opposite direction" to be precise. This eventuality was explored by Kalecki (1938), quoted in Keynes (1939).[1]

Under increasing marginal costs, real wages fluctuate countercyclically if the degree of competition (or its inverse, the markup factor) is constant. Money wages, responding positively to increasing labour demand, fluctuate procyclically. Real and money wages are consequently supposed to move in opposite directions, as conjectured by Keynes. One way to reconcile theory and observation is to assume decreasing marginal costs, which is admissible if competition is imperfect. Another is to admit that the degree of competition fluctuates itself procyclically, hence that the markup factor decreases on the upswing, countering the latter's influence on money wages and thus nourishing (or, the other way round, expressing) price stickiness. Two major candidates to the status of *stylized facts* hence emerge from the preceding argument (in addition to the assumed procyclicality of money wages): price stickiness, which would become one of the distinctive features of New Keynesian macroeconomics half a century later,[2] and markup countercyclicality, also an important but far from dominant feature of New Keynesianism.[3]

Price stickiness was already a theme played in the late 1930s, in particular in the context of the empirical inquiry on entrepreneurs' behaviour conducted between 1936 and 1939 by the Oxford Economists' Research Group. According to the results of this inquiry (Hall and Hitch 1939) entrepreneurs resort to full-cost pricing, a practice consisting in the application of a markup factor to the *average total* cost of some *customary* output. This practice annihilates in itself the price variability along the business cycle, but combines in addition with other factors of price stickiness identified by the Oxford inquiry, namely the fact that "changes in price are frequently very costly, a nuisance to salesmen, and are disliked by merchants and consumers" and the fact that "there are conventional prices to which customers are attached" (Hall and Hitch 1939, p.22). More importantly still in the perspective of this chapter, producers' conjectures about their competitors' reactions may reinforce this tendency to price rigidity in oligopolistic markets: "Although producers do not know what their competitors would do if they cut prices, they fear that they would also cut. [By contrast,] although they do not know what competitors would do if they raised prices, they fear that they would not raise them at all or as much" (Hall and Hitch 1939, p.22). This asymmetry results into a perceived *kinked demand* curve, "the kink occurring at the point where the price, fixed on the 'full-cost' principle, actually stands" (Hall and Hitch 1939, pp.22-23). The kink translates into a discontinuity of the marginal revenue able to neutralise

[1] On the role played by imperfect competition in Keynes's theory, see Dos Santos Ferreira (2019), and more btoadly in the prewar theory of the business cycle, see d'Aspremont *et al.* (2011).

[2] See the first volume (*Imperfect Competition and Sticky Prices*) of Mankiw and Romer, eds (1991), which collects the main founding articles of this approach.

[3] See section VII of Mankiw and Romer, eds (1991), in its second volume (*Coordination Failures and Real Rigidities*). In this section, Stiglitz (1984) offers a concise overview of possible ways to reconcile theory and the obsevation of procyclical real wages. See also Rotemberg and Woodford (1991) on the cyclical markup behaviour.

the impact on the producer's optimal decisions of moderate demand and cost shocks: "Prices so fixed have a tendency to be stable. They will be changed if there is a significant change in wage or raw material costs, but not in response to moderate or temporary shifts in demand" (Hall and Hitch 1939, p.33).

While significant as a rationale for price rigidity, the kinked demand hypothesis has another possibly still more important implication. Since the kink occurs at some specific but somewhat *arbitrary* conventional price, it leads to equilibrium indeterminacy. As put by Sweezy, who introduced idependently the kinked demand hypothesis in the same year, "there may be any number of price-output combinations which constitute equilibriums in the sense that, ceteris paribus, there is no tendency for the oligopolist to move away from them. But which of these combinations will be actually established in practice depends upon the previous history of the case" (Sweezy 1939, p.573). We will consider in subsubsection 4.3.2 the role played by this indeterminacy, possibly coupled with path dependence, in the theory of economic fluctuations.

The type of producers' conjectures leading to the kinked demand is far from arbitrary, but is more easily rationalised when considered in the context of the business cycle, with deviations from ongoing prices more likely to occur upwards in expansion and downwards in recession, thus envisaged against each one of the two segments of the kinked demand curve in a different phase of the cycle. This contextualisation of the conjectural asymmetry at the basis of the kinked demand is strikingly argued in Abramowitz (1938):

> "When demand is increasing generally, an increased share of the market can be secured at the expense of a relatively small absolute decrease in the sales of rivals; but when demand is stationary or falling, all of one's gains must be at the expense of competitors. It is, moreover, not only more difficult to detach the old customers of a rival than to attract new customers, but rivals are likely to struggle harder to keep what they already have than to secure a proportionate part of an increase of demand" (Abramowitz 1938, p.206).

As a consequence, it can indeed be reasonably expected that a price cut by some producer is more likely to be met in recession than in expansion and,

> "[if] reductions in price are always met by rivals, the output which will maximize profits is that for which marginal cost equals marginal revenue, reckoned on the assumption that price-cuts are accompanied by appropriate reduction of rivals' prices. This definition of marginal revenue makes it the same for a single member of a market as for a unified monopoly" (Abramovitz 1938, p.193). So, "the stage of the cycle most likely to produce prices appropriate to monopoly is that of recession; while in the later stages of depression, and in revival and prosperity, forces appear to be present which tend to bring prices to the position appropriate to competition" (ibid., p.206).

These forces result from the fact that "business men are interested not only in exploiting, as well as they can, an established monopoly position within an industry" but that "they are interested, too, in increasing their share of the market" (ibid., p.196). The trade-off between these two motives tends to be resolved in favour of the collusive motive in recession, of the competitive motive in expansion, bringing about the markup countercyclicality suggested by the Dunlop-Tarshis observation. We shall come back to this point in subsubsection 4.3.2.

2 The prevalence of large firms

As we have shown, imperfect competition is present in modern macroeconomics from its very beginning in the late Thirties, principally in relation to the analysis of the cyclical behaviour of wages and prices, associated with markup countercyclicality and price stickiness. It is only forty years later that this research program has been reconstituted in the New Keynesian macroeconomics, essentially as a way to introduce nominal price stickiness by assuming adjustment costs, pending on price setting firms. After having explored a broader methodological agenda, the New Keynesian approach became more and more identified with the Dixit and Stiglitz (1977) modelling of monopolistic competition in output markets. Associated with CES aggregators, monopolistic competition results in markup constancy, strongly contrasting with the markup variability emphasized in the Thirties as recalled in particular by Rotemberg and Woodford (1992, 1999). It is possible to circumvent this limitation by assuming non-CES aggregators and, under some assumptions, it is even sometimes possible to say that "monopolistic competition mimics oligopolistic competition" (Parenti *et al.* 2017). Anyway, it is monopolistic and not oligopolistic competition that has become and remains the prevailing approach to imperfectly competitive markets in macro and trade general-equilibrium models. These models allow for increasing returns to scale and product differentiation, but, as well-emphasised by Neary (2016), "since they assume that firms are atomistic and do not engage in strategic behavior, they represent little advance in descriptive realism over models of perfect competition." Monopolistic competition represents the smallest step away from perfect competition.

But recently some further steps have been taken, and others should follow, all motivated, as in the Thirties, by some relevant *stylized* facts. Actually, there is a large number of extensive empirical works that have established those *stylized* facts. For instance, Hottman *et al.* (2016) investigate firm heterogeneity, focusing on the four components of firm-size distribution put forward by recent research in trade and macroeconomics (*e.g.*, Melitz 2003): marginal cost, quality or taste ("appeal" for short), markups and product scope (the number of products produced by a firm).[4] Parting from the standard monopolistic com-

[4] For their empirical investigation of multiproduct firms, they use a very fine classification of products based on "barcodes" and the data (for the US) provided by the Nielsen HomeScan database giving price and sales information for millions of products (instead of few thousands

petition approach, Hottman *et al.* (2016) introduce a model where some firms may be large in the industry defined by their product group, assumed separable from other product groups, thus allowing for strategic interactions in their market while excluding intergroup strategic interactions. We will come back to this type of model in the following section. The data presented by Hottman *et al.* show that a typical industry configuration is oligopolistic, consisting in a dominant subset of a few large multiproduct firms and a competitive fringe of small firms having trivial market shares (on average five firms produce half of all the output of the industry, and 98% of firms have market shares of less than 2%), but they exclude monopoly, the largest firm having only a market share of 22%.

In the recent empirical literature there is also a large amount of research about another *stylized* fact, reinforcing the general observation that many industries compete under oligopolistic conditions. There is large evidence that concentration has increased in the past two decades, clearly for the US economy but also, in varying degrees, for the rest of the world, with in the US a resulting increase in markups for the dominant firms. This increase in concentration is well documented in several recent studies, using different sets of data. For example, Grullon *et al.* (2019) argue that, in more than 75% of US industries, concentration has increased on the basis of Herfindahl-Hirschman indexes (HHi). Similarly, for Gutiérrez and Philippon (2017), the mean HHi has been increasing since the mid-nineties in the US.

There has been intense debate concerning these stylized facts and their economic consequences. First, a rise in concentration at the aggregate level is compatible with less concentration at the local level. A good example is Walmart, the largest US firm in 2015 and the largest in the retail industry, which has increased competition in localities where it has introduced its stores but, at the same time, has reinforced its dominant position by "massive investment in proprietary software to manage their logistics and inventory control" (Autor *et al.* 2020). From a methodological point of view, computing aggregate HHi only gives a very general picture. This is clearly documented in the work of Bighelli *et al.* (2023) where a European HHi is derived by aggregating country-specific concentration indices, using micro-aggregated panel data for 15 European countries. In line with findings for the US, they show a general increase in concentration in Europe, with some countries and some sectors playing a key role. Firm concentration only increases in 5 out of the 15 countries, and manufacturing is the main sector where this happens, in particular the German manufacturing sector. Concentration is declining in many other sectors, most importantly in the Information and Communications Technologies (ICT) sector, in contrast with the US evidence of an ICT sector dominated by internet giants.

However, the main empirical debate is about the economic interpretation of this rise in concentration, reminding the old "market power vs. efficiency" de-

with standard industry classifications), arguing that this is the relevant definition of a product since "any substantive change in product characteristics is accompanied by the introduction of a new barcode". Most (two-third) of these barcoded products are food items, but there are others like medications, housewares, detergents, and electronics.

bate from the late 1970s between the structure-conduct-performance school and the Chicago school of industrial economics (Bain 1951, Demsetz 1973).[5] Following the "didactic" terminology of Covarrubias *et al.* (2020), there is "good" concentration resulting from increasing competition and the superior efficiency of large firms, and there is "bad" concentration resulting from barriers to competition erected by dominant firms with increased market power. Analysing micro panel data from the U.S. Economic Census since 1982, Autor *et al.* (2020) argue in favour of a "good" concentration in the US industries, resulting from increasing market size and technological change. But others have presented arguments more in favour of "bad" concentration. Looking at the evolution of markups in the US, De Loecker *et al.* (2020) report a dramatic change in the distribution of markups since 1980: the upper tail has experienced a sharp rise.[6] Covarrubias *et al.* (2020) argue that barriers to entry (*e.g.* patents), weak antitrust policy and/or lobbying has decreased domestic competition in many US industries. More precisely, "good" concentration (as in the 1990s) may become "bad" (as after 2000), with increasing barriers to entry. As mentioned by Azar and Vives (2021), another *stylized* fact may also explain this evolution, showing a lack of antitrust enforcement: in the US there has been a dramatic increase of institutional investment (including mutual funds and index funds) especially in concentrated industries[7], *e.g.* airline and banking (see Azar *et al.* 2018).

Whether "good" or "bad," concentration has important macroeconomic implications. As well argued by Gabaix (2011), the oligopolistic behaviour of large and interdependent firms ("the incompressible “grains” of economic activity") is important at the aggregate level and has significant effects on growth, but also on other macroeconomic variables. This so-called *granularity hypothesis* is documented by him for the US, about one-third of variations in output growth being explained by idiosyncratic movements of the largest 100 firms. Likewise, di Giovanni and Levchenko (2012) show that lowering trade barriers favours the large most productive firms, increasing the granularity of the economy. The fat-tailedness of the distribution of firm sizes makes the central limit theorem unapplicable so that aggregate shocks do not count exclusively and idiosyncratic shocks to large firms and their interactions may affect not only their own market but the economy as a whole.

[5] This is well summarized in Martin (2002, chaps. 5 and 6).

[6] Barkai (2020), studying the US nonfinancial corporate business over the period 1984 to 2014, documents declines in both the labour share and the capital share in favour of a large increase in the share of pure profits, "indicative of an increase in market power and a decline in competition".

[7] As emphasized by Posner *et al.* (2017), in their proposal for new antitrust regulation, the “Big 3” asset managers: BlackRock, Vanguard, and State Street hold the largest proportion of shares for almost 90% of S&P 500 firms (they held only 25% in 2000).

3 General equilibrium with oligopolistic industries

Since the seminal work of Gabszewicz and Vial (1972) and the overview of Hart (1985), the difficulties of developing a general equilibrium model with oligopolistic competition that could be sufficiently tractable and could be used in international trade and macroeconomics have been well-recognized. The main difficulty is certainly to integrate strategic interactions among firms into a general equilibrium concept. In particular, the choice of the quantity or the selling price as the strategic variable of the firm (usually viewed as the choice between the Cournot and Bertrand approaches) may look arbitrary. The success and the tractability of Dixit and Stiglitz (1977) monopolistic competition model in so many areas is due to its ability to bypass these difficulties. This is achieved by a set of convenient assumptions. It is a two-sector general equilibrium model, with an imperfectly competitive sector producing differentiated goods and a perfectly competitive sector producing a homogenous good (taken as numeraire) and representing the rest of the economy. Each firm is assumed to have a negligible impact on its competitors (in the working paper version there is a continuum of firms), thus avoiding direct strategic interactions. It acts as a monopoly in its own niche and so the choice of the strategic variable is indifferent.

The main (testable) ingredient of this model is the separability assumption, introducing a subutility function on the bundles of differentiated goods. This function works as an aggregator transforming those bundles into volumes of a composite good. This separability implies the analysis "to depend on the intra- and intersector elasticities of substitution" (Dixit and Stiglitz 1977, p.297). In the standard case the intrasectoral elasticity of substitution is assumed constant. Another standard assumption is symmetry, concerning both the subutility function and the marginal and fixed costs of production of all goods.

The empirical evidence that we have summarised in the previous section, showing the prevalence of large firms, has quite naturally put in question the use of the full-fledged version of this model. But, in order to maintain analytical tractability, the transition from working with monopolistic competition to working with oligopolistic competition occurs very gradually. We shall distinguish three stages. In a first stage, the assumption that sectors are populated by negligible firms and the subutility symmetry assumption are maintained (the Chamberlin "large group" case), but the constancy of the elasticity of intrasectoral substitution is abandoned (Feenstra 2003, Zhelobodko *et al.* 2012, Parenti *et al.* 2017, Matsuyama and Ushchev 2022) and/or the heterogeneity of firms is allowed for (Melitz 2003, Melitz and Ottaviano 2008, Autor *et al.* 2020). Monopoliostic competition is maintained in a more sophisticated way, but strategic interdependencies remain excluded at this stage.[8] In a second stage, the model is extended to the multi-group case, each differentiated good being produced

[8] Boar and Midrigan (2023) use the Kimball aggregator and the associated demand system, which can be micro-founded by explicitly modeling oligopolistic competition (Atkeson and Burstein, 2008); see p.8. See also Edmond, Midrigan and Xu (2023).

by a group of firms and oligopolistic competition is explicitly introduced. But it is now the number of groups which is assumed large (typically a continuum), so that each firm is still negligible relative to the economy as a whole, and only intra-group interactions in some pre-defined strategic variable (price or quantity) are integrated.[9] In the third stage, the importance of big firms at the aggregate level (the granularity hypothesis) is acknowledged, hence the economy can no more be viewed as composed of negligible groups. Oligopolistic competition prevails with both intragroup and intergroup strategic interactions, as in Burstein *et al.* (2023).

3.1 Sophisticated monopolistic competition

In this subsection two steps that have been taken to generalise the Dixit-Stiglitz model will be mentioned while assuming symmetry and negligible firms. This is to allow first for a variable elasticity of intrasectoral substitution and, second, for some heterogeneity of firm productivity.

3.1.1 Variable elasticity of intrasectoral substitution

Since we remain in the Dixit-Stiglitz monopolistic competition model, although extended to variable elasticity of intrasectoral substitution, the choice of the strategic variable is still indifferent. So let us assume that firms are price-setters. All firms will not necessarily be active at equilibrium. We start by introducing notation that will be useful in the whole section and for that purpose suppose first a finite number of firms. We will then turn to the limit case of monopolistic competition.

We suppose a representative consumer with preferences represented by a separable utility function $U\left(X\left(\mathbf{x}\right), z\right)$, where $\mathbf{x} \in \mathbb{R}_{+}^{n}$ is the basket of n differentiated goods sold by the n firms in the imperfectly competitive sector, X is a sub-utility or aggregator function and $z \in \mathbb{R}_{+}$ is a good taken as numeraire and supplied to a perfectly competitive market.

The utility function U and the subutility function X are assumed increasing and strongly quasi-concave. The consumer inelastically supplies L units of labour at wage w and receives a profit Π from the imperfectly competitive sector (the equilibrium profit of the competitive sector is zero).[10] We thus have income $Y = wL + \Pi$. In the monopolistic competition case with free-entry the imperfectly competitive sector equilibrium profit Π also vanishes.

The consumer's programme can be solved in two stages. In a first stage, the consumer chooses the quantity x_i of each good i given some quantity $\underline{X}$ of the

[9] See Costa and Dixon (2011), Neary (2016), Hottman (2016), Atkeson and Burstein (2008), Burstein, Carvalho and Grassi (2023), Edmond, Midrigan and Xu (2023), Gnewuch (2022).

[10] The profit of the competitive sector is zero, either because the numeraire is a non-produced good or because it is assumed to be produced under constant returns to scale.

composite good:[11]

$$\min_{x\in\mathbb{R}^n_+}\left\{\mathbf{px}\,|X(\mathbf{x})\geq \underline{X}\right\}\equiv e(\mathbf{p},\underline{X})\ \text{(the expenditure function)}$$
$$\begin{aligned}p_i &= (\partial_X e(\mathbf{p},\underline{X}))\,\partial_i X(\mathbf{x})\equiv \underline{P}\ \partial_i X(\mathbf{x})\ \text{(FOC)}\\ x_i &= \partial_{p_i} e(\mathbf{p},\underline{X})\equiv H_i(\mathbf{p},\underline{X})\quad \text{(Shephard's lemma)}\end{aligned}$$

where $H_i(\mathbf{p},\underline{X})$ is the Hicksian demand. In the second stage, the consumer chooses the quantities $\underline{X}$ of the composite good and z of the numeraire good:

$$\max_{(\underline{X},z)\in\mathbb{R}^2_+}\left\{U(\underline{X},z)\,|e(\mathbf{p},\underline{X})+z\leq Y\right\}.$$

The solution determines the *Marshallian demand* $\underline{X}=D(\mathbf{p},Y)$ for the composite good and the demand $z=Y-e(\mathbf{p},D(\mathbf{p},Y))$ for the numeraire good. We denote $\alpha_i\equiv\epsilon_i X(\mathbf{x})$ the impact of a variation in the quantity of good i on the volume of the composite good and $\beta_i\equiv\epsilon_X H_i(\mathbf{p},\underline{X})$ the impact of a variation in the volume of the composite good on the demand for good i, at prices. The two elasticities of substitution which play a fundamental role in the analysis can now be introduced. The *intrasectoral elasticity of substitution* of good i for the composite good can be equivalently defined in dual terms (by referring to FOC and Shephard's lemma):

$$s_i\equiv-\frac{\partial(x_i/\underline{X})}{\partial(p_i/\underline{P})}\frac{p_i/\underline{P}}{x_i/\underline{X}}=\frac{1-\alpha_i}{-\epsilon_i\partial_i X(\mathbf{x})}=\frac{-\epsilon_i H_i(\mathbf{p},\underline{X})}{1-\alpha_i\epsilon_X H_i(\mathbf{p},\underline{X})}.$$

As to the *intersectoral elasticity of substitution* of good i for aggregate consumption Y, it can be defined as:

$$\sigma_i\equiv-\left.\frac{d(x_i/Y)}{d(p_i/1)}\right|_{X(\mathbf{x})=D(\mathbf{p},Y)}\frac{p_i/1}{x_i/Y}=\frac{-\epsilon_{p_i}D(\mathbf{p},Y)}{\alpha_i}.$$

Letting $Q_i(\mathbf{p},Y)\equiv H_i(\mathbf{p},D(\mathbf{p},Y))$ denote the Marshallian demand for good i, a *price equilibrium* p^* is solution to the following programme for each firm i, with c_i the unit cost and ϕ_i the fixed cost of firm i (only incurred at a positive output)

$$\max_{p_i\in[c_i,\infty)}(p_i-c_i)\,Q_i((p_i,\mathbf{p}_{-i}),Y^*),$$

with $Y^*=wL+\sum_{i=1}^n((p_i^*-c_i)\,x_i^*-\phi_i)\geq wL$, $x_i^*=Q_i\left(\left(p_i^*,\mathbf{p}_{-i}^*\right),Y^*\right)$. We let n^* denote the number of active firms at equilibrium. The first order conditions for the price equilibrium lead, for each firm i, to the Lerner index of degree of monopoly

$$\mu_i^*\equiv\frac{p_i^*-c_i}{p_i^*}=\frac{1}{(1-\alpha_i^*\beta_i^*)\,s_i^*+\alpha_i^*\beta_i^*\sigma_i^*},$$

[11] In the following, we will denote:

$$\partial_x f(x,y)\equiv\frac{\partial f(x,y)}{\partial x}\ \text{and}\ \epsilon_x f(x,y)\equiv\frac{\partial f(x,y)}{\partial x}\frac{x}{f(x,y)}$$

the *partial derivative* of f with respect to x, at (x,y), and the corresponding *elasticity*, respectively.

equal to the harmonic mean of $1/s_i^*$ and $1/\sigma_i^*$, with weights respectively equal to $1-\alpha_i^*\beta_i^*$ and $\alpha_i^*\beta_i^*$.

Consider now the limit case of an infinite number of symmetric firms (the "large group" case in Chamberlin's sense). Following the literature (*e.g.* Zhelobodko *et al.* 2011, Parenti *et al.* 2017, Matsuyama and Ushchev 2022), we may assume a continuum of horizontally differentiated varieties indexed by $i \in [0, n]$ (where n is the mass of firms) and a symmetric subutility function X, as well as uniform costs $c_i = c$ and $\phi_i = \phi$ for any i. In that case the elasticity α_i^* of the subutility X vanishes and the first order condition reduces to

$$\mu_i^* = \frac{1}{s_i^*},$$

erasing the intersectoral effects on firm behaviour.

Also, when α_i vanishes, we obtain for the elasticity of intrasectoral substitution in a symmetric equilibrium $\mathbf{x}^*$:

$$s^* = \frac{\partial_i X\left(\mathbf{x}^*\right)}{-\partial_{ii}^2 X\left(\mathbf{x}^*\right) x^*} \equiv \frac{1}{r_X\left(x^*\right)},$$

where $r_X\left(x^*\right)$ is the Arrow-Pratt measure of relative risk aversion applied to the sub-utility function X along the diagonal. This value can be interpreted as the *relative love for variety* (see Zhelobodko *et al.* 2011), varying inversely with substitutability: the more you love variety the less you are prone to substitute a good for another.

In general, at a symmetric equilibrium, the elasticity of intrasectoral substitution is a function $s\left(x^*, n^*\right)$ of the symmetric consumption level x^* and the mass n^* of active firms. As emphasised by Parenti *et al.* (2017) it characterises the preferences along the diagonal and hence can be taken as the primitive of the model: $s\left(x^*, n^*\right)$ is sufficient to characterise symmetric free-entry equilibria, satisfying $\left(p^*-c\right) x^* = \phi$. On this basis they show the ability of the extended versions of the Dixit-Stglitz model allowing for variable elasticity of substitution (VES) to replicate the behaviour of oligopolistic competition. For instance, assuming $s\left(x^*, n^*\right)$ nonincreasing in x^* and increasing in n^*, generates a pro-competitive effect of an increase in the mass of firms and a lower markup and larger consumption resulting from a higher income. The properties of $s\left(x^*, n^*\right)$ are directly linked to the properties of the sub-utility.

If the sub-utility $X\left(\mathbf{x}\right)$ is homothetic, its derivative with respect to x_i is homogeneous of degree 0, depending only on $x_i/X\left(\mathbf{x}\right)$, hence on n^* in a symmetric equilibrium. Thus, in this case, the elasticity of substitution s evaluated at a symmetric consumption profile depends solely on the mass n^* of available products. If the sub-utility is additive, say $X\left(\mathbf{x}\right) = \int_0^n u\left(x_i\right) di$, its derivative with respect to x_i depends only on x_i, hence on the per capita consumption x^* in a symmetric equilibrium. Zhelobodko *et al.* (2011) showed in this additive case that both pro-competitive and anti-competitive effects can be obtained depending on the love for variety $r_u\left(x\right) = -\, xu''\left(x\right)/u'\left(x\right)$ being increasing or decreasing in the level of consumption, itself varying inversely with n^*.

If the subutility is a sum of power functions, it is both homothetic and additive, hence s is constant, resulting in a constant equilibrium price $p^* = c/(1-\mu^*) = c/(1-1/s)$ of the composite good, independent of the number of firms and of the consumption level. Feenstra (2003), with homothetic translog subutility, and Melitz and Ottaviano (2008), with quadratic sub-utility, get a variable elasticity of substitution in consumption and in the number of firms (with pro-competitive effects). These results, obtained by choosing adequately the variable elasticity of substitution (VES), led Thisse and Ushchev (2018) to conclude: "The VES model of monopolistic competition is able to mimic key results of oligopoly theory. To a certain extent, we therefore find the dichotomy between oligopolistic and monopolistic competition unwarranted (p.95)." However, such a sharp conclusion can only be verified by building a full oligopolistic macroeconomic model beforehand.

3.1.2 Introducing firm heterogeneity

A further generalisation of the monopolistic competition model can be obtained by introducing firms with heterogeneous productivity in a way opened by Melitz (2003). This is to assume that there is a probability distribution G of unit costs defined on some interval $[0, c^{\max})$ and that firms are in some sort behind a "veil of ignorance": each firm has to decide whether to enter or not without knowing its unit cost and, if entering, has to pay an entrance fee ϕ^E. With a continuum of firms the consumer's demand to a firm with unit cost c, choosing the price p, can be denoted $Q_c((p, \mathbf{p}), Y)$. Notice that the price distribution $\mathbf{p}$ and the total income Y are here economy-wide elements which cannot be affected by an infinitesimal firm. Using the notations $\Pi^*(c)$ for the equilibrium profit of a firm with unit cost c ($\Pi^*(c) \equiv \max_{p\in[c,\infty)} (p-c)\, Q_c((p, \mathbf{p}^*), Y^*)$) and c^0 for the cut-off unit cost ($\Pi^*(c^0) = 0$), the *ex-ante* condition for entry is

$$\int_0^{c^0} \Pi^*(c)\, dG(c) \geq \phi^E,$$

with equality at a free-entry equilbrium. The cut-off unit cost c^0 can be taken as the (inverse) measure of the *market toughness*, since it will exclude from activity all firms drawing a unit cost which exceeds it.

Denoting by p_c^* and x_c^* the equilibrium price and quantity of a firm with unit cost c ($x_c^* = Q_c((p_c^*, \mathbf{p}^*), Y^*)$) and by n^* the equilibrium mass of firms (or consumed varieties), the first order condition for the maximisation of Π is at equilibrium

$$x_c^* = (p_c^* - c)\left(-\partial_{p_c} Q_c((p_c^*, \mathbf{p}^*), Y^*)\right).$$

Assuming with Melitz and Ottaviano (2008) quadratic subutility X, hence quasi-linear demand $Q((p_c^*, \mathbf{p}^*), Y^*) = a - bp_c^*$, this first order condition expresses an increasing linear relation $x_c^* = b(p_c^* - c)$ between the output and the markup: bigger firms set higher markups. More precisely, we may compute (in terms of the cut-off and the drawn unit costs):

$$x_c^* = \frac{b}{2}\left(c^0 - c\right),\; p_c^* = \frac{c^0 + c}{2} \text{ and } \Pi^*(c) = \frac{b}{4}\left(c^0 - c\right)^2.$$

More productive firms (with a lower c) are bigger, set lower prices (but higher markups) and earn higher profits. Tougher markets (with a lower c^0) lead to lower output (less active firms too), prices and profits.

We see that a sophisticated approach to monopolistic competition already allows to take into account differences in firm size and profitability, in spite of the basic assumption of negligible firms.

3.2 Monopolistic competition across groups but oligopolistic competition within

Up to now we have focused on a pure monopolistic competition approach, assuming a large number (even a continuum) of producers of differentiated goods, each acting as a monopoly. In this approach, negligible firms do not engage in strategic behavior and all interactions are dissolved in some macro parameters, taken as given by each individual firm. Large "superstar" firms may be introduced in this approach but it remains true that "entry is never difficult and firm behavior is never strategic" (Neary 2016, p.687).

It is the merit of Peter Neary to have defended brilliantly in a sequence of papers an intermediate approach pursuing the "new trade theory agenda of integrating international trade with industrial organization" and introducing his concept of General Oligopolistic Equilibrium (GOLE). We shall briefly present this approach on the basis of Neary (2016) which is his last and most comprehensive model in the sequence.[12] It is a general equilibrium model including oligopolistic markets for goods and a competitive labor market. A continuum of goods is still assumed, but now associating with each good k a finite group $\mathcal{N}_k$ of producers forming an "industry" (with $\#\mathcal{N}_k = n$ for every k for simplicity). Hence firms are large in their industry but small in the economy. The aggregator $\widetilde{X}(\mathbf{X})$ is assumed additively separable: $\widetilde{X}(\mathbf{X}) = \int_0^1 u(X_k)\,dk$. Moreover, to allow for an explicit solution[13] in the multi-country context with a representative consumer per country, u is assumed quadratic: $u(X_k) = aX_k - \frac{1}{2}bX_k^2$. Maximising $\widetilde{X}$ in X_k under the budget constraint $\int_0^1 P_k X_k dk \leq Y$ one gets linear inverse and direct "perceived" demand functions

$$P_k = \frac{1}{\lambda}(a - bX_k) \text{ and } X_k = \frac{1}{b}(a - \lambda P_k),$$

where the Lagrange multiplier λ is supposed to be taken as a given (as a demand shifter parameter) by the firms. Since $P_k X_k = \left(aP_k - \lambda P_k^2\right)/b$ and $\int_0^1 P_k X_k dk = Y$, we get the expression for the marginal utility of income:

$$\lambda = \frac{a\mu_1^p - bY}{\mu_2^p},$$

[12] For a survey of Neary's work on General Oligopolistic Equilibrium see Colacicco (2015).

[13] More generally, we need additive and quasi-homothetic preferences. The assumption in the text is a special case that Neary calls "continuum-quadratic preferences."

with $\mu_1^P = \int_0^1 P_k dk$ and $\mu_2^P = \int_0^1 P_k^2 dk$ the first and second moments of the price distribution.[14] Since λ is taken as given by the firms it is convenient to let $\lambda = 1$ and hence to have the marginal utility of total income playing the role of numeraire.

At a General Oligopolistic Equilibrium, Cournot competition is assumed in each industry. So, in each group k, the law of one price applies and each firm $i \in \mathcal{N}_k$ acts as a monopolist maximizing its profit Π_i^k in x_i^k, the quantity it produces, relative to a residual demand $D^k(P_k) - \sum_{j \in \mathcal{N}_k \setminus \{i\}} x_j^k$, where $D^k(P_k) = (a - P_k)/b$. By symmetry, and with unit cost c_k, the first order condition leads to

$$\frac{P_k - c_k}{P_k} = \frac{1}{n} \frac{1}{\sigma(P_k)}, \text{ with the elasticity } \sigma(P_k) = \frac{P_k}{a - P_k}.$$

Therefore, the Cournot price P_k^{C} and the Cournot per firm production x_k^{C} in industry k can be computed to be, respectively,

$$P_k^{\mathrm{C}} = \frac{a + nc_k}{n+1} \text{ and } x_k^{\mathrm{C}} = \frac{a - c_k}{b(n+1)}.$$

This can be linked to the labour market by assuming, in each industry k, a fixed labour input γ_k per unit output so that $c_k = w\gamma_k$ and, at a GOLE, the wage (common to all industries) is such that the labour market must clear:

$$L = \int_0^1 n\gamma_k x_k^{\mathrm{C}} dk = \int_0^1 \frac{\gamma_k (a - w\gamma_k) n}{b(n+1)} dk.$$

Integrating the last expression one can obtain the equilibrium wage

$$w = \left(a\mu_1^\gamma - \frac{n+1}{n} bL \right) \frac{1}{\mu_2^\gamma},$$

where $\mu_1^\gamma = \int_0^1 \gamma_k dk$ and $\mu_2^\gamma = \int_0^1 \gamma_k^2 dk$ denote the first and second moments of the technological distribution. We see that the wage is increasing in n, so that a pro-competitive policy raises the wage rate. Also, using this formula as well as the equilibrium quantities, we can compute the aggregate profit of all industries

$$\Pi = \left(\frac{na^2 \left(\mu_2^\gamma - (\mu_1^\gamma)^2 \right)}{b(n+1)^2} + \frac{bL^2}{n} \right) \frac{1}{\mu_2^\gamma},$$

which is decreasing in n, so that a pro-competitive policy raises the wage share of national income.

[14] "Like all members of the Gorman polar form family, quadratic preferences as in (5) imply that all income–consumption curves are linear (though not necessarily through the origin) so tastes are homothetic at the margin. Hence they allow for consistent aggregation over individuals, or, in a trade context, countries, with different incomes, provided the parameter b is the same for all" (Neary 2016, p.673).

In this multi-group context, there is another natural way of generalising the Cournot solution without assuming a continuum of industries and symmetry within each industry. It builds upon an essential feature of Cournot's approach for homogeneous goods, the "law of one price," now adapted to the multiproduct case. In Cournot's words, "the price is necessarily the same" for all firms supplying the same market. This amounts to consider the demand function as a vector-valued function $\mathbf{D}$ of the vector of prices $\mathbf{P} = (P_k)_{k=1}^{K}$ of all the homogeneous goods

$$\mathbf{D}(\mathbf{P}, Y) = \left(D^1(\mathbf{P}, Y), ..., D^k(\mathbf{P}, Y), ..., D^K(\mathbf{P}, Y)\right),$$

with $P_k \geq 0$ and $D^k(\mathbf{P}, Y) \geq 0$ for $k = 1, ..., K$, and Y denoting the consumer's income. In each industry the finite set $\mathcal{N}_k$ of firms produce the same homogeneous good. Each producer $i \in \mathcal{N}_k$ can supply a quantity x_i^k produced at a unit cost c_i^k. Firms in each group are accordingly assumed to behave *à la* Cournot within the group, taking as given the price indices of other groups. This may be called "Cournotian monopolistic competition" since a firm is considered to be large in its own group but small economy-wide. A way to view this Cournotian competition in each group k, is to suppose that each firm i acts as a monopoly, manipulating the price P_k and choosing a quantity x_i^k so as to obtain the monopoly solution on the residual group demand curve $D^k\left(P_k, \mathbf{P}_{-k}^*, Y^*\right) - \sum_{j \neq i} \mathbf{x}_{-j}^{k*}$, taking as given its direct rivals' equilibrium quantities and the equilibrium market price of each other good. We get a concept introduced in d'Aspremont *et al.* (1991, 1997):[15] producers play Cournot in the markets for their own products, taking other goods prices as given. In the limit case of a continuum of groups, we get back to Neary general oligopolistic equilibrium (GOLE) if we assume continuum-quadratic preferences. Dixit-Stiglitz monopolistic competition is obtained if all groups are singletons.

3.3 Intra- and inter-group oligopolistic competition under granularity.

As well argued in Gabaix (2011) firm-level shocks can generate aggregate fluctuations. This is further analysed by Burstein *et al.* (2023) who study markup cyclicality in a granular macroeconomic model with oligopolistic competition. For that purpose, they suppose a finite number of groups (in contrast to the continuum of sectors assumed in Atkeson and Burstein 2008) and a discrete number of firms per group. Following granular firm-level shocks, they focus not only in sector and economy-wide output fluctuations, but on the cyclical behavior of markups generated by these fluctuations. This is analysed both theoretically and empirically (based on French administrative data) at three levels: the firm, the sector and the economy-wide level. Their main conclusion is that "the introduction of variable markups dampens granular aggregate volatility". So their model represents an important step in integrating strategic interactions among big firms in a general equilibrium model. However, the other

[15] See also Costa (2004) and Costa and Dixon (2011).

difficulty facing such a model, that of choosing the strategic variable (price vs quantity), remains. They propose to formulate the equilibrium conditions under both approaches (Bertrand and Cournot), but focus on the case of Cournot competition "because it generates more markup variation than Bertrand and is thus better able to match estimates of incomplete pass-through and markup-size relationship"(Burstein *et al.* 2023, p.7).

Without developing the full Burstein *et al.* (2023) theoretical dynamic model, we can show how the static version of their model, as well as our models of the previous subsections (the single-group price-competition model of subsection 3.1 and the multi-group Cournotian monopolistic model of subsection 3.2) can be integrated in a larger general equilibrium oligopolistic model with a finite number of groups and a discrete number of firms. In such a model we will assume that firms adopt strategy pairs, namely price-quantity pairs. This larger model allows for product differentiation and strategic interactions both at the intra- and inter-group level and inbeds the choice of the strategic variable in a more general setting where firms may exhibit different degrees of "competitive toughness" allowing for a continuum of competitive regimes, price and quantity competition being two particular possibilities.

3.3.1 A general equilibrium oligopolistic model

To keep the model tractable and simplify firms quantity conjectures, we first extend the separability assumption introduced by Dixit and Stiglitz on the representative consumer's utility function to the multi-group case by assuming that the subutility function X is itself separable: $X(\mathbf{x}) \equiv \widetilde{X}\left(X_1\left(\mathbf{x}^1\right), ..., X_K\left(\mathbf{x}^K\right)\right)$, meaning that the set of N differentiated goods can be partitioned into K groups $\mathcal{N}_k$ $(k = 1, ..., K)$, each group being aggregated into a composite good through the corresponding aggregator function X_k. For instance, in Burstein *et al.* (2023) model, $\widetilde{X}$ is assumed to be a CES aggregator[16] and, as in Atkeson and Burstein (2008), each X_k is assumed to be a CES aggregator[17] for group k.

More generally, the utility function of the representative consumer can be simply written as

$$\widetilde{U}\left(X(\mathbf{x}), z\right) = U\left(X^1\left(\mathbf{x}^1\right), ..., X^K\left(\mathbf{x}^K\right), z\right),$$

where X^1,..., X^K are increasing functions. Thanks to separability, we still consider two stages when solving the utility maximisation programme. Minimising

[16] This is:

$$\widetilde{X}\left(X_1\left(\mathbf{x}^1\right), ..., X_K\left(\mathbf{x}^K\right)\right) \equiv \sum_{k=1}^{K}\left(A_k^{1/\sigma} X_k^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)},$$

where A_k is a demand shifter to be used in their calibration exercise.

[17] This is:

$$X_k\left(\mathbf{x}^k\right) \equiv \sum_{k=1}^{K}\left(A_{ki}^{1/s}\left(x_i^k\right)^{(s-1)/s}\right)^{s/(s-1)},$$

where A_{ki} is a firm-quality shifter. It is assumed that $\sigma < s$ so that "with a finite number of sectors and a discrete number of firms per sector, firm-level shocks can generate aggregate fluctuations as in Gabaix (2011)".

the expenditure on each composite good $X^k\left(\mathbf{x}^k\right)$, $k=1,...,K$, one obtains $e^k\left(\mathbf{p}^k, X_k\right)$, the *expenditure function in group* k and the *Hicksian demand function* $H_i^k\left(\mathbf{p}^k, X_k\right)$ for good i in group k. Maximising $U\left(X_1,...,X_K,z\right)$ under the budget constraint $\sum_{k=1}^K e^k\left(\mathbf{p}^k, X_k\right)+z\leq Y$, one obtains $D^k\left(\mathbf{p}^1,...,\mathbf{p}^K,Y\right)$, defining the *Marshallian demand function* D^k for each k, and

$$z=Y-\sum_{k=1}^K e^k\left(\mathbf{p}^k, D^k\left(\mathbf{p}^1,...,\mathbf{p}^K,Y\right)\right).$$

Also, for tractability, we assume homotheticity (for the particular case of Cournotian Monopolistic Competition we assume perfect substitutability in each group), thus preserving the associated simplification of firms price conjectures. The functions X^k $(k=1,...,K)$ being homogeneous of degree one, the expenditure function is linear in the utility level: $e^k\left(\mathbf{p}^k, X_k\right)=P^k\left(\mathbf{p}^k\right)X_k$, with $P^k\left(\mathbf{p}^k\right)$ viewed as a price index for group k, and the Hicksian demand function for the group k is linear in X_k: $H_i^k\left(\mathbf{p}^k, X_k\right)=\partial_i P^k\left(\mathbf{p}^k\right)X_k$ (by Shephard's lemma). Hence, the Marshallian demand is separable in prices and linear in income: $D^k\left(\mathbf{p},Y\right)=\widetilde{D}^k\left(P^1\left(\mathbf{p}^1\right),...,P^K\left(\mathbf{p}^K\right)\right)Y$ and producers in each group may be assumed to conjecture price index values for the other groups.

3.3.2 A general oligopolistic equilibrium

Although in each group k there are now N_k firms, each producing a differentiated good i at unit (labour) cost c_i^k and fixed (labour) cost ϕ_i^k, we keep, for the moment, the simple description of the labour market given above where the consumer inelastically supplies L units of labour at a wage equal to 1 (the numeraire good is assumed to be produced by labour under constant returns to scale on a one to one basis). Hence the consumer income is $Y=L+\Pi$ where Π is the profit from the imperfectly competitive sector (the equilibrium profit of the competitive sector is nil). Our definition of equilbrium is based upon interpreting the Cournot-Bertrand debate as the opposition, for the non-cooperative producers involved, between competition for market size (Cournot), which is in their common interest, and competition for market shares (Bertrand), which expresses their conflicting interests. Every firm i in every group k behaves strategically in price-quantity pairs, $\left(p_i^k, x_i^k\right)\in\mathbb{R}_+^2$ and, at an *oligopolistic equilibrium,* maximises its profit $\left(p_i^k-c_i^k\right)x_i^k-\phi_i^k$ under two constraints:

(i) a *constraint on market share* (referring to competition within group k and to the first stage of the consumer's utility maximisation), *i.e.* $x_i^k\leq\partial_i P^k\left(p_i^k,\mathbf{p}_{-i}^{k*}\right)X^k\left(x_i^k,\mathbf{x}_{-i}^{k*}\right)$, anticipating the equilibrium strategies of other firms in group k.

(ii) a *constraint on market size* (referring to competition with other firms in all groups, as well as with competitive firms in the other sector and to the second stage), *i.e.* $X^k\left(x_i^k,\mathbf{x}_{-i}^{k*}\right)\leq\widetilde{D}^k\left(P^{1*},...,P^k\left(p_i^k,\mathbf{p}_{-i}^{k*}\right),...,P^{K*}\right)Y$.

At equilibrium, profits should be non-negative, namely $\left(p_i^{k*}-c_i^k\right)x_i^{k*}-\phi_i^k\geq 0$, and the consumer non-rationed (hence the constraints hold as equalities).

Several variants can be considered according to the degree in which each firm internalises the effect of its strategic choice on the aggregate income Y, the so-called income feedback effects (Hart 1985) or Ford effects[18] (d'Aspremont *et al.* 1989a, 1990, d'Aspremont and Dos Santos Ferreira 2017). If firm i has a myopic income-taking behavior, aggregate income is supposed to be fixed at its equilbrium value, *i.e.*

$$Y = Y^{*} = L + \sum_{k=1}^{K} \sum_{i=1}^{n_k} \left(\left(p_i^{k*} - c_i^k \right) x_i^{k*} - \phi_i^k \right) \text{ (no Ford effects).}$$

Alternatively, if firm i has a farsighted behavior taking into account all income feedback effects (full[19] Ford effects), then

$$Y = Y^{*} = z^{*} + \sum_{k=1}^{K} \sum_{\{j \in \mathcal{N}_k : j \neq i\}} p_j^{k*} x_j^{k*} + p_i^k x_i^k \text{ (full Ford effects).}$$

3.3.3 The no Ford-effects case

In characterising the oligopolistic equilibrium by looking at the first order condition, two elasticities are crucial, as in the Dixit-Stiglitz model (but now groupwise): the *intragroup* elasticity of substitution s_i^k, which is the elasticity of $x_i^k / X^k \left(\mathbf{x}^k \right) = \partial_i P^k \left(\mathbf{p}^k \right)$ (at equilibrium) with respect to $p_i^k / P^k \left(\mathbf{p}^k \right)$, hence $s_i^k = -\epsilon_i \left(\partial_i P^k \left(\mathbf{p}^k \right) \right) / \left(1 - \alpha_i^k \right)$ (with $\alpha_i^k = \epsilon_i P^k \left(\mathbf{p}^k \right) = \epsilon_i X^k \left(\mathbf{x}^k \right) = p_i^k x_i^k / P^k \left(\mathbf{p}^k \right) X^k \left(\mathbf{x}^k \right)$ by homothetic separability), and σ^k the *intergroup* elasticity of substitution σ^k (identical firm-wise with homothetic separability), which is the elasticity of $X^k \left(\mathbf{x}^k \right) / Y = \widetilde{D}^k \left(P^k \left(\mathbf{p}^k \right), \mathbf{P}^{-k} \right)$ (at equilibrium) with respect to $P^k \left(\mathbf{p}^k \right) / 1$, hence $-\epsilon_k \widetilde{D}^k \left(\mathbf{P} \right)$, with both elasticities in absolute values. Let $\left(\mathbf{p}^{k*}, \mathbf{x}^{k*} \right)_{k=1,\ldots,K}$ be an oligopolistic equilibrium in the no Ford-effects case. Then, from the first order conditions for profit maximisation, the relative markup of each firm i in each group k is derived as the weighted harmonic mean of the reciprocals of the two elasticities s_i^{k*} and σ^{k*}:

$$\frac{p_i^{k*} - c_i^k}{p_i^{k*}} = \frac{\theta_i^{k*} \left(1 - \alpha_i^{k*} \right) + \left(1 - \theta_i^{k*} \right) \alpha_i^{k*}}{\theta_i^{k*} \left(1 - \alpha_i^{k*} \right) s_i^{k*} + \left(1 - \theta_i^{k*} \right) \alpha_i^{k*} \sigma^{k*}} \equiv \mu_i^{k*},$$

[18] "I believe in the first place that, all other considerations aside, our own sales depend in a measure upon the wages we pay. If we can distribute high wages, then that money is going to be spent and it will serve to make storekeepers and distributors and manufacturers and workers in other lines more prosperous and their prosperity will be reflected in our sales. Country-wide high wages spell country-wide prosperity, provided, however, the higher wages are paid for higher production" (Henry Ford 1922, p.124).

[19] In Appendix A.8, Burstein *et al.* (2023) solve for markups in the case in which each firm maximises real profits internalising the effect of their individual choice of output or prices on aggregate output and the real wage, thus relaxing our baseline behavioural assumption. Firms do not internalise, however, the impact that changes in profits have on the welfare of the firm's owner (Azar and Vives 2021).

where $\theta_i^{k*} \equiv \lambda_i^{k*} / \left(\lambda_i^{k*} + \nu_i^{k*}\right) \in [0,1]$, with λ_i^{k*} and ν_i^{k*} the Lagrange multipliers associated with the constraints on market share and on market size, respectively. Hence θ_i^{k*}, the relative shadow price of relaxing the constraint that reflects the conflictual side of competition, measures the "*competitive toughness*" displayed by firm i in group k at the equilibrium.

The vector $\boldsymbol{\theta}^{k*} = \left(\theta_1^{k*}, ..., \theta_{n_k}^{k*}\right)$ of the competitive toughnesses of the different active firms in group k specifies a *regime of competition*, which can be continuously modified by varying this vector in $[0,1]^{n_k}$. By varying $\boldsymbol{\theta}^{k*}$, standard regimes like price and quantity equilbria ($\theta_i^* = 1/2$ and $\theta_i^{k*} = 1/\left(1 + s_i^{k*}/\sigma^{k*}\right)$, respectively, for any active firm i in group k), or the collusive solution ($\boldsymbol{\theta}^{k*} \equiv \mathbf{0}$) can be considered.[20] However, existence of the whole spectrum of potential equilibria (for all values of $\boldsymbol{\theta}^{k} \in [0,1]^{n_k}$) is generally not satisfied.

To summarise, the main competition regimes can be presented under homothetic separability in the following table:

Competition regime	Competition toughness (all i)	Markup (all i)
Collusion	$\theta_i^{k*} = 0$	$\mu_i^{k*} = 1/\sigma^{k*}$
Quantity competition	$\theta_i^{k*} = 1/\left(1 + s_i^{k*}/\sigma^{k*}\right)$	$\mu_i^{k*} = (1-\alpha_i^*)/s_i^{k*} + \alpha_i^*/\sigma^{k*}$
Price competition	$\theta_i^{k*} = 1/2$	$\mu_i^{k*} = 1/\left[(1-\alpha_i^*) s_i^{k*} + \alpha_i^* \sigma^k\right]$
Monopolistic competition	$\theta_i^{k*} > 0$ and $\alpha_i^{k*} \simeq 0$	$\mu_i^{k*} = 1/s_i^{k*}$
	or $\theta_i^{k*} = 1$	$\mu_i^{k*} = 1/s_i^{k*}$
Perfect competition	$\theta_i^{k*} > 0$ and $\alpha_i^{k*} \simeq 0,$	$\mu_i^{k*} = 0$
		(with $\lim_{n_k \to \infty} \left(1/s_i^{k*}\right) = 0$)

3.3.4 The full Ford-effects case

With full Ford-effects, a similar formula may be derived from first order conditions. The relative markup μ_i^{k*} is again the weighted harmonic mean of the reciprocals of the intra- and intergroup elasticities of substitution. The intragroup elasticity of substitution s_i^{k*} and the weight $\theta_i^{k*}\left(1 - \alpha_i^{k*}\right)$ on its reciprocal are unchanged, but the intergroup elasticity has to be redefined[21] as $\widetilde{\sigma}^{k*} \equiv \left(\sigma^{k*} - \gamma^{k*}\right) / \left(1 - \gamma^{k*}\right)$, where γ^{k*} is the budget share of the k^{th} composite good in the whole expenditure, the weight on its reciprocal being contracted by $1 - \gamma^{k*}$:

$$\mu_i^{k*} = \frac{\theta_i^{k*}\left(1 - \alpha_i^{k*}\right) + \left(1 - \theta_i^{k*}\right)\alpha_i^{k*}\left(1 - \gamma^{k*}\right)}{\theta_i^{k*}\left(1 - \alpha_i^{k*}\right) s_i^{k*} + \left(1 - \theta_i^{k*}\right)\alpha_i^{k*}\left(1 - \gamma^{k*}\right)\widetilde{\sigma}^{k*}}, \text{ with } \gamma^{k*} = \frac{P^{k*}X^{k*}}{Y^*}.$$

As before, the intragroup elasticity completely determines the markup of firm i in the limit cases of a negligible market share ($\alpha_i^{k*} \to 0$) or of maximum competitive toughness ($\theta_i^{k*} \to 1$), and the intergroup elasticity completely determines

[20] This includes the new form of collusion resulting from common ownership and the recent dramatic increase of institutional investment (the stylised fact that we already mentioned in section 2).

[21] See d'Aspremont and Dos Santos Ferreira (2021), pp. 53-54.

the markup of firm i in the opposite limit cases of monopoly ($\alpha_i^{k*} \to 1$) or collusion ($\theta_i^{k*} \to 0$). However, the most significant consequence of the Ford effect is the transformation of the intersectoral elasticity of substitution itself. The redefined elasticity $\widetilde{\sigma}^{k*}$ is larger (resp. smaller) than the original σ^{k*} if $\sigma^{k*} > 1$ (resp. $\sigma^{k*} < 1$). In other words, the Ford effect increases (resp. decreases) the relevant elasticity of intersectoral substitution and accordingly exerts *ceteris paribus* a depressing (resp. enhancing) effect on the equilibrium markup when the goods in the group k and the numeraire good are substitutes (resp. complements). Naturally, this effect is stronger the higher the budget share γ^{k*}.

4 Macroeconomic implications of oligopolistic competition in the output markets

Imperfect competition between firms in an output market introduces a markup of price over marginal cost. From the normative viewpoint, this price distortion is welfare degrading since it breaks the equality between the marginal utility derived from output consumption and the marginal labour disutility imposed by the corresponding production cost. It thus calls for some form of corrective policy. In addition, the market power of monopolistic firms generally redistributes income from workers to firm owners, an effect ignored when the profit is assumed to be transferred to a representative household, but which should be taken into account otherwise.

In this last section, we discuss some macroeconomic consequences of markup variations resulting from changes in the intensity of competition among firms and from large producers' strategic behaviour adjustments. Rising markups reduce consumer welfare through price distortion and their variability increases the volatility of consumption over time. This discussion is illustrated by three simple instances of the basic model which has been presented in section 3. In the first instance we show that wage flexibility that may be effective to cure unemployment under perfect or monopolistic competition may well turn ineffective in the presence of large firms. In the second instance, we extend the same simple oligopolistic model to overlapping generations to show the influence of markup variability on the business cycle, markup variability being associated either with the variability of the number of active firms (more generally, of concentration) or with the variability of competitive toughness. In the third instance, we extend this OLG model by having both consumers and firms living two periods and let the firms make strategic investment decisions in the first period. We then illustrate in particular how the Lotka-Volterra predator-prey mechanism underlies the investment-firm creation dynamics.

4.1 Underemployment and the possibility of *involuntary* unemployment

To illustrate the macroeconomic consequences of the price distortion on employment and since our focus is on output markets, we will adopt a cursory treatment of labour and capital markets[22] and will in general assume symmetry.[23] As a first step, we start with the simpler case of monopolistic competition with a continuum of firms. By contrast, in a second step, we will reduce the model to a finite number of large firms competing in prices.

So, assume a continuum of firms, each producing a differentiated good by employing c units of labour per unit of output, and further assume a representative household attaining utility $u(X)z - vl$, quasi-linear in both z and l. Here, u is an increasing and strictly concave function with argument X (the volume of a composite good resulting from the aggregation of a bundle $\mathbf{x}$ of the differentiated products), z is the quantity of a non-produced good (the numeraire), and l is the labour supplied at a disutility rate $v \in \mathbb{R}_+$ up to the endowment L.

Taking the standard CES aggregator $X = \left(\int_0^1 x_i^{(s-1)/s} di\right)^{s/(s-1)}$, with $s > 1$, expenditure minimisation over the purchase of the differentiated goods at prices $\mathbf{p}$, aggregated into the index $P = \left(\int_0^1 p_i^{1-s} di\right)^{1/(1-s)}$, gives the demand $x_i = (p_i/P)^{-s} X$ for the i-th differentiated good. Utility maximisation over consumption under the budget constraint $PX + z \le Y$, where Y is the income of the household, leads then (thanks to utility quasi-linearity in z) to the share of the composite good in total expenditure $PX/Y = \epsilon u(X) / (1 + \epsilon u(X))$, where $\epsilon u(X) \equiv u'(X) X/u(X)$. As well known, this share is constant when u is a power function, making us fall in the Cobb-Douglas case. Otherwise, the volume X of the composite good is still uniquely determined as a decreasing demand function $D(P/Y)$. Take now the household's income $Y = wl + \Pi + Z$, where Π is the profit transferred by the firms to the household, Z the endowment of non-produced good and w the wage. This leads to labour supply $l = (Y - \Pi - Z)/w$. Maximising the indirect utility $\mathcal{V}(Y) = u(X)(Y - PX) - v(Y - \Pi - Z)/w$ (with $X = D(P/Y)$) and applying the envelope theorem, we obtain as the first order condition $\mathcal{V}'(Y) = u(D(P/Y)) - v/w \ge 0$, hence that the wage w cannot be smaller than the household's reservation wage $\underline{w} \equiv v/u(D(P/Y))$ for labour supply l to be positive ($l = L$ if the inequality is strict).

Consider the firm side. Profit maximisation by any monopolistic firm leads to the *Lerner index of degree of monopoly* $\mu \equiv (P - wc)/P = 1/s$, meaning that the marginal cost wc should be augmented by the markup factor $1/(1-\mu) = s/(s-1)$, or equivalently that the firm's reservation wage $\overline{w} \equiv (1-\mu) P/c$ is equal to the marginal revenue product of labour P/c reduced by the factor $1 - \mu$. As a consequence of the augmented price, the household's reservation wage $\underline{w} = v/u(D(P/Y))$ is itself higher than what would correspond to the real value of that cost. Referring to situations such that the employment does not reach the labour endowment ($l < L$), we see that the market power of the

[22] The macroeconomic implications of large firms' market power in labour and capital markets are analysed in Berger *et al.* (2022) and Ritschel (2023), respectively.

[23] Edmond *et al.* (2023) analyse the welfare costs of markups by considering three channels: (i) the aggregate markup, acting like a uniform output tax, (ii) misallocation of factors of production when symmetry is broken, and (iii) inefficient entry. Roar and Midrigan (2020) further take into account distribtional effects, by breaking with the representative household assumption.

monopolistic firm generates under wage flexibility an *underemployment* equilibrium, dominated in terms of consumer's utility by the competitive equilibrium, where $P^* = \underline{w}^* c$ instead of $P = \underline{w}c/(1-\mu) > \underline{w}c > \underline{w}^* c$.

We represent such an equilibrium in Figure 1a, where employment l is measured along the horizontal axis and the wage w along the vertical axis. By taking the Cobb-Douglas case, with $u(X) = X^\gamma$ and $\gamma \in (0,1)$, we have $D(P/Y) = (\gamma/(1+\gamma))\, Y/P = \gamma Z/P$, so that both reservation wages are functions of the sole variable P and ultimately of l, as $P = c\gamma Z/l$. The household's reservation wage is represented in Figure 1a by the thin decreasing curve and the firm's reservation wage by the thick decreasing curve (for $\mu = 1/s$) and by the dashed decreasing curve under perfect competition (for $\mu = 0$).[24] The intersection of the reservation wage curves corresponds to the underemployment equlibrium in the former case ($\mu = 1/s$) and to the competitive equilibrium in the latter ($\mu = 0$), with a higher employment and a lower wage.

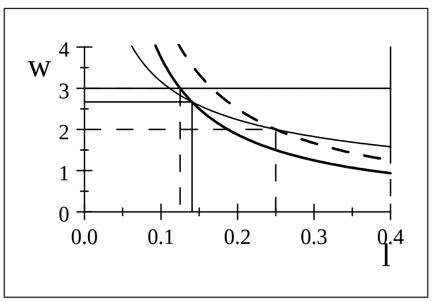

Fig. 1a

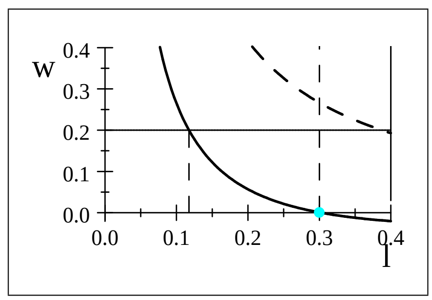

Fig. 1b

Can monopolistic competition lead to an *unemployment* equilibrium? It can, if wage flexibility is not ensured, if $w > \underline{w} = v/u(D(P/Y))$ ($w = 3$ in Figure 1a) and $l = cD(P/Y) < L$, with $P = wc/(1-\mu)$, the wage being rigid downwards as the result of a union decision, of a bargain between firms and workers, of a minimum wage law, or whatever. That situation might be qualified as one of *voluntary* unemployment, since it would result from a refusal to accept the appropriate lower wage.[25]

Wage flexibility would naturally be the cure for this type of unemployment, because a wage decrease would bring it to its reservation level $\underline{w} = v/u(D(P/Y))$, erasing the excess of labour supply, but also because it would diminish prices and stimulate demand, hence output and employment. But does the latter channel always work? It does as long as P tends to zero along with w,

[24] Figure 1a has been drawn by using the parameter values $v = c = Z = 1$, $\mu = 0.25$ ($s = 4$), $\gamma = 0.5$ and $L = 0.4$.

[25] Keynes refers to "voluntary" unemployment as one "due to the refusal or inability of a unit of labour, as a result of legislation or social practices or of combination for collective bargaining or of slow response to change or of mere human obstinacy, to accept a reward corresponding to the value of the product attributable to its marginal productivity" (Keynes 1936, p.6).

for instance under constancy of μ, since P/Y tends then to zero, pushing output demand to infinity. Constancy of μ is entailed by perfect competition, where $\mu = 0$, but results under monopolistic competition from the specific assumption of a CES aggregator, as we have seen in 3.1.1.[26]

However, constancy of μ does not necessarily apply, even in the CES case, in the presence of large firms. Suppose indeed that, instead of a continuum of producers of differentiated goods, we have a finite set of n producers engaged in *oligopolistic* price competition.[27] At a symmetric price equilibrium the Lerner index takes the value

$$\mu \equiv \frac{p - wc}{p} = \frac{1}{(1 - 1/n)\, s + (1/n)\, \sigma\,(P/Y)},$$

again (as above in 3.3.3) a weighted harmonic mean of the reciprocals of the two elasticities of substitution, the *intrasectoral* s between the differentiated goods and the *intersectoral* $\sigma \equiv -\epsilon D\,(P/Y)$ between the composite good and the numeraire, as given by the absolute value of the elasticity of the demand for the composite good.[28] Complementarity between the composite good and the numeraire translates into a value of σ smaller than one, which may become, if σ is an increasing function[29] and as P decreases, small enough as to make μ tend to one. The markup factor would then tend to infinity, eventually blocking the effect on prices of the downward wage adjustment. Output demand can in this case remain far below L/c in spite of an indefinite wage decrease.

Such a situation is represented in Figure 1b, drawn on the assumption of the utility function $u\,(X) = \ln\,(1 + X)$, which leads to the intersectoral elasticity of substitution $\sigma = 1/\left(1 - \epsilon^2 u\,(X)\right)$, with $\epsilon^2 u\,(X)$ negative and decreasing.[30] The employment $l = 0.3$ is here an employment ceiling, the degree of monopoly μ reaching then the unit value and the firm's reservation wage $\overline{w}$ correspondingly the zero value. In this example, with a zero labour disutility rate v and an

[26] We recall the reference to Matsuyama and Ushchev (2022), who propose a larger class of aggregators that allow for markup factor variability.

[27] The CES aggregators become in this case $X = \left(\sum_i x_i^{(s-1)/s}\right)^{s/(s-1)}$ and $P = \left(\sum_i p_i^{1-s}\right)^{1/(1-s)}$. Symmetry across differentiated goods leads to $X = n^{s/(s-1)}x$ and $P = n^{1/(1-s)}p$, so that $PX = npx$.

[28] Notice that $\mu \to 1/s$ as $n \to \infty$, the limit case of monopolistic competition. More generally, as n becomes large, the degree of monopoly approaches the reciprocal of the elasticity s of intrasectoral substitution, so that a small number of firms is required for the intersectoral elasticity σ of substitution to play a significant role. Let us however emphasise that this does not imply that the *economy* itself has only a small number of firms, as our discussion may in fact refer to a *representative industry* among a huge set of identical industries.

[29] According to the so-called *Marshall's first law of demand*, its Marshallian elasticity $\sigma\,(P/Y) \equiv -D'\,(P/Y)\,(P/Y)\,/D\,(P/Y)$ is positive (demand is decreasing). According to *Marshall's second law of demand*, σ is an increasing function (see Marshall 1920, III, IV, 2).

[30] Explicitly, we have:

$$\epsilon^2 u\,(X) = \frac{1 - X/\ln\,(1 + X)}{1 + X}.$$

Figure 1b is based on the parameter values $n = 2$ and $s = 1.1$, so that $\mu = 1$ when $\sigma = 0.9$ (at $l = 0.3$). The other parameter values are the same as for Figure 1a, except v, now assumed equal to zero.

ensuing zero household's reservation wage $\underline{w}$, the *unemployment* rate is higher than an incompressible 25% floor at whatever positive wage (such as $w = 0.2$ in Figure 1b). It is important to contrast the firm's reservation solid curve, drawn for $n = 2$, with the dashed curve that would apply in the limit case of an infinite number of firms, which would not lead to the existence of an employment ceiling.

The situation just described is reminiscent of Keynes's *involuntary* unemployment, in the sense that "there may exist no expedient by which labour as a whole can reduce its *real* wage to a given figure by making revised *money* bargains with the entrepreneurs" (Keynes 1936, p.13). In the *General Theory* the existence of involuntary unemployment is essentially ascribable to the incapacity of financial markets to coordinate intertemporal decisions. However, the present approach to involuntary unemployment[31] shares with Keynes's approach two (related) ideas: that the source of the phenomenon is not to be found in the labour market but in other markets (here, the output markets) and that the problem does not consequently lie in wage downward rigidity.

The possibility of involuntary unemployment may lead us to reevaluate the impact of fiscal policy. Take indeed the simplest case of a fixed target G of public nominal expenditure in the composite good, financed by a lump sum tax $T = G$ on the household income. If public expenditure does not modify the preferences of the household or enters additively in the utility function, nothing is changed in the household demand behaviour, except that it now refers to disposable income, so that the private demand for the composite good becomes $D\left(P/\left(Y - G\right)\right)$. An increase in the target G has the usual direct expansive effect on total demand $D\left(P/\left(Y - G\right)\right) + G/P$ through public demand, countered by the dissuasive effect on private demand through the reduction of the household disposable income.[32] In the present context, it has however another important effect, through the markup. Indeed, the Marshallian elasticity σ of total demand for the composite good is now a weighted arithmetic mean of the absolute values of the two elasticities, of private and public demand, the former assumed smaller than one and the latter equal to one. As a consequence, as G increases, more relative weight is put on the higher elasticity, making σ increase. The downward effect on σ of a price reduction can thus be countered by the upward effect of an increase in nominal public expenditure, helping to restore the efficiency of wage flexibility in the correction of "involuntary" un- or under-employment (see d'Aspremont *et al.* 1995).

[31] This approach has been exploited under different regimes of competition by d'Aspremont *et al.* (1989a, 1989b, 1990, 1991), Dehez (1985), Silvestre (1990).

[32] The expansive effect remains the dominating effect. The Haavelmo theorem tells us that, while the sum of the *direct* effects of an increase in G on income $Y = PD\left(P/\left(Y - G\right)\right) + G + Z$ is given by the partial derivative

$$\partial Y/\partial G = D'\left(P/\left(Y - G\right)\right)\left(P/\left(Y - G\right)\right)^2 + 1 < 1,$$

by taking into account the *indirect* expansive effect of G on Y, we end up with the unit multiplier

$$dY/dG = \partial Y/\partial G - \left[D'\left(P/\left(Y - G\right)\right)\left(P/\left(Y - G\right)\right)^2\right] dY/dG = 1.$$

4.2 Markup variability and endogenous fluctuations

In this subsection two sources of endogenous fluctuations will be exhibited, local dynamic indeterminacy of one steady state or steady state indeterminacy.

4.2.1 Local dynamic indeterminacy

Another remarkable property of the markup introduced by oligopolistic competition in the output markets is its propensity to variate, principally with firm creation and destruction and, more generally, with changes in market concentration. Still referring to a regime of price competition, this results immediately, in our simple model, from the expression of the Lerner index as the harmonic mean $\mu \equiv (p - wc)/p = 1/((1 - 1/n)s + (1/n)\sigma)$ or, in an asymmetric equilibrium, $\mu_i \equiv (p_i - wc)/p_i = 1/((1 - \alpha_i)s + \alpha_i \sigma)$, where α_i is the budget share of good i. Under the conventional assumption that the differentiated products are more substitutable among themselves than relatively to the non-produced good $(s > \sigma)$, firm creation, usually in the expansionary phase of the business cycle, translates into markup erosion. Also, under asymmetry, a firm gets a higher degree of monopoly as it becomes larger.[33]

To illustrate the influence of markup variability on the business cycle, let us again resort to a simple model, a dynamic (overlapping generations) extension of the model of last subsection. The representative household is now assumed to live two periods, working in the first and consuming in both. The non-produced numeraire good is not anymore consumed but used by the young to transfer purchasing power to the next period. It can readily be assimilated to money. Assuming $X^a \widehat{X}^{1-a} - vl$ as the utility of the young household, with $a \in (0,1)$ the propensity to consume (when young) and $\widehat{X}$ the consumption of the composite good planned for the old age, we obtain $X = aY/P$ and $\widehat{X} = (1-a)Y/\widehat{P} = m/\widehat{P}$ (m and $\widehat{P}$ being the money balance and the expected future price index, respectively). The total demand for the composite good is now $(aY + M)/P$, the sum of the young and old representative consumers' demands (M being the money stock, equal at equilibrium to the desired money balance m), which is equal to $Y/P = (1/(1-a))M/P$ at equilibrium. As to the reservation wage, obtained from the first order condition for maximising indirect utility $\mathcal{V}(Y) = (a/P)^a \left((1-a)/\widehat{P}\right)^{1-a} Y - v(Y - \Pi)/w$, it is now an increasing linear function of the geometric mean of the present and future price indices (with weights equal to the propensities to consume and to save, respectively): 1

$$\underline{w} = \underbrace{\frac{v}{a^a (1-a)^{1-a}}}_{V} P^a \widehat{P}^{1-a} \leq w.$$

On the production side, we add to the preceding framework increasing re-

[33] Again, we will here stick for simplicity to symmetric equilibria. Burstein *et al.* (2023) and Gnewuch (2022) use a model with oligopolistic competition and firm heterogeneity, focusing on (asymmetric) firm-level shocks.

turns to scale (*internal* to each firm i) in the form of a fixed labour cost. If the marginal cost c and the number n of firms (hence the degree of monopoly μ) are constant we obtain very simple dynamics. Symmetric equilibria under perfect foresight ($\widehat{P}_t = P_{t+1}$) and underemployment ($cM/\left((1-a)P_t\right) < L$) are described by the following one-dimensional discrete linear dynamical system (obtained from the equality $(1-\mu)P_t = \underline{w}_t c$):

$$P_{t+1}^{a-1} = \frac{Vc}{1-\mu} P_t^{a-1}.$$

This system leads to monotonic trajectories, constant (in the singular case where $Vc = 1-\mu$) or increasing to infinity (if $Vc < 1-\mu$). Trajectories decreasing to zero (if $Vc > 1-\mu$) imply regime switching, when the underemployment constraint is violated.

Oligopolistic competition opens the way in this simple framework to richer dynamics through the variability of $c/(1-\mu)$. Let us consider the case of a fixed labour cost $\phi > 0$, required only when the firm becomes active, with no barriers to entry.[34] Given that $\mu_t = 1/\left((1-1/n_t)s + (1/n_t)\right)$, since $\sigma = 1$ in the present framework, we let the number n of active firms be determined by the zero profit condition:

$$\mu_t Y = n_t w_t \phi.$$

Under the underemployment regime ($cM/\left((1-a)P_t\right) < L - n_t\phi$), hence with $w_t = \underline{w}_t$, this leads to the dynamical system

$$P_{t+1}^{a-1} = V\left(A + BP_t\right) P_t^{a-1}, \text{ with } V \equiv \frac{v}{a^a (1-a)^{1-a}},\ A \equiv c\frac{s}{s-1},\ B \equiv (1-a)\frac{\phi}{M}$$

and with the steady state $P^* = (1/V - A)/B$. We do not have a linear or log-linear dynamical system anymore. For a high propensity to consume, we can for instance obtain the system represented in Figure 2,[35] exhibiting a cycle of period 3 ($P_t = 0.262$, $P_{t+1} = 5.285$, $P_{t+2} = 0.00526$, $P_{t+3} = 0.262$). By the Sharkovsky's theorem, we know that the system has then cycles of any period. Markup variability, associated with the variability of the number of active firms, introduces non-linearity, creating the conditions for the emergence

[34] The case of a decreasing marginal cost could be considered also. To keep things simple, assume it to be equal to $cx_i^{-\gamma}$, with $0 < \gamma < s-1$, so as to have the marginal cost decrease less than the marginal revenue, thus satisfying the second order profit maximisation condition. Under symmetry, $cx^{-\gamma} = CP^{\gamma}$ (with $C = cn^{\gamma s/(s-1)}\left((a/(1-a))M\right)^{-\gamma}$), so that the dynamical system is modified, P_{t+1} keeping the exponent $a-1$ but P_t getting the exponent $\gamma + a - 1$. For $\gamma > 1-a$, we obtain oscillatory trajectories, damped if $\gamma < 2(1-a)$ and becoming explosive as γ exceeds $2(1-a)$. At $\gamma = 2(1-a)$, these trajectories form a cycle of period 2, which lacks robustness just because of the log-linearity of the dynamical system.

[35] We use the parameter values $a = 0.9$, $V = 1$, $A = 0.675$ and $B = 0.25$. We are not trying to calibrate the model, which is designed as a strict pedagogical device. However, it can easily be checked that we have enough parameters to control the values of V (by v), A (by c), B (by ϕ/M), and (by L) to keep the trajectories within the admissible region corresponding to the underemployment regime.

of robust endogenous fluctuations (driven by shocks on expectations, without any shocks on the fundamentals).[36]

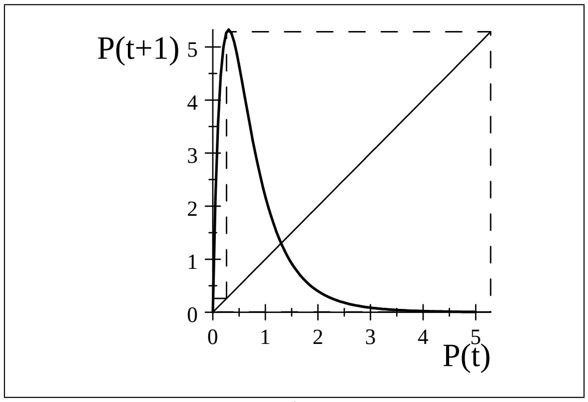

Fig. 2: A 3-cycle

We can even get a larger picture, going beyond deterministic (periodic or quasiperiodic) perfect foresight equilibria, and consider stationary stochastic rational expectations equilibria as the mode of endogenous fluctuations. Their existence results from local (dynamic) indeterminacy of a steady state (also of a closed orbit), in the sense that there is a continuum of other equilibrium paths arbitrarily close to the steady state. This is the case if the steady state is an attractor, the condition for which in the preceding example is that $\left|dP_{t+1}/dP_t\right|_{P_t=P^*} < 1$, namely that $a < (1+VA)/2 < 1$. Expectations can then randomize over the paths converging to the steady state, by referring to some extrinsic stochastic process (which leaves unaltered all the fundamentals). A so-called *sunspot equilibrium* obtains when those expectations are fulfilled.[37] It will display endogenous fluctuations if the probabilities in the stochastic process are state-dependent, for instance if the process is Markovian. Consider a stationary Markov chain with a finite set of states $k = 1, ..., K$ and transition probabilities $[\pi_{kk'}]$. Assume that the young representative consumer views the future price of the composite good as a random variable depending upon this stochastic process, and maximises the mathematical expectation of his lifelong utility conditional on his present information, say at state k. We obtain as equilibrium conditions K equations (for each state $k = 1, ..., K$):

$$\sum_{k=1}^{K} \pi_{kk'} P_{k'}^{a-1} = V\left(A + BP_k\right) P_k^{a-1} \equiv f\left(P_k\right).$$

Does an equilibrium exist? Take a set $\{P_k\}$ of prices in the vicinity of the steady state price P^*. If the steady state is locally indeterminate, if it is an attractor, the set of images $\{f(P_k)\}$ will be included in the interval $\left[\min\left(P_k^{a-1}\right), \max\left(P_k^{a-1}\right)\right]$,

[36] See Woodford (1990) and Guesnerie and Woodford (1992).
[37] See Benhabib and Farmer (1999).

so that the K equations can be satisfied by an appropriate (large) choice of the transition probabilities. On the contrary, if the steady state is a source, there will be no solution to the preceding equations.

To allow for comparisons with the remaining literature on endogenous fluctuations and to assess the empirical plausibility of the required existence conditions, it is necessary to move to two-dimensional dynamical systems, by introducing capital along with labour as a factor of production: see Dos Santos Ferreira and Lloyd-Braga (2005) and Seegmuller (2009), in the contexts of quantity and price competition, respectively, and in a broader perspective Lloyd-Braga *et al.* (2014).[38]

4.2.2 Steady state indeterminacy

Local dynamic indeterminacy of a steady state entails existence of stationary stochastic equilibria in the vicinity of the steady state. It is accordingly a source of endogenous fluctuations, the amplitude of which may nevertheless remain insignificant. Another route to stationary stochastic equilibria results from the possible existence of a continuum of steady states, allowing expectations to randomise across them and so to give amplitude to the resulting endogenous fluctuations. Oligopolistic competition is a powerful source of such steady state indeterminacy.

Entry and exit Let us take an example, still resorting to the same simple model, now under a regime of Cournotian monopolistic competition. We come back to the assumption of a continuum of industries producing differentiated goods to be delivered to a young and an old representative consumers, with now symmetric Cobb-Douglas preferences for those goods.[39] In each industry j, there is a *variable* number n_j of active firms, which compete in quantities for demand $(aY + M)/p_j = M/(1-a)\,p_j$. The corresponding symmetric (Cournot) equilibrium degree of monopoly is now $\mu_j = 1/n_j$.

On the basis of a fixed positive labour cost ϕ and in order to determine the number of active firms, we have formerly applied the conventional zero profit condition, which ensures both *profitability* (active firms cover their costs and would do no better by ceasing activity) and *sustainability* (no inactive firm would do better by becoming active). However, these two Nash equilibrium conditions can also be satisfied with positive profits, the zero profit condition being only sufficient, not necessary, for a free entry equilibrium. *Profitability* requires that at a symmetric Cournot equilibrium profile, the n active firms make *non-negative* profits: $\mu Y = M/(1-a)\,n \geq nw\phi$ (we are dropping for shortness the industry subscript). *Sustainability* requires that the $(n+1)$-th firm would not make a positive profit by becoming active, while conjecturing the global quantity offered

[38] An older contribution, associating decreasing marginal cost and markup variability stemming from the utility function specification, is d'Aspremont et al. (1995), in the context of Cournotian monopolistic competition.

[39] The quantity and price aggregators are in this limit case geometric means: $\ln X = \int \ln x_j dj$ and $\ln P = \int \ln p_j dj$.

by their rivals at that profile, namely $(M/(1-a))((1-1/n)/wc)$:

$$\max_{p}\left\{(p-wc)\left(\frac{1}{p}-\frac{1-1/n}{wc}\right)\right\}\frac{M}{1-a}\leq w\phi,$$

hence, at profit maximising price $p=wc/\sqrt{1-1/n}$,

$$1-\sqrt{1-1/n}\leq\underbrace{\frac{(1-a)\,\phi}{M}}_{B}w.$$

Profitability and sustainability impose a ceiling and a floor, respectively, on the admissible number of active firms:

$$\underline{n}(w)\equiv\frac{\overline{n}(w)}{2-1/\overline{n}(w)}\equiv\frac{1}{\sqrt{Bw}}\frac{1}{2-\sqrt{Bw}}\leq n\leq\frac{1}{\sqrt{Bw}}\equiv\overline{n}(w).$$

The interval of admissibility $[\max(2,\underline{n}(w)),\overline{n}(w)]$ has at least two integers if $Bw<\left(1.5-\sqrt{1.25}\right)^{2}$, hence if the ratio of individual fixed cost to income is low enough. The Cournot free entry equilibrium is indeterminate in that case.

A selection mechanism must then be imagined, possibly having each firm respond to an extrinsic impulse, which we may call after Keynes *animal spirits*, "a spontaneous urge to action rather than inaction" (Keynes 1936, p.161). The simplest example of such impulse may be given by a random variable uniformly distributed over an admissible set $\mathcal{N}$ of integers, suggestting the number n of active firms at equilibrium. Shifting from the industry to the economy level, we may then assume independently distributed random variables for all the industries. By the law of large numbers, this selection mechanism would lead to a geometric mean of industry degrees of competition $1-\mu_j$, namely $(1-\overline{\mu})=\prod_{n\in\mathcal{N}}(1-1/n)^{1/\#\mathcal{N}}$. However, along with this idiosyncratic signal, we may consider a systemic one, for instance still the same random variable concerning now the whole economy, coupled with another (independent) random variable measuring the intensity $\rho\in[0,1]$ of the signal and indicating the mass of industries where the systemic signal would be intense enough to dominate the idiosyncratic one.

Let us refer again to a discrete stationary stochastic equilibrium. Each state k $(k=1,...,K)$ will be characterised by the number $n_k\in\mathcal{N}$ of active firms suggested by the systemic signal and by the intensity $\rho_k\in\{\rho_1,...,\rho_K\}\subset[0,1]$ of this signal, both leading together by the law of large numbers to the price index

$$P_k=\frac{w_k c}{(1-\overline{\mu})^{1-\rho_k}(1-1/n_k)^{\rho_k}}.$$

Notice that the systemic signal ensures variability of the markup across states ($\rho_k\equiv 0$ implies constancy of $\mu=\overline{\mu}$) and that the idiosyncratic signal ensures potential continuity of its values ($\rho_k\equiv 1$ implies $\mu=1/n_k$, with n_k *integer*). The system of corresponding equilibrium conditions cannot anymore be established by relying upon the zero profit equation, but the wage reservation value still applies in an underemployment regime: $w_k = VP_k^a/\mathbb{E}\left[\widetilde{P}^{a-1}\middle| k\right]$. We thus obtain for each state k the equilibrium condition:

$$\mathbb{E}\left[\widetilde{P}^{a-1}\middle| k\right] = \frac{Vc}{\left(1-\overline{\mu}\right)^{1-\rho_k}\left(1-1/n_k\right)^{\rho_k}} P_k^{a-1}.$$

In the case of dynamic local indeterminacy, it was necessary to assume state dependent transition probabilities, otherwise the system of equilibrium conditions would degenerate into a single one. Now, it is possible to take the simpler case where $\pi_{kk'} = \pi_{k'} = (1/\#\mathcal{N})\Pr(\rho_k)$ for any k, leading to a constant $\mathbb{E}\left[\widetilde{P}^{a-1}\middle| k\right] = \left(\sum_{k'=1}^{K}\pi_{k'}P_{k'}^{a-1}\right) \equiv \overline{P}^{aa-1}$, but with coordinated variations of P_k and (n_k, ρ_k). Formally, the system behaves then *as if* it were subject to exogenous random shocks on the markup via the number of active firms. Let us however emphasise that we are not referring (as *e.g.* Gnewuch 2022) to exogenous random shocks on a *fundamental* (a given number of active firms) but to a stochastic selection mechanism coordinating firms' conjectures on the *endogenous* variable n in the presence of *indeterminacy*.

The conditions for existence of a stationary stochastic equilibrium are not exhausted by taking into account the K preceding aggregate equilibrium conditions, since profitability and sustainability must be warranted at each industry j level (the previously established condition $\underline{n}(w_k) \leq n_j \leq \overline{n}(w_k)$ depends on the economy variable w_k in state k). The admissible set $\mathcal{N}$ of numbers of active firms should verify $\mathcal{N} \subset [\underline{n}(\min\{w_k\}), \overline{n}(\max\{w_k\})]$, a condition bounding the possible amplitude of equilibrium price fluctuations. We shall not pursue the technical argument further, rather evoking the limit case where the representative consumer consumes only when old ($a \to 0$). In that case, the wage $w_k = v\overline{P}$ is state independent, and so are $\overline{n} = \sqrt{M/\phi v\overline{P}}$ and $\underline{n} = \overline{n}/\left(2 - 1/\overline{n}\right)$, leading to an admissible set $\mathcal{N}$ easy to determine in relation to the sole price index mean $\overline{P}$.

Referring to the related literature, based on larger models (with capital and labour), Dos Santos Ferreira and Dufourt (2006) proposed a calibrated *Real Business Cycle* model along the same lines (quantity competition with fixed costs), and Dos Santos Ferreira and Lloyd-Braga (2008) an overlapping generations model with price competition and decreasing marginal costs. Dos Santos Ferreira and Dufourt (2017) suggested, in the context of a Cournotian OLG model, a taxation-subsidisation policy allowing to dissolve the indeterminacy and to conserve as the unique steady state equilibrium the efficient one with respect to the following trade-off: decreasing the number of active firms means higher price distortion but increasing the number of active firms aggravates the useless duplication of fixed costs. Implementing this type of fiscal policy may lead to a significant welfare gain attributable to an "efficient stabilization effect" which couples two different actions, the stabilisation action responding to risk aversion and the allocative action allowing to increase efficiency.

Variability of competitive toughness We have up to now associated local dynamic indeterminacy as well as steady state indeterminacy principally with the variability of the number of active firms (more generally, market concentration). Another important source of indeterminacy, already mentioned in section 1, is the variability of competitive conduct, typically introduced in oligopoly theory, in the late 1930s, by Sweezy (1939) and Hall and Hitch (1939), through the kinked demand device associated with a fundamental asymmetry of conjectured competitors' reactions.

Woodford (1990) also assumes that the representative firm faces a demand with a kink at some "market price" but not because of an asymmetry in sellers' conjectures, rather because of the behaviour of buyers knowing the price distribution (highly concentrated on that price) and searching at a significant cost for the lowest price. A price above the market price will repel buyers confronted with it, since they will be confident in finding easily a lower price. A price below the market price will not attract but few buyers from other firms, since they do not expect to find it promptly, if they decide to search. Although with a different foundation, this kinked demand plays the role pointed out half a century before: it insulates the equilibrium price from moderate productivity shocks and demand shifts, and it fosters indeterminacy translating into the existence of a continuum of Nash equilibria and the possibility of endogenous fluctuations.

Our own approach to oligopolistic competition (presented in subsection 3.3), with firms choosing a price-output combination under a constraint on market share and a constraint on market size, makes them face a kinked demand, with Hicksian and Marshallian demands on each side of the kink. Here, kinked demand has yet a different foundation but it still leads to a continuum of oligopolistic equilibria. Integrated in a dynamic model, it is thus the source of steady state indeterminacy, with consequences similar to those of the model examined in the preceding paragraph, which can be easily transposed. Take an economy with constant elasticities of intra- and intersectoral substitution, s and σ respectively, such that $s > \sigma$. In the simplest case of full symmetry, a systemic signal would now coordinate the n producers of differentiated goods, in state k ($k = 1, ..., K$), on an oligopolistic equilibrium parameterised by an index of competitive toughness θ_k. This leads to the stationary stochastic equilibrium condition (for each k):

$$\mathbb{E}\left[\widetilde{P}^{a-1}\middle| k\right] = \frac{Vc}{1-\mu_k}P_k^{a-1}, \text{ with } \mu_k = \frac{\theta_k\left(1-1/n\right)+\left(1-\theta_k\right)\left(1/n\right)}{\theta_k\left(1-1/n\right)s+\left(1-\theta_k\right)\left(1/n\right)\sigma},$$

referring to a stochastic process with probabilities which may be, or not, state-dependent. If they are state-independent, states characterised by tougher competition, hence smaller markups, will clearly exhibit lower prices and larger produced quantities, whereas states with softer competition and larger markups, will have higher prices and lower output.

This cyclical pattern of the trade-off between competition for market share and competition for market size was already well identified in the late 1930s, in particular by Abramowitz (1938), already quoted at length in section 1. Rotemberg and Saloner (1986) proposed a foundation for this cyclical pattern using a model of repeated oligopolistic interaction. They assumed implicit collusion enforced by the threat of a price war if any firm ceases to cooperate. The reason why the phase of the cycle plays a role is that "when demand is high, the benefit from deviating from the output that maximizes joint profits may exceed the punishment a deviating firm can expect" (Rotemberg and Saloner 1986, p.390). Firms consequently tend to abide by the implicit collusive agreement during recessions but to break it during booms. Although focusing primarily on the industry level, the paper also addresses the economy level on the basis of a general equilibrium model with two sectors, one competitive, the other oligopolistic, which is close to the model we have been using. However, fluctuations are not endogenous but introduced by assuming exogenous (and unexplained) demand shifts. Rotemberg and Woodford (1992) build on this paper to construct a calibrated RBC type model with firms involved in repeated oligopolistic interaction. This model allows to analyse the effects on economic activity of exogeneous demand shocks, resulting from changes in government purchases. They conclude that the responses predicted by the oligopolistic model are closer to the empirical responses than the corresponding predictions of the competitive model.

4.3 Strategic investment

The last step in our exploration of the macroeconomic implications of oligopolistic output markets concerns investment decisions, conventionally identified with consumers' saving decisions, with small firms renting in each period the capital that has been previously accumulated by the consumers. To examine the difference it makes to attribute instead investment decisions to large firms, let us come back to the Cournotian monopolistic competition OLG model we have used in subsection 4.2, now with both consumers and firms living two periods. As an additional major difference, we assume in place of a non-produced numeraire, allowing to make intertemporal transfers of purchasing power, a capital good produced by labour (which is now the numeraire) on a one to one basis. Yet another major difference is that profits are assumed to be distributed as dividends to the *old* consumer, who is the capital owner. In the following, we will resort to d'Aspremont *et al.* (2015) and to d'Aspremont and Dos Santos Ferreira (2021, 4.2).

The young consumer's consumption, labour supply and saving decisions *under perfect foresight* at time t are now $X_t = al_t/P_t$, $K_t = (1-a)\, l_t$ and $l_t \in (0, L)$ only if $w_t \equiv 1 = VP_t^a\,(P_{t+1}/r_{t+1})^{1-a} \equiv \underline{w}_t$, where r_{t+1} is the expected factor of return on capital. Employment is determined by the sum of production and investment requirements, that is, in a symmetric situation, $l_t = c_t\,(X_t + r_t K_{t-1}/P_t) + K_t$, where the first term is the sum of the young and the old consumers' consumption multiplied by c_t, the unit labour cost at time t, and the second term is the investment. According to the conventional approach to investment decisions, investment K_t is decided by the young consumer at time t, firms renting that capital at time $t+1$. We will by contrast take into account the fact that aggregate investment K_t, while constrained by the young consumer's saving decision at time t, is in fact the result of individual decisions of investing firms made also at time t.

These decisions are made in the context of a two-stage game played by firms born at time t, each firm i (in industry j) choosing to invest k_{ijt} at the first stage and to produce x_{ijt+1} at the second stage at a unit labour cost reduced by the invested capital. The investment effects are partly internal, appropriated by firm i, partly external, created by the capital invested by the other $n_{jt}-1$ firms in industry j, an externality which may be important in particular in the case of R&D investment. Specifically, we assume the expected unit labour cost c_{ijt+1} to be equal to $ck_{ijt}^{-\eta}\prod_{h\neq i}k_{hjt}^{-\varepsilon/(n_{jt}-1)}$ (with c, η and ε positive), which corresponds to the production function $F(k_{ijt},l_{ijt})=(1/c)\prod_{h\neq i}k_{hjt}^{\varepsilon/(n_{jt}-1)}k_{ijt}^{\eta}l_{ijt}$, with output elasticity $1+\eta+\varepsilon$, hence displaying economies of scale. So, even if we stick to the conventional approach where capital is rented, its introduction in the model first adds one dimension to the dynamical system and second, coupled with the assumption of economies of scale, leads to decreasing marginal costs, a possible source of endogenous fluctuations that we have already considered in subsection 4.2. Nonetheless, replacing rented capital by invested capital prior to production is not innocuous, since it introduces a commitment effect on the firms side, absent in the conventional approach. The combined effect of the young consumer's saving decision K_t and of the individual investment decisions k_{ijt} of the firms to be born determines the equilibrium number $n_{jt}=K_t/k_{ijt}$ of viable young firms.

Let us analyse the two-stage game played by the firms born at time t. Take industry j and recall that, conditional on the first stage choices $\mathbf{k}_{jt}$, the firms play a Cournot game at the second stage facing a demand Y_{jt+1}/p_{jt+1}, on the basis of the expected industry revenue Y_{jt+1}. The second stage equilibrium degree of monopoly of firm i (corresponding to a Cournot asymmetric equilibrium) is $\mu_{ijt+1}\equiv 1-c_{ijt+1}/p_{jt+1}=q_{ijt+1}/Q_{jt+1}$, where q_{ijt+1} and Q_{jt+1} denote the output of firm i and industry j, respectively. By adding over the n_{jt} firms producing at time $t+1$, and then replacing $1/p_{jt+1}$, we obtain: $q_{ijt+1}=\left(1-(n_{jt}-1)\,c_{ijt+1}/\sum_i c_{ijt+1}\right)Q_{jt+1}$. Since $Q_{jt+1}=Y_{jt+1}/p_{jt+1}$, the first stage payoff of firm i (on the basis of the expected industry revenue Y_{jt+1}) is then:

$$\Pi\left(k_{ijt},\mathbf{k}_{-ijt}\right)=\mu_{ijt+1}p_{jt+1}q_{ijt+1}-k_{ijt}=\left(1-(n_{jt}-1)\frac{c_{ijt+1}}{\sum_i c_{ijt+1}}\right)^2 Y_{jt+1}-k_{ijt}.$$

The first order condition for the maximisation in k_{ijt} of this payoff can be expressed, in a symmetric equilibrium, as

$$k_{jt}=2\left(1-\frac{1}{n_{jt}}\right)^2\left(\frac{1}{n_{jt}}\right)\left(\eta-\frac{\varepsilon}{n_{jt}-1}\right)Y_{jt+1}.$$

Notice that firm i's investment is positive only if its internal effect η on firm i's unit cost dominates its external effect $\varepsilon/\left(n_{jt}-1\right)$ on each one of firm i's competitors.

Since the economy is composed of a continuum of identical industries of unit mass, the *average* number of firms and the *average* degree of monopoly in the economy may be treated as continuous variables by slightly breaking symmetry of outcomes across industries. Somewhat abusively, we will bypass computations of the relevant means and simply drop the industry subscript, at the same time ignoring the integer restraint. The aggregate revenue is equal to the consumption expenditures of the young and the old consumers:

$$Y_{t+1} = a\underbrace{\left(\left(1 - 1/n_t\right) Y_{t+1} + K_{t+1}\right)}_{l_{t+1}} + \underbrace{\left(1/n_t\right) Y_{t+1}}_{r_{t+1} K_t} = \frac{a}{\left(1-a\right)\left(1 - 1/n_t\right)} K_{t+1}.$$

By combining this expression with the former first order condition for profit maximisation and denoting the young consumer's time preference by $\rho \equiv a/\left(1-a\right)$, we obtain the difference equation:

$$2\rho n_{t+1} k_{t+1} = \frac{n_t k_t}{\eta - \left(\eta + \varepsilon\right)/n_t}, \qquad ((1))$$

which alone determines the steady state equilibrium value $n^* = 1 + \left(2\rho\varepsilon + 1\right)/\left(2\rho\eta - 1\right)$, imposing the parameter restriction $1/2 < \rho\eta \leq 1 + \rho\varepsilon$ (so that $2 \leq n^* < \infty$). Now, using the wage equation $1 = VP_t^a \left(P_{t+1}/r_{t+1}\right)^{1-a}$ together with the former expression for the aggregate revenue and the first difference equation, we obtain another difference equation:

$$\frac{k_{t+1}^{\eta+\varepsilon}}{n_{t+1}\eta - \left(\eta + \varepsilon\right)} = 2\left(cV\right)^{1+\rho} \left(\frac{k_t^{-(\eta+\varepsilon)}}{1 - 1/n_t}\right)^{\rho}. \qquad ((2))$$

The model dynamics are thus described by a two-dimensional dynamical system in the (average) number of firms per industry n_t and in the (average) capital per firm k_t. Notice that these two variables are also the indicators of the (average) markup factor and of the (average) unit production cost, respectively.

We may refer to the log-linearised dynamical system at the steady state (n^*, k^*) by differentiating the two difference equations:

$$\begin{bmatrix} 1 & 1 \\ -\frac{n^*\eta}{n^*\eta - (\eta+\varepsilon)} & \eta + \varepsilon \end{bmatrix} \begin{bmatrix} d\ln n_{t+1} \\ d\ln k_{t+1} \end{bmatrix} = \begin{bmatrix} 2 - \frac{n^*\eta}{n^*\eta - (\eta+\varepsilon)} & 1 \\ -\frac{\rho}{n^*-1} & -\rho\left(\eta+\varepsilon\right) \end{bmatrix} \begin{bmatrix} d\ln n_t \\ d\ln k_t \end{bmatrix},$$

and obtain the corresponding Jacobian matrix (with $\zeta \equiv \eta + \varepsilon$)

$$J = \frac{1}{\frac{n^*\eta}{n^*\eta - \zeta} + \zeta} \begin{bmatrix} 2\zeta - \frac{n^*\eta\zeta}{n^*\eta-\zeta} + \frac{\rho}{n^*-1} & \left(1+\rho\right)\zeta \\ 1 - \left(1 - \frac{n^*\eta}{n^*\eta-\zeta}\right)^2 - \frac{\rho}{n^*-1} & \frac{n^*\eta}{n^*\eta-\zeta} - \rho\zeta \end{bmatrix}.$$

A straightforward but lengthy analysis of the properties of matrix J shows that, for a non-degenerate region of the space of parameters $\zeta \times \rho$, a Hopf bifurcation occurs when varying η, so that a limit cycle exists in the vicinity of the steady state. We shall skip this analysis and just consider a special case that can be easily interpreted. Under the parameter values $\eta = \varepsilon = \zeta/2 = \rho/4 = \sqrt{3/8}$, the steady state (average) number of firms is $n^* = 3$ and the dynamical system becomes:

$$\begin{bmatrix} d\ln n_{t+1} \\ d\ln k_{t+1} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \begin{bmatrix} d\ln n_t \\ d\ln k_t \end{bmatrix},$$

namely a log-linearised discrete version of the Lotka-Volterra predator-prey dynamical system. This highlights the core of the model dynamics: by reducing costs of production, investment feeds firm creation ($d\ln n_{t+1} = d\ln k_t$) which, by squeezing markups, ruins firms' appetite to invest ($d\ln k_{t+1} = -d\ln n_t$). An invariant cycle of period 4 ensues:

$$d\ln n_t = d\ln k_{t-1} = -d\ln n_{t-2} = -d\ln k_{t-3} = d\ln n_{t-4}.$$

Outside this particular case, the interacting effects are more nuanced and diversified, leading in particular to higher period limit cycles, but the predator-prey mechanism still underlies the investment-firm creation dynamics.

From the static analysis of under- and unemployment equilibria to the dynamic analysis of the business cycle, we have shown how the presence of large, strategically interacting, producing and investing firms can significantly affect macroeconomic issues, a point that has not yet received full attention from mainstream macroeconomics. We think that is urgent to join the recent call of Xavier Vives: "In summary, it is high time that oligopoly is integrated with full force in the toolbox of macroeconomics. The machinery is there and now it should be put to work" (Vives 2021).

References

[1] Abramovitz, M. (1938). Monopolistic Selling in a Changing Economy. *Quarterly Journal of Economics* 52: 191-214.

[2] d'Aspremont, C., Dos Santos Ferreira, R. (2016). Oligopolistic vs. monopolistic competition: Do intersectoral effects matter? *Economic Theory* 62: 299-324.

[3] d'Aspremont, C., Dos Santos Ferreira, R. (2017). The Dixit-Stiglitz economy with a 'small group' of firms: A simple and robust equilibrium markup formula. *Research in Economics* 71: 729-739.

[4] d'Aspremont, C., Dos Santos Ferreira, R. (2021). *The Economics of Competition, Collusion and In-between.* Cham: Palgrave Macmillan.

[5] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (1989a). Unemployment in a Cournot oligopoly model with Ford effects. *Recherches Économiques de Louvain/Louvain Economic Review* 55: 33–60.

[6] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (1989b). Unemployment in an extended Cournot oligopoly model. *Oxford Economic Papers* 41: 490–505.

[7] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (1990). On monopolistic competition and involuntary unemployment. *The Quarterly Journal of Economics* 105: 895–919.

[8] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (1991). Imperfect competition, rational expectations and unemployment. In Barnett, W. *et al*. (ed.), *Equilibrium theory and applications: Proceedings of the sixth international symposium in economic theory and econometrics*. Cambridge: Cambridge University Press (353–381).

[9] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (1995). Imperfect competition in an overlapping generations model: A case for fiscal policy. *Annales d'Economie et de Statistique* 37/38: 531–555.

[10] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (1997). General Equilibrium Concepts under Imperfect Competition : A Cournotian Approach. *Journal of Economic Theory* 73: 199–230.

[11] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (2011). Imperfect competition and the trade cycle: Aborted guidelines from the late 1930s. *History of Political Economy* 43: 513-536.

[12] d'Aspremont, C., Dos Santos Ferreira, R., Gérard-Varet, L.-A. (2015). Investissement stratégique et fluctuations endogènes. *Revue Economique* 66: 351-368.

[13] Atkeson, A., Burstein, A. (2008). Pricing-to-Market, Trade Costs, and International Relative Prices. *American Economic Review* 98: 1998-2031.

[14] Autor, D., Dorn, D., Katz, L. F., Patterson, C., Van Reenen, J. (2020). The Fall of the Labor Share and the Rise of Superstar Firms. *Quarterly Journal of Economics* 135: 645-709.

[15] Azar, J., Schmalz, M.C., Tecu, I. (2018). Anti-Competitive Effects of Common Ownership. *Journal of Finance* 73: 1513-1565.

[16] Azar, J., Vives, X. (2021). General Equilibrium Oligopoly and Ownership Structure. *Econometrica* 89: 999-1048.

[17] Bain, J. S. (1951). Relation of Profit Rate to Industry Concentration: American Manufacturing, 1936–1940. *Quarterly Journal of Economics* 65:293-324.

[18] Barkai, S. (2020). Declining Labor and Capital Shares. *Journal of Finance* 75: 2421-2463.

[19] Benhabib, J., Farmer, R. E. A. (1999). Indeterminacy and Sunspots in Macroeconomics. In Taylor, J. B., Woodford, W. (ed.), *Handbook of Macroeconomics*, vol. 1A. Amsterdam: Elsevier (387–448).

[20] Berger, D., Herkenhoff, K., Mongey, S. (2022). Labor Market Power. *American Economic Review* 112: 1147-1193.

[21] Bighelli, T., di Mauro, F., Melitz, M. J., Mertens M. (2023). European Firm Concentration and Aggregate Productivity. *Journal of the European Economic Association* 21: 455-483.

[22] Boar, C., Midrigan, V. (2023). Markups and Inequality. WP November 2023, forthcoming in the *Review of Economic Studies*.

[23] Burstein, A., Carvalho, V. M., Grass, B. (2023). Bottom-up Markup Fluctuations. Cambridge Working Papers in Economics 2096 (revised 6.11.2023).

[24] Colacicco, R. (2015). Ten Years of General Oligopolistic Equilibrium: A Survey. *Journal of Economic Surveys* 29: 965-992.

[25] Costa, L. F. (2004). Endogenous Markups and Fiscal Policy. *Manchester School* 72: 55-71.

[26] Costa, L. F., Dixon, H. D. (2011). Fiscal policy under imperfect competition with flexible prices: An overview and survey. *Economics: The Open-Access* 5: 1-57.

[27] Covarrubias, M., Gutiérrez, G., Philippon, T. (2020). From Good to Bad Concentration? U.S. Industries over the past 30 years. *NBER Macroeconomics Annual* 34:1-46.

[28] Dehez, P. (1985). Monopolistic equilibrium and involuntary unemployment. *Journal of Economic Theory* 36: 160-165.

[29] De Loecker, J., Eeckhout, J., Unger, G. (2020). The Rise of Market Power and the Macroeconomic Implications. *Quarterly Journal of Economics* 135: 561-644.

[30] Demsetz, H. (1973). Industry structure, market rivalry, and public policy. *Journal of Law and Economics* 16: 1-9.

[31] Dixit, A. K., Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *American Economic Review* 67: 297-308.

[32] Dos Santos Ferreira, R. (2019). Imperfect Competition. In Dimand, R. W., Hagemann, H. (ed.), *The Elgar Companion to John Maynard Keynes*. Edward Elgar (302-307).

[33] Dos Santos Ferreira, R., Dufourt, F. (2006). Free entry and business cycles under the influence of animal spirits. *Journal of Monetary Economics* 53: 311-328.

[34] Dos Santos Ferreira, R., Dufourt, F. (2017). Optimal fiscal policy in sunspot-driven oligopolistic economies. *Journal of Public Economic Theory* 19: 620-638.

[35] Dos Santos Ferreira, R., Lloyd-Braga, T. (2005). Non-linear endogenous fluctuations with free entry and variable markups. *Journal of Economic Dynamics and Control* 29: 847-871.

[36] Dos Santos Ferreira, R., Lloyd-Braga, T. (2008). Business cycles with free entry ruled by animal spirits. *Journal of Economic Dynamics and Control* 32: 3502-3519.

[37] Dunlop, J. T. (1938). The Movement of Real and Money Wage Rates. *Economic Journal* 48: 413–34.

[38] Edmond, C., Midrigan, V., Xu, D. Y. (2023). How Costly Are Markups? *Journal of Political Economy* 131; 1619-1675.

[39] Feenstra, R.C. (2003). A homothetic utility function for monopolistic competition models, without constant price elasticity. *Economics Letters* 78: 79-86.

[40] Ford, H. (1922). *My Life and Work*. London: William Heinemann.

[41] Gabaix, X. (2011). The Granular Origins of Aggregate Fluctuations. *Econometrica* 79: 733-772.

[42] Gabszewicz, J., Vial, J.-P. (1972). Oligopoly "à la Cournot" in a general equilibrium analysis. *Journal of Economic Theory* 4: 381-400.

[43] di Giovanni, J., Levchenko, A. A. (2012). Country Size, International Trade, and Aggregate Fluctuations in Granular Economies. *Journal of Political Economy* 120: 1083-1132.

[44] Gnewuch, M. (2022). Market Power and Macroeconomic Fluctuations. WP (November 2022).

[45] Grullon, G., Larkin, Y., Michaely, R. (2019). Are US Industries Becoming More Concentrated? *Review of Finance* 23: 697-743.

[46] Guesnerie, R., Woodford, M. (1992). Endogenous Fluctuations. In Laffont, J.-J. (ed.), *Advances in Economic Theory: Proceedings of the Sixth World Congress of the Econometric Society*. Cambridge University Press (289-412).

[47] Gutiérrez, G., Philippon, T. (2017). Declining Competition and Investment in the U.S.. NBER Working Paper 23583.

[48] Hall, R. L., Hitch, C. J. (1939). Price Theory and Business Behaviour. *Oxford Economic Papers* 2:12–45.

[49] Hart, O. D. (1985). Imperfect Competition in General Equilibrium: An Overview of Recent Work. In Arrow, K. J., Honkapohja, S. (ed.), *Frontiers of Economics*. Oxford: Basil Blackwell.

[50] Hottman, C. J., Redding, S. J., Weinstein, D. E. (2016). Quantifying the Sources of Firm Heterogeneity. *Quarterly Journal of Economics* 131: 1291-1364.

[51] Kalecki, M. (1938). The Determinants of Distribution of the National Income. *Econometrica* 6: 97–112.

[52] Keynes, J. M. (1936). *The General Theory of Employment, Interest, and Money*. London: Macmillan.

[53] Keynes, J. M. (1939). Relative Movements of Real Wages and Output. *Economic Journal* 49: 34-51.

[54] Lloyd-Braga, T., Modesto, L., Seegmuller, T. (2014). Market distortions and local indeterminacy: A general approach. *Journal of Economic Theory* 151: 216-247.

[55] Mankiw, N. G., Romer, D. (ed.) (1991). *New Keynesian Economics*. Cambridge, Ma: MIT Press.

[56] Marshall, A. (1920). *Principles of Economics* (8th edition). London: Macmillan.

[57] Martin, S. (2002). *Advanced Industrial Organization*. 2nd edition. Oxford: Blackwell.

[58] Matsuyama, K., Ushchev, P. (2022). Destabilizing Effects of Market Size in the Dynamics of Innovation. *Journal of Economic Theory* 200: 105415.

[59] Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* 71: 1695-1725.

[60] Melitz, M., Ottaviano, G. (2008). Market Size, Trade, and Productivity. *Review of Economic Studies* 75: 295-316.

[61] Neary, J. P. (2016). International Trade in General Oligopolistic Equilibrium. *Review of International Economics* 24: 669-698.

[62] Parenti, M., Ushchev, P., Thisse, J.-F. (2017). Toward a theory of monopolistic competition. *Journal of Economic Theory* 167: 86-115.

[63] Posner, E. A., Scott Morton, F. M., Weyl, E. G. (2017). A Proposal to Limit the Anti-Competitive Power of Institutional Investors. *Antitrust Law Journal* 81: 669-728.

[64] Ritschel, P. (2023). Capital Market Power and Economic Growth in an Overlapping-Generations Model with Rational Expectations. *Theoretical Economics Letters* 13: 1253-1265.

[65] Rotemberg, J. J., Saloner, G. (1986). A Super Game-Theoretic Model of Price Wars during Booms. *American Economic Review* 76: 390-407.

[66] Rotemberg, J., Woodford, M. (1991). Markups and the Business Cycle. In Blanchard, O. J., Fischer, S. (ed.), *NBER Macroeconomics Annual*, vol. 6. MIT Press (63-140).

[67] Rotemberg, J. J., Woodford, M. (1992). Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity. *Journal of Political Economy* 100: 1153-1207.

[68] Rotemberg, J. J., Woodford, M. (1999). The Cyclical Behavior of Prices and Costs. In Taylor, J. B., Woodford, W. (ed.), *Handbook of Macroeconomics*, vol. 1B. Amsterdam: Elsevier (1051-1135).

[69] Seegmuller, T. (2009). Capital-labor Substitution and Endogenous Fluctuations: A Monopolistic Competition Approach with Variable Mark-up. *Japanese Economic Review* 60: 301-319.

[70] Silvestre, J. (1990). There May Be Unemployment When the Labour Market Is Competitive and the Output Market Is Not. *Economic Journal* 100: 899-913.

[71] Stiglitz, J. E. (1984). Price Rigidities and Market Structure. *American Economic Review* 74: 350-355.

[72] Sweezy, P. M. (1939). Demand under Conditions of Oligopoly. *Journal of Political Economy* 47: 568-73.

[73] Tarshis, L. (1939). Changes in Real and Money Wages. *Economic Journal* 49: 150-54.

[74] Thisse, J.-F., Ushchev, P. (2018). Monopolistic competition without apology. In Corchon, L., Marini, M. (ed.), *Handbook of Game Theory and Industrial Organization*, Vol.1. Edward Elgar (93-136).

[75] Vives, X. (2021). Rise of the superstar firms: Taking oligopoly seriously in macroeconomics. CEPR *VoxEU Column* 20 Jan 2021.

[76] Woodford, M. (1990). Self-Fulfilling Expectations and Fluctuations in Aggregate Demand. NBER Working Paper 3361.

[77] Zhelobodko, E., Kokovin, S., Parenti, M., Thisse, J.-F., 2012. Monopolistic competition: Beyond the constant elasticity of substitution. *Econometrica* 80: 2765-2784.