The Complex Interactions between Economic Growth and Market Concentration in a Model of Structural Change*

Tommaso Ciarli†, Marco Valente‡

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Abstract

In this paper we contribute to the analysis of the trade-off of consumer heterogeneity and market concentration for economic development. We study the relation between market concentration and economic growth, along different phases of economic development during which the economy goes through a number of changes in the structure of production and consumption. We focus on three main aspects of structural change that are correlated to both market concentration and economic growth: (i) changes in demand preferences, via imitation of consumption consumption; (ii) different product variety, measured as disparity among the quality of consumables; and (iii) different pricing strategy, segmenting the access to 'luxury' goods.

We use a model of the interactions between several facets of structural change, such as firms' size and hierarchical structure, innovation in capital vintages, the emergence of social classes, income distribution, and consumption preferences across and within classes. We find that market concentration has a significant and positive impact on economic growth only in the presence of a sufficiently large demand. We find the strongest effect when the distribution of firm size becomes more skewed, concentrating on firms producing goods of higher quality and price. We also find that this effect is strongly influenced by different facets of structural change through the behaviour of lower income classes, whereas the supply side effect of product disparity, ceteris paribus, has no significant effect on growth.

Keywords: economic growth; structural change; market concentration; consumer dynamics; product variety; agent based simulations
JEL: O11; O41; O33; C63

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†SPRU, University of Sussex, UK, t.ciarli@sussex.ac.uk

‡University of L'Aquila, IT, marco.valente@univaq.it

1 Introduction

The process of economic development observed in the last three centuries is best interpreted as the interaction among sundry structural changes. The classical structural change hypothesis that countries develop by moving out from agriculture into manufacturing and services is an 'emergent property' of these interactions, and taken alone is of limited help to understand economic development. For instance, economists have extensively discussed the role of the incumbent sectors in shaping processes of structural changes in relation to technological change, industrial organisation, income distribution, and the demand for new goods and services they generate (Baldwin, 1956; North, 1959). With reference to the first industrial revolution, economic historians have highlighted quantitative and qualitative changes in the sectoral composition of employment and value added, as well as in income distribution, class mobility, workers skills and capabilities, market structure, capital deepening, firm size and the organisation of production, the number and quality of goods and services consumed, and so forth (Berg, 2002; Desmet and Parente, 2012; Mokyr, 1992; Voigtländer and Voth, 2006; Voth, 2003).

Most of these different facets of structural change interact and, alike a complex system, the properties emerging from such interactions – for instance in terms of economic growth and sectoral shifts – cannot be deduced from the properties of one single facet (Beinhocker, 2006). For example, the introduction of capital intensive technologies induces a higher concentration of capital and production (due to increasing returns). In turn, large firms need to standardise the production process and workers output. As a result, firms become complex hierarchical organisation were each hierarchical level has a different command over the production process. Such hierarchical organisation of labour is also based on different compensations, and contributes in defining different social classes. Different labour classes may develop distinct preferences which, by segmenting the market, has the opposite effect of reducing standardisation. In turn, consumers select products and firms from the market, which may induce concentration of capital in an even smaller number of producers and, as a consequences, capital production in a smaller number of large firms. Market concentration may increases the access to capital and increase incentives to innovation, depending on the sectoral regimes. So on and so forth.

The main aim of this paper is to study the relation between market concentration and economic growth, along different phases of economic development during which the economy goes through a number of changes in the structure of production and consumption. We focus on three main facets that are correlated to both market concentration and economic growth: (i) changes in demand preferences, following a process of imitation of less wealthy income classes of wealthier income classes; (ii) different pricing strategy, segmenting the access to luxury goods; and (iii) different product variety, measured as disparity among the quality of consumables, affecting the selection of firms for a given distribution of consumer preferences.

We use a model of the interactions between several facets of structural change, such as firms' size and hierarchical structure, innovation in capital vintages, the emergence

of social classes, income distribution, and consumption preferences across and within classes.

The main features of the model which are relevant to this paper are as follows. First, firms in the consumable market produce a non-homogeneous good for different consumers niches. Second, each niche is a class of consumers with a different income and preferences for price and quality, representing the Engel's law. Whereas workers in the top income classes differentiate their consumption basket by choosing goods of higher quality and price, workers in the lower income classes imitate their preferences. Third, classes and their wages are endogenously determined in the model. A new income class emerges when firm size reaches a given threshold, requiring one more managerial layer. A new income class constitutes as well a new consumption niche, which has a significant impact on firms' selection only if it grows in population, which require firms to grow in size. In turn, firm's size depends on the level and the concentration of the demand. The latter is also a function of firm size – through the emergence of new consumer classes and niches. In the model we make a number of simplifying assumptions, focussing on the interaction of the different facets of structural change. We do not include a labour and a financial market, and we assume the economy to be closed. We also assume no entry of new firms.

The economic development literature has extensively investigated the relevance of demand for economic growth and industrialisation. For instance, the structuralist approach to economic development has shown that domestic and foreign demand are essential determinants of industrialisation (Kaldor, 1966) and of the technological specialisation of economies, which in turn determine growth (see Cimoli and Porcile, 2013; Cimoli et al., 2010, for up-to-date elaborations of the Prebish-Singer and the balance of payment constraint hypotheses). Following the discussion on balanced (e.g. Rosenstein-Rodan, 1943) and unbalanced (e.g. Hirschman, 1977) growth Murphy et al. (1989b) suggest that the emergence of an industrial sector requires two conditions. First, improvement in productivity in the existing sectors, to generate the surplus for a sustainable demand for manufactured goods. Second, redistribution of income to sustain the demand for a broad range of manufactured goods, rather than only for luxury (imported) goods. The industrialisation process may be driven either by the expansion of a mass market of consumers, or by a smaller set of consumers that are willing to pay a higher price for more sophisticated goods (Föllmi and Zweimüller, 2006). The literature on development and inequality has extensively analysed this trade off between market size and price effect.

In this paper we take a different perspective, which has attracted less attention in the literature. We investigate the effect of social classes, which develop distinct consumption preferences, on the concentration of the market, and how this influences growth. Crucially, there are feedbacks between economic growth and market concentration. For different patterns of growth and investment, Engel's law and consumer imitation determine firm selection via consumers choice of goods. In other words, the distribution of consumers across classes, which in our model is endogenous to growth and investment, influences market concentration.

In our case higher selectivity on price – by low income classes – reduces the size of the

market for sophisticated goods, increases firm selection and is likely to increase market concentration – for a given distribution of quality/price. As consumers preferences evolve and price selectivity decreases, the market for sophisticated goods increases, and market concentration is likely to decrease. As consumers selective on quality grow in numbers, the selection shifts on the products' quality, and market concentration is driven by top income classes. Market concentration, therefore, changes along different phases of economic development. And its effects on growth are also likely to change. Under high concentration firms grow bigger, with higher labour costs and price differentiation – which may induce more selection. However, for a sufficiently large demand, bigger firms may generate capital for R&D investment, following a Schumpeter Mark II innovation pattern (Malerba and Orsenigo, 1995). In more competitive markets, instead, we may observe more distributed R&D investment of smaller size.

We are not aware of any systematic study that would suggest which regime is more conducive to growth. Our hypothesis is that different regimes may be relevant in different phases of the development/industrialisation process. For example, whereas the industrial revolution has seen the growth of small firms into mass standardised production, other experiences of recent industrialisation, such as Japan and Korea, have witnessed the success of massive public-private investments in large companies for industrial development.

However, as suggested at the outset, the results depend on the complex interactions between different facets of structural change. For instance, in our model price differences depend on the given quality but are also influenced by different growth dynamics. First, larger firms have relatively larger labour costs, due to the growth of hierarchical organisations. Second, price is also determined by the productivity of capital vintages: firms with larger demand invest more and are likely to have a higher productivity (lower prices). In other words, in the presence of high price selectivity high market concentration is likely also when no differences in product quality are assumed. Moreover, the unsophisticated mass consumption generates most of the demand, and final results are likely to depend on its behaviour and income.

The structuralist literature on demand-led industrialisation implies a trade-off of consumer heterogeneity for economic development. On the one hand homogeneous consumers create a mass market, which is very competitive because of product standardisation. In the presence of increasing returns to scale larger firms would benefit most, and therefore market concentration should lead to higher growth rates. However, low competition and high barrier to entry for new innovative entrants is likely to reduce growth in the medium run. On the other hand, consumers heterogeneity creates niches, less competition, therefore more profitable and larger firms who can escape competition and investing more in R&D.

In this paper we contribute to the analysis of this trade-off focussing on consumers features (imitation), and on price and quality distributions, and study their effects on macro-economic performance through market concentration. We find that market concentration has a significant and positive impact on economic growth only in the presence of a sufficiently large demand (Schumpeter Mark II). When demand is not sufficient, con-

centration has no significant effect. We find the strongest effect on the model when the distribution of firm size becomes more skewed, and concentrates on firms producing goods of higher quality and price. We also find that this effect is strongly influenced by different facets of structural change. In particular, the behaviour of the less wealthy income classes is crucial in determining the pattern of concentration and growth. When they can imitate the consumption patterns of their wealthier peers they spur economic growth, and when they are forced to niches of lower quality product because of large price differences, they segment the market and reduce the impact on economic growth. In contrast, we find that the supply side only effect of product disparity, ceteris paribus, has no significant effect on growth.

In the following section we quickly mention the relevant literatures on which we build our analysis. We first discuss the methodological approach to analyse interrelated structural changes, and then quickly review the related literature and papers. In section 3 we describe the model, focussing on the main aspects of interest to this paper, and on the modifications with respect to Ciarli et al. (2010) and Ciarli et al. (2012). In Section 4 we present and discuss the results, and in Section 5 we conclude.

2 Modelling Structural Changes and Related Literature

2.1 An Agent-Based Approach to Structural Change

The literature on economic development and growth typically refers to structural change as the reallocation of labour and value added across sectors (e.g. Kuznets, 1966; Baumol, 1967; Ngai and Pissarides, 2007). A closer look reveals more interrelated processes of structural change. For instance, in a fairly comprehensive analysis of the experience of a hundred countries for three decades after the second world war, Chenery and Syrquin (1989) find a number of common patterns of industrialisation and urbanisation. Sectoral reallocations are induced by significant changes in private consumption and investment shares, with consumption moving toward less basic needs. More idiosyncratic country specific features, such as the size of demand for technological opportunities, affect the micro dynamics of structural change.

Other, more or less general, stylised facts emerge from the longer history of the industrial revolution. Among these are: the growth of firm size accompanied by the concentration of production in large capital intensive firms (Desmet and Parente, 2012); the wider increased use of capital embedded technologies across sectors which accompanies an overall increases in productivity (Kuznets, 1973); the increase in the number of goods for final consumption (Berg, 2002); the process of urbanisation, the emergence of the bourgeois class, and the increase in income inequality (McCloskey, 2009); and the increase in population, and in market size (Voth, 2003).

As already noted, many of these structural changes are interrelated, some precede economic growth, and some are induced by it. The multiple and interrelated sources of structural change are highlighted in the following definition (Saviotti and Gaffard, 2008, p. 115):

> In a systemic framework, structural change can be defined as a change in the structure of the economic system, that is, in its components and in their interactions. Components are not just industrial sectors, but also entities at lower levels of aggregation, such as particular goods or services, and other activities and institutions, such as technologies, types of knowledge, organizational forms etc.

Similarly, Matsuyama (2008, italics is ours) defines structural change in the New Palgrave Dictionary of Economics as

> a *complex*, intertwined phenomenon, not only because economic growth brings about complementary changes in various aspects of the economy, such as the sector compositions of output and employment, the organization of industry, the financial system, income and wealth distribution, demography, political institutions, and even the society's value system, but also because these changes can in turn affect the growth processes

Unfortunately, the usual framework of economic growth theory that represents growth along a balanced path with no structural changes, is not well suited to understand process of economic development and long term growth (Acemoglu, 2008, p. 693): "Behavior along or near the BGP [balanced growth path] of a neoclassical or endogenous growth economy provides a good approximation to the behavior of relatively developed societies. But many salient features of economic growth at earlier stages of development are not easy to map to this orderly behavior of balanced growth."

In order to study the structural changes that are both an outcome and a consequence of economic growth we need at least two main departures from standard theory and methods of economic growth. First, we must study the growth patterns of aggregate variables as the outcome of microeconomic direct interactions (Kirman, 2010), where structural changes can be modelled. Second, we must concede that such microeconomic interactions are the result of individuals behaviour which is based on simple routines which are in constant adaptation, rather than on perfectly rational behaviour (World Bank, 2015).

In other words, structural transformations closely resemble the dynamics of a complex evolving system – the closest metaphor we have to the observed world (Beinhocker, 2006). That is, first, individuals interact directly – not exclusively through prices (Schelling, 1978). This has consequences on the diffusion of information, and on individuals' and organisations' behaviour, observable, for example, in the division of labour, trade, business fluctuations, and the diffusion of technologies. Second, individuals access local information, compare a limited set of alternatives, and have limited ability to form expectations and to compute probabilities (Simon, 1969). Only in relatively closed environments (experiments), and under quite stringent conditions, individual responses can be attached with a probability distribution. Third, the effect of the departure from the stylised rational behaviour do not necessarily cancel out in the aggregate because of the large differences among individuals, organisations, and societies. For example in terms of income distribution (Gabaix and Landier, 2008), firm growth rates (Bottazzi and Secchi,

2006), innovations (Silverberg and Verspagen, 2007), firm size (Simon and Bonini, 1958), and other social and natural phenomena (Mitzenmacher, 2004). Using the example of firm size, the skewed distribution means that the action of some firms have a huge impact on the system with respect to others, and that firms' heterogeneity persists through time (technology, productivity, profits, growth) (Dosi et al., 2010b). Fourth, such heterogeneities also give way to processes of cumulative causation and path dependence, which in the development literature are analysed as poverty traps (Easterly, 2006). If we are interested in the analysis of development dynamics (rather than comparative statics) our objective is to investigate change, not equilibria. We are interested in the absence of equilibria, in how societies at large, and their components, evolve from one condition of relative stability to the next, through structural changes.

Models accounting for micro interactions, bounded rationality, heterogeneity, and out of equilibrium evolutionary dynamics cannot have closed form solutions and must be developed and analysed using computational methods. Computational economics offers tools to develop discrete time models, populated by different sets of agents, which in each time period are defined by a set of micro states, parameters, and adaptive decision rules. An interaction structure defines how different agents influence each other. The micro states result from those interactions, rules of behaviour and micro parameters. The interactions can be across different levels – from micro to macro. As a result, aggregate dynamics are analysed as emergent properties, such as the economic output and its distribution emerge from the behaviour of individuals and organisations in an economy.

A number of computational models have been developed to analyse economic growth and other macro properties, such as Leijonhufvud (2006); Colander et al. (2008); LeBaron and Tesfatsion (2008); Buchanan (2009); Farmer and Foley (2009); Dawid and Semmler (2010); Delli Gatti et al. (2010); Dosi et al. (2013); Fagiolo and Roventini (2012).

2.2 Related Literature

We where inspired by a number of scholarships for different aspects of the model presented here. Our model mainly fits in the evolutionary tradition of economic growth (Nelson and Winter, 1982; Silverberg and Verspagen, 2005; Cimoli, 1988; Metcalfe et al., 2006). Particularly with models which analyse the effect of the demand on growth (Dosi et al., 1994; Verspagen, 2002), which combine structuralist and evolutionary views of economic development (Cimoli, 1988; Cimoli and Porcile, 2009; Verspagen, 1993), which combine evolutionary and keynesian view of macroeconomics (Dosi et al., 2015, 2013, 2010a), and models that investigate the relation between variety and economic growth (Saviotti and Pyka, 2008, 2004).

Although our methodology is largely different, we learned from the work of Pasinetti (1981) on structural dynamics the relevance of changing consumption patterns and vertically related sectors. More in general, our theoretical work is inspired by the structuralist school in economic development (Cornwall and Cornwall, 1994; Hirschman, 1958; Kaldor, 1966; Palma, 2008; Prebish, 1950; Singer, 1950; Syrquin, 1988).

Discounting for the different methodological approach to modelling economic behaviour, our paper is related to the unbalanced growth models such as Murphy et al. (1989b,a). In these models workers are employed into two sectors producing goods for final consumption: agriculture and manufacturing. Agricultural products are the basic consumers need, and are purchased before the consumers can access the manufacturing goods. All consumers receive a salary from working in one of the two sectors. Some consumers receive also a rent from land or from capital shares. As in most growth models, manufacturing is assumed to be the sector with increasing returns.[1] However, before investment in manufacturing takes place, a demand for manufacturing goods must exist. For this to happen, workers in the agricultural sector must earn a wage that is above the living wage that is necessary to purchase agricultural products. This may occur for two necessary but not sufficient conditions: technological change in agriculture which increases productivity, and a redistribution of income from landowners to farmers. The two conditions together determine an increase in wages which is sufficient to expand the market for manufacturing goods that induce investment in the industrial sector.

Our model differs from Murphy et al. (1989b,a) in several respects. First, radical methodological differences subsumes a number of assumptions related to micro foundations, agents rationality, heterogeneity, and out of equilibrium analysis, which were discussed above. Second, we do not distinguish between agriculture and manufacturing: in our model, firms in the consumables market produce a good with a different quality index which we interpret here as the product "sophistication". Sophistication may be found in any sector, agriculture, textile, high-tech, or service. Third, we abstract from any physical limit to production, although production capacities, including workers and capital, require time to build. Fourth, we assume that firms producing sophisticated goods exist from the outset, although their market share may be initially very small. Fifth, our main contribution is that we focus on market concentration, rather than on income concentration, and we consider the former to be an outcome of consumer income and preferences. Therefore, we directly study the effects of income distribution, and related preferences, on consumption.

Beyond Murphy et al. (1989b), the question of how demand influences economic growth through income and preferences has received a vast attention. Part of the literature has discussed how the standardisation of production and the homogenisation of consumer preferences has contributed to the industrial revolution in large economies such as the U.S. (e.g. Chenery et al., 1984; Rosenberg, 1972). In contrast, much theory and evidence have shown that economic growth is related to love for variety. See for example Berg (2002) on the evidence from the English industrial revolution; Aoki and Yoshikawa (2002); Bertola et al. (2006); Patriarca and Vona (2009) for models where escaping consumer satiation drives economic growth, and Saviotti and Pyka (2008, 2004) for models where increasing product variety sustains economic growth. See also the new

[1] Even theories of economic growth that do not explicitly refer to industrialisation processes, require modelling investment in a sector in which productivity growth is sustained (and not limited by resources such as agriculture), the economy diversifies, skill labour is required, producers need to escape consumer satiation, or some other mechanism which is typical of manufacturing (Ciarli and Di Maio, 2014).

trade theory since the model by Krugman (1980), which includes consumers love for variety preferences.

By looking at social classes, income, and consumption preferences, our contribution also talks to the still controversial literature on growth and inequality. However, instead of investigating the relation between inequality and economic growth as is usually done, we investigate the less studied relation between concentration on the supply side and growth via investment and technological change.[2]

A number of models have analysed the relation between product innovation, inequality, and growth, considering consumers with heterogeneous preferences. Zweimller (2000) is very similar to ours in modelling poor consumers that mainly purchase basic needs, and rich consumers that mainly purchase luxury goods. It also extends Murphy et al. (1989b) to a dynamic setting. The model suggests that redistributive policies from the rich to the poor increase economic growth by inducing more innovation activity, stimulated by a larger demand. Using non-homothetic preferences, and releasing the assumption of a fixed mark-up, Föllmi and Zweimüller (2006) discuss the trade off between the 'price effect' with large income inequality – innovators can set a large price for rich consumers, and the 'market size effect' with low income inequality – innovators face a larger demand. They find that under given conditions the price effect can be larger than the market size effect. In our model we do not have product innovation, but process innovation through the intermediate sector, which reduces the cost of producing final goods. Such differences across firms' final good prices are essential when low income classes are selective on price differences. Moreover, in our model consumer preferences are also part of the structural transition, and change across and within income classes. In short, we are more explicit on the endogenous formation of social classes, and on how consumer preferences changes with income and imitation (related to income distribution).

Similar in spirit but also different in methods is the literature on Unified Growth Theory, which attempts to model endogenously the transition from low Malthusian growth to the fast economic growth following the industrial revolution (e.g. Galor, 2010; Desmet and Parente, 2012). Relatively closer to our work, Desmet and Parente (2012) model the transition from Malthusian growth to exponential growth in a unified growth theory model where the main triggers of the transitions are increasing firm size and an expansion of the consumer market, which brings about a greater variety of goods. The increase in firm size triggers a greater investment which raises productivity. In our model the increase in firm size also induces more investment and productivity growth, as well as an increase in demand, However, the key to industrial transformation is the emergence of new consumer classes triggered by firm size and organisation.

Finally, few contributions have modelled the effect of market concentration on economic growth. Peretto (1999b) models a two sector economy in which an intermediate sector that invest in R&D and increases productivity is the core of the endogenous growth process. The intermediate sector goes through different industrial cycles with different market concentration and firm size. The transition from an intermediate sector with

[2]In our model the direct sources of inequality have a negative effect on growth, as discussed in a different paper (Ciarli et al., 2012).

small firms that do not invest in R&D to an intermediate sector with a lower number of large firms with large investment in R&D accompanies the transition from a low to a fast growing economy. Peretto (1999a) finds a trade off between the number of firms and growth, due to the lower returns to R&D with a large number of firms with lower R&D investment per capita, and overall lower increase in productivity. In our model market concentration in the sector of consumable also generates concentration in the intermediate sector which produce capital goods and innovate. However, in our model concentration is endogenous to a number of demand dynamics, which are related to the growth of firms in the consumable sector, as we discuss in the next section. Moreover we not always find a positive relation between market concentration, productivity and output growth.

3 The model

We model an artificial economy composed of three sectors: a consumable sector populated by F firms indexed $f \in \{1; 2; ...F\}$, a capital good sector populated by G firms indexed $g \in \{1; 2; ...; G\}$, and a household sector populated by $N(t)$ consumers/workers divided into $H(t)$ classes indexed $z \in \{1; 2; ...; \Lambda(t)\}$. The model is an extension of Ciarli et al. (2012, 2010), where a detailed description can be found.[3] Here we provide a more informal description focusing on the original aspects of the model that are most relevant to this paper.

Product Characteristics

Firms in the consumables market produce a non-homogeneous good differing in terms of quality ($i_{2,f}$) and price ($i_{1,f}(t) = p_f(t)$). The quality is assigned at the outset linearly increasingly with respect to firm index from $\underline{i_2}$ to $\overline{i_2}$. Where $\underline{i_2}$ and $\overline{i_2}$ are exploited to study how the distribution of variety affects the economic development pattern of an economy. Products with higher quality are more sophisticated and should be thought as luxury goods. Products with lower quality are less sophisticated and should be thought as satisfying basic needs. Changes in the distribution of quality and in the disparity of goods on the market is one of the facets of structural change considered in this paper. Rather than investigating the emergence of new goods, we investigate the chagning composition of demand and supply.

The price is set independently by each as a mark-up rule ($\mu_f(t)$) on labour costs $c_f(t)$:[4]

$$p_f(t) = i_{1,f}(t) = (1 + \mu_f(t))c_f(t) \tag{1}$$

[3]The model is implemented using the platform *Laboratory for Simulation Development – LSD* (Valente, 2008). The platform allows a modular design of simulation models and, though simple to use, is particularly suited for large scale simulation analysis. See `www.labsimdev.org` for further details. The code for this specific model is available upon request.

[4]This assumption is supported by empirical evidence dating back to Hall and Hitch (1939) and, more recently, to Blinder (1991) and Hall et al. (1997). For a recent review of price-setting behaviour in the Euro area, see Fabiani et al. (2006).

We assume that firms producing a good of higher quality also have larger market power. The mark-up is thus proportional to quality, with the minimum mark-up $\underline{\mu}$ corresponding to the minimum quality $\underline{i_2}$, and the maximum mark-up $\overline{\mu}$ corresponding to the maximum quality $\overline{i_2}$. Given $\underline{\mu}$ and $\overline{\mu}$, the mark-up level is proportional to the quality of a firms's product relative to the quality range $\left[\underline{i_2}, \overline{i_2}\right]$:

$$\mu_f = \frac{i_{2,f(t)} - \underline{i_2}}{\overline{i_2} - \underline{i_2}} \left(\overline{\mu} - \underline{\mu}\right) + \underline{\mu} \tag{2}$$

In other words, for a given $\overline{\mu}$ the distribution of mark-ups among firms is independent from the quality range $\left[\underline{i_2}, \overline{i_2}\right]$. This ensures that we can compare economies with different product disparity, without confounding quality and price effects.

Consumer Selection of Goods and Firms

Different income classes (z) have different preferences with respect to price and quality and a different purchasing power (defined below), following the model by Valente (2012). Preferences define the characteristics of the basket of selected goods, whereas purchasing power (income) determine the level of demand for the firms producing a good with the selected characteristics (the demand is equally shared among the selected firms).

Consumers have limited information on the true quality and price of products.[5] The choice is made with respect to a *perceived* value drawn from a normally distributed random function centred on the true values. At the core of the model lies the purchasing routine of bounded rational consumers. The preferences of the consumer (identical for all members of a class) are defined as thresholds with respect to quality and price defining the minimum quality and the highest price of the good that they are ready to purchase. The thresholds are defined in terms of a given percentage above (for price) or below (for quality) the best product, according to the perceived values. Consumers that are very selective with respect to quality purchase only goods that have a quality similar to the best good in the market. Consumers that are very selective with respect to price purchase only goods with a price similar to the least expensive good in the market. Conversely, consumers that are not selective with respect to price (quality) will be ready to purchase nearly any good, irrespective from the differences in price (quality) among firms. If a given products fails to pass the threshold on either the price (too high) or quality (too low), then the product is discarded. If all the products are discarded, then the best one is chosen. In case more than one product passes both threshold, then the consumer chooses one with randomly with a uniform probability.

We assume that price selectivity decreases with a class income, whereas quality selectivity increases with a class income. These differences should be thought as a way to represent the Engel's law (satiation with basic needs). The lowest income class is very selective with respect to price – implying that only the cheapest products are purchased – and not at all selective with respect to quality – implying no selection concerning

[5]Evidence on consumer difficulty in assessing product quality and price is discussed, for example, in Celsi and Olson (1988); Hoch and Ha (1986); Rao and Monroe (1989) and Zeithaml (1988).

quality. The following classes are defined with preferences which are increasingly less selective with respect to price and more selective with respect to quality. We indicate with υ^{max} (υ^{min}) the selectivity of the poorest (wealthiest) class with respect to price (quality) and the selectivity of the wealthiest (poorest) class with respect to quality (price), where $\upsilon^{max} + \upsilon^{min} = 1$

$$\upsilon_{p,z=1} = \upsilon_{q,z=\infty} = \upsilon^{max}$$
$$\upsilon_{q,z=1} = \upsilon_{p,z=\infty} = \upsilon^{min}$$

where the second index indicates the class.

When a new class $z + 1$ is formed, its levels of selectivity are defined as:

$$\upsilon_{p,z+1} = (1 - \delta_\varsigma)\upsilon_{p,z} + \delta_\varsigma \upsilon^{min} \tag{3}$$
$$\upsilon_{q,z+1} = (1 - \delta_\varsigma)\upsilon_{q,z} + \delta_\varsigma \upsilon^{max} \tag{4}$$

where z is the income class and increases monotonically with income, and δ_ς is a parameter indicating the extent to which wealthier classes differentiate themselves with respect to less wealthy classes in terms of consumption preferences. The theoretical last class of infinitely wealthy consumers have preferences defined as:

$$\upsilon_{p,z=\infty} = \upsilon_{q,z=1} = \upsilon^{min}$$
$$\upsilon_{q,z=\infty} = \upsilon_{p,z=1} = \upsilon^{max}$$

indicating minimum selectivity with respect to price and maximum selectivity with respect to quality. The closer the values of υ^{max} and υ^{min}, the more similar the consumption patterns across classes, the larger the market for all goods (no niche markets can emerge), and the lower the selectivity of firms.

In addition to Engel curves representing the shift from basic inexpensive goods to luxury expensive goods as income grows, we also model the imitation of consumers of lower income classes of the preferences of higher income classes. Consumption is an act with strong social implications, as famously noted by Veblen (2005). In many, if not all, examples of modern industrial growth, increasing incomes and productivity have been accompanied by the adoption of consumers' habits of higher social status classes by low income classes. The concept of "aspirational" consumer is a well known feature of the marketing literature, and it has been studied also in the economic literature (Cowan et al., 1997) as well as in development economics. For example, Kaus (2013) shows that rapid social changes make imitation of consumers' styles more visible. In our model we assume that when a new, wealthier, class emerges, adopting more conspicuous consumption preferences (more selective with respect to quality and less with respect to price), consumers from all existing classes shift their own preferences, reducing (increasing) price (quality) selectivity. Formally, when a new class $z = Z$ emerges, all other classes $z < Z$ change their selectivity according to the following equation:

$$\upsilon_{p,z<Z} = (1 - \alpha)\upsilon_{p,z+1} + \alpha\upsilon_{p,z+1} \tag{5}$$
$$\upsilon_{q,z<Z} = (1 - \alpha)\upsilon_{q,z+1} + \alpha\upsilon_{q,z+1} \tag{6}$$

where α is a parameter defining the imitation of immediately higher income classes. In the next section we study the effect of α on he model results.

Labour Demand and the Emergence of Consumer Classes

In our model consumer selection and industrial dynamics co-evolve. By selecting goods produced by a subset of firms, consumers increase market concentration. Higher market concentration implies a more skewed distribution of firm size, with some firms growing larger. As firms grow large they require additional workers and capital goods, producing more firm heterogeneity (therefore selection). On the one hand, additional workers require additional supervisor, which require additional tiers of managers. The growth of managerial classes has two effects: first, it increases the number of consumer classes and therefore the number of consumer niches with different consumption preferences (selectivity); second, it increases the overall cost of labour and, therefore, firm output price.[6] Given the assumption that wealthier classes choose more sophisticated goods, firms that produce goods of higher quality may start gaining market shares. This may change firm selection, and the distribution of firms. However, larger classes – those at the bottom of the organisation pyramid, which select firms on the basis of the good's price – form the bulk of consumption. Therefore, the composition of the consumables market will reflect the composition of the demand – which in turn is influenced by the former.

On the other hand, additional capital may be of higher productivity with respect to the current capital stock of the firm and its competitors. Capital investment has the effect of increasing firm productivity and, therefore, reducing output price. We discuss labour demand firms organisation, and capital investment and productivity, in turn.

Given the number of workers $L^1_{f|g}(t)$ required to produce firm's output in time t ($Q_{f|g}(t)$) – in both the consumable (f) and the capital good (g) sectors, we assume that a firm hires $L^1_{f|g}(t)/\nu$ second tier managers ($L^2_{f|g}(t)$) to organise the shop-floor, where ν is the number of subordinates for any manager at any level of the organisational pyramid (Simon, 1957). When the number of second tiers managers also reaches ν ($L^2_{f|g}(t) = \nu$), the firm hires one third tier manager ($L^3_{f|g}(t)$) to organise production. So on and so forth as long as the number of managers in the highest tier grows beyond ν. In other words, we model firms with the well known hierarchical structure (Simon, 1957; Lydall, 1959; Waldman, 1984; Abowd et al., 1999; Prescott, 2003) which is given by the number of workers in the first tier ($L^1_{f|g}(t)$) and the set multiplier which defines the number of workers per supervisor (ν):

$$L^l_{f|g}(t) = \nu^{1-l} L^1_{f|g}(t) \tag{7}$$

where l is the tier level. The total number of workers in the economy is then simply given by $L_{f|g}(t) = L^1_{f|g}(t) \sum_{l=1}^{\Lambda_{f|g}(t)} \nu^{1-l}$.[7] We also assume inertia in the labour market, in the way explained in Ciarli et al. (2012, section 2.2.2).

[6] For a discussion on firm size and labour cost see also Brown and Medoff (1989); Criscuolo (2000); Bottazzi and Grazzi (2010).

[7] The level of demand depends on the income of each income class, as we will se further on.

As widely discussed in the literature we assume that individuals working in higher tiers of the organisation earn a multiple b of the workers in the tier immediately below $(l-1)$. The wage paid to workers in each organisational tier is computed as:

$$w^l_{f|g}(t) = b^{l-1} w^1_{f|g}(t) \tag{8}$$

where $w^1_{f|g}(t) = \omega w_m(t-1)$, i.e. the wage paid to the first class is a fixed multiple ω of the minimum wage $w_m(t-1)$. The minimum wage is a function of unemployment, productivity, and inflation. A national wage is first determined on the basis of a wage curve (Blanchflower and Oswald, 2006; Nijkamp and Poot, 2005), and is then updated if both labour productivity and consumer prices increase. Details of the whole process are explained in equations 33-35 in Ciarli et al. (2010).

Earning differences among classes are not confined to wages only (Atkinson, 2007). Firms distribute to executives (from $l = 2$ above) the cumulated profits $R^D_{f|g}(t)$ which are not used for capital investment – in the consumable sector – or in research and development (R&D) – in the capital good sector. The share of profits to each tier of executives is proportional to the wage differences, and is equal for each executive:

$$\psi^l_{f|g}(t) = \frac{b^{l-1}}{\sum_{l=2}^{\Lambda_{f|g}(t)} b^{l-1}} R^D_{f|g}(t) \; \forall l \in \{2; ...; \Lambda_{f|g}(t)\} \tag{9}$$

Finally, we assume that each tier of workers l that is added in a firm as a consequence of the growth of sales, corresponds to one more class z of consumers $l = z$. Therefore we also assume that consumer preferences are strongly related to a worker employment status.

Capital Investment and Productivity Growth

Firms in the consumable sector differentiate themselves with respect to competitors for a given quality and the price, which depends on variable labour costs. Labour costs depend on the number of executive tiers – the more are the workers, the higher the diseconomies of scale due to to the organisational structure, for a given ν – and on the productivity of the capital stock $A_f(t)$. Firm productivity depends on a firm's investment and on the R&D activity of capital suppliers.

Each firm has a capital stock $K_f(t)$ formed of different vintages $k_{h,f}$ purchased in different periods τ.[8] The overall level of firm productivity, weights the productivity of each capital vintage (a_{g,τ_h}) by its contribution to the overall stock and is computed as:

$$A_f(t) = \sum_{h=1}^{V_f(t)} \frac{k_{h,f}(1-\delta)^{t-\tau_h}}{K_f(t)} a_{g,\tau_h} \tag{10}$$

where $V_f(t)$ is the total number of capital vintages in firm f; h is an index for a single vintage; δ is the depreciations rate of capital; and g is the index of the capital good firm from which the capital vintage was purchased in time $t = \tau$.

[8] In the first period firms have one single vintage.

A firm f invests in a new capital vintage whenever its output falls below its demand because of capital constraints. First, a firm f selects a firm g in the capital good sector with a probability increasing with the productivity of the capital good that can be produced by g ($a_{g,t-1}$), and decreasing with its price ($p_{g,t-1}$) and the relative time needed by g to produce the new capital good, with respect to competitors. We assume that capital good firms produce only when they receive an order, that producing capital goods takes time (Amendola and Gaffard, 1998), and that firms produce on a first-in first-out basis. Second, firm f places an order to the selected g. Finally, depending on g production capacity and the number of orders in line, the capital goo is delivered and added to the stock. We assume that when a firm places an order it uses the cumulated profits – which are then no more available for sharing to executives – and can access an unconstrained financial market.

It is important to note that when firm f places an order for a capital good it needs to wait until delivery before it can place a new order. This delays consumable good firms' reaction to changes in the demand (composition). More crucially, when the market is very concentrated, capital good firms receive few but massive orders. This is because of two features in our model. First, the few successful firms in the consumable market see their demand increasing while they wait for a capital vintage ordered previously. Second, the few capital producers that receive the bulky orders invest massively in R&D (more below), increase their productivity and become more attractive, unless their production queue is too long.

Therefore, the market concentration in the capital good sector is equivalent to the market concentration in the capital good sector. We now turn to the R&D and innovation in capital vintages in the capital good sector to discuss how this may affect the innovation process.

Innovation and the Productivity of Capital Vintages

The demand faced by firms in the capital goods sector ($K_g^d(t)$) equals the sum of orders of capital goods received from firms in the consumables sector in period t, plus the orders which are still in production. The demand determines the number of workers hired at the shop floor level in each period ($L_g^1(t)$).

Firms in the capital goods sector devote a share ρ of profits cumulated in the past to R&D through the employment of engineers (Llerena and Lorentz, 2004).[9] However, we assume that the total number of engineers $L_g^E(t)$ should not exceed a given ratio ν^E of the shop-floor workers. For a given amount of investment we assume that R&D is uncertain with respect to both whether it will produce any innovation and to the extent to which a successful innovation improves the productivity of the capital vintages produced (Nelson and Winter, 1982). We follow standard Schumpeterian growth models to model innovation as a stochastic process (Aghion and Howitt, 1998; Silverberg and Verspagen, 2005; Dosi et al., 2010a). First, the probability that an investment in R&D

[9] As already discussed above, profits that are not invested in R$D or capital are distributed to executives.

will succeed and produce some innovation depends on the number of engineers working on the innovation:

$$P_g(t) = 1 - e^{-\zeta L_g^E(t-1)} \tag{11}$$

where ζ is a parameter that accounts for other differences that may affect the innovation probability.

Second, if the innovation succeeds, the productivity of the vintages produced starting from $t+1$ is a stochastic improvement with respect to the vintages that the firm used to produce until the last period:

$$a_{g,\tau} = a_{g,\tau-1}\left(1 + max\{\varepsilon_g(t); 0\}\right) \tag{12}$$

where $\varepsilon_g(t) \sim N(0; \sigma^a)$. In other words, firms search for new technologies locally, where the local knowledge depends on their own past technological achievements. The improvement is given by a stochastic variable distributed normally with a given variance σ^a, which determines the speed at which the productivity of new vintages increase.

It is important to note that in our model the amount of investment in R&D for productivity increases: (i) the higher the investment ($L_g^E(t)$) the higher the probability of innovating; (ii) the more the innovation done in the past, the higher the productivity of future vintages; (iii) the higher the productivity of the capital produced by a firm g the higher the probability that it will receive future orders, increasing even more the resources invested in R&D – unless the higher prices and the longer waiting queues of larger successful firms compensate for the higher productivity. As a consequence, market concentration in the capital good sector should induce more innovation, as in as Schumpeter Mark II model (Malerba and Orsenigo, 1995).

Output and Costing

Production in the final good sector ($Q_f(t)$) follows adaptive expectations with respect to the final demand (Chiarella et al., 2000; Dosi et al., 2015). Expectations are formed as a result of the demand from consumers in the different classes in $t-1$. The difference between the current and the expected demand is transformed into positive and negative (backlogs) inventories ($S_f(t)$) (Blanchard, 1983; Blinder, 1982). Firms produce using a fixed coefficient production function with labour ($L_f^1(t-1)$) and capital ($K_f(t-1)$) as inputs. For a given level of output the amount of labour required depends on the productivity of the stock of capital vintages accumulated by the firm ($A_f(t-1)$), whereas for capital we assume a fix capital intensity (D_f). The complete determination of output is illustrated in equations 1-4 in Ciarli et al. (2012). We also assume no constraint in accessing capital and labour. However, labour demand (first tier) is inertial (adjusts slowly to changes in firm demand), and capital supply depends on the productive capacity of firms in the intermediate sector.

Variable costs $c_f(t)$ for firms in the final sector depend exclusively on wages. Therefore, they depend on the number of workers, and on the number of tiers. In particular, workers above the first tier do not participate in the production, and therefore reduce

productivity by definition. The number of workers per output depend on the productivity of the capital vintages. The higher the capital investment of a firm f, the higher its productivity, the lower its costs and price. Finally, the profits ($\pi_f(t)$) used for future investments and distributed as shares to executives are simply the difference between the value o sales and variable costs.

Production in the intermediate sector ($Q_g(t)$) is determined by the orders from the consumable sector and is just-in-time (Cooper and Haltiwanger, 2006; Doms and Dunne, 1998). Firms use only labour as input with constant returns to scale and productivity (for shop-floor workers).

The price of capital vintages ($p_g(t)$) is a fixed mark-up μ_g on variable costs, which in this case depends on the number of workers and of engineers. Similarly, the profits ($\pi_f(t)$) reinvested in R&D and distributed to executives are computed as the difference between the value of sales and the cost of workers, executives and engineers.

Firm's Demand

The demand for firms in the intermediate sector is determined by the capital investment of firms in the consumable sector, as already discussed. We close the model by forming the demand for firms in the consumable sector. We have already extensively discussed how consumers in different classes choose among the goods offered by firms. We need only define how much each class spends.

The income of each class of workers z results from the sum of the wages w and of the bonuses ψ of all workers, in all firms in both sectors (f, g), in the corresponding organisational tier $l = z$:

$$W_z(t) = \sum_{f=1}^{F} w_f^l(t) L_f^l(t-1) + \sum_{f=1}^{F} \psi_f^l(t) + \sum_{g=1}^{G} w_g^l(t) L_g^l(t-1) + \sum_{g=1}^{G} \psi_g^l(t) \qquad (13)$$

Given the income consumers in each class adjust the consumption level smoothing short term consumption changes Krueger and Perri (2005a). The consumption in period t is thus a linear combination of the past an present income:

$$C_z(t) = \gamma C_z(t-1) + (1-\gamma) W_z(t) \qquad (14)$$

where γ is the smoothing factor.

Finally, the consumption of the workers of each class ($C_z(t)$) is shared equally among all the firms in the consumable sectors which are selected – because they are above the quality threshold and below the price threshold. As discussed above, firms's market shares can be affected by a large number of factors: (i) firms' labour, capital, and quality; (ii) classes' preferences; (iii) the class composition of the demand. All factors reflect different facets of structural change: (i) firm size and organisation, capital productivity and deepening, and product variety; (ii) emergence of different needs and consumption patterns as a result of income growth; (iii) emergence of different social classes. All these factors, in turn, are affected by market concentration.

In the next section we analyse the relation between market concentration and a number of structural changes in our model. Next, we study how these properties change for different distributions of product disparity, different patterns of adaptation of consumer preferences, and pricing strategies.

4 Results

In this section we discuss the main model properties, and analyse how they are influenced by three parameters accounting for (i) imitation for consumer preferences across classes, (ii) mark-up rate, and (iii) product disparity.

4.1 Model Properties

We discuss the model properties associated to the relation between market concentration, per capita output, demand preferences (dynamic), and product quality (static) and price (dynamic).

We analyse the properties numerically, by simulating the model dynamics one hundred times to control for different random events. The model is initialised using a "benchmark" configuration of the parameters and initial values (Table 1) that is congruent with empirical observation (when data is available).

As with previous versions (Ciarli et al., 2010, 2012; Lorentz et al., 2014), the model shows an endogenous growth path that through time becomes exponential.[10] In this paper we are mainly interested in the relation between market concentration and economic growth, along different phases of economic development during which the economy goes through a number of changes in the structure of production and consumption. We plot this relation in Figure 1. On the horizontal axis is the inverse Herfindahl index (IHI) for firms' market shares. The IHI ranges between one and F, where one means that only one firm dominates the market, and F means that all firms have the same shear of the market.[11] In other words, the higher the IHI the lower the concentration. On the vertical axis we measure two growth related variables: per capital output, and the weighted average productivity of the capital used by firms in the consumable market.

The figure shows two different relations, for both output and productivity, corresponding to two distinct stages of economic growth. The first phase, to which we refer as Malthusian (stagnation), is characterised by linear output growth and per capita stagnation. All dots horizontally aligned to the x-axis correspond to this phase, when, as Figure 1 shows, changes in market concentration are not related to per capita output and average productivity. In the second stage, to which we refer as Kaldorian (exponential growth), the average capital productivity and per capital output increase with market concentration (lower IHI), and is cyclical.[12]

[10] Results not shown for reasons of space, are available to the interested readers.

[11] We run a a model with 50 firms in the consumable sector.

[12] The fact that output per capita is lower than productivity depends on the diminishing returns to scale due to the increasing number of managers to coordinate larger organisations. As a consequence,

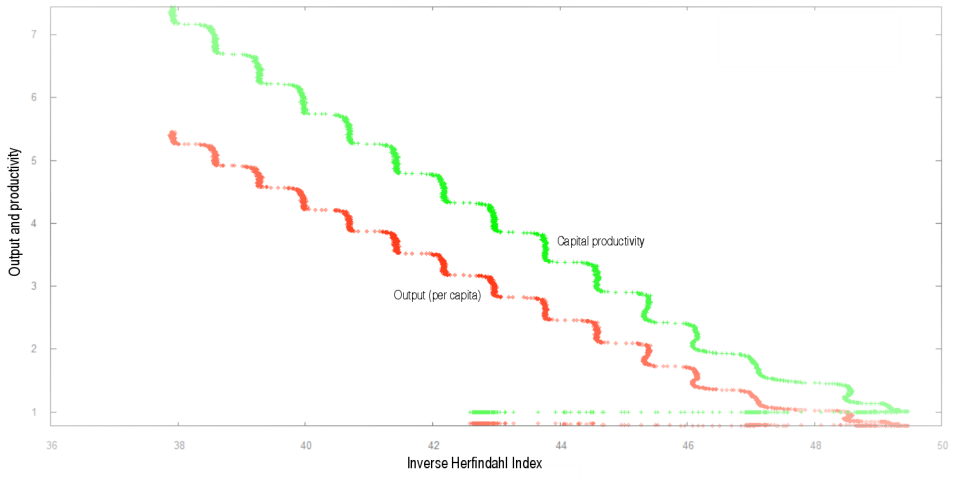

Figure 1: Average weighted productivity of the capital used by firms in the consumable market (top series) and output per capita (lower series) – vertical axis – plotted against the inverse Herfindahl index of market shares of firms in the consumable sector – horizontal axis.

The key to explain the relation between market concentration and increase in productivity, leading to per capita output growth is capital investment. As firms sales grow, they increase capital capacity, requesting new capital vintages to the intermediate sector firms, who increase R&D investments as their output increases. The sales of firms in the consumable market can increase because of the level, or the concentration of demand. Demand level depends on the number of workers, whereas demand concentration depends on consumers' selectivity, and therefore on the composition of workers.

In Figure 2 we plot the times series of the IHI. Considering that the take-off – income growth with productivity growth – begins around period 900, the initial concentration is associated with economic stagnation. This is because the demand level is too low even for the firms with higher market shares to invest in new capital vintages. In other words, in a stage of low demand we do not observe a Schumpeter mark II dynamics: profits are redistributed and not invested, and firms in the intermediate market are idle. The concentration of the market has no effect. However, after a period of quasi perfect market competition, during which labour and demand increase, the market begins to concentrate again, favouring firms with highest quality, which induce large investment in capital and R&D. During this phase we observe the positive relation between market concentration, productivity, and per capita output.

These two phases in which concentration has a significantly different effect on economic growth are characterised by a complex interplay between changes in demand level and composition, firm competitiveness and growth, and market structure. Which also

part of the increase in productivity due to technological innovation is spent to compensate decreasing productivity caused by the increasing size of firms.

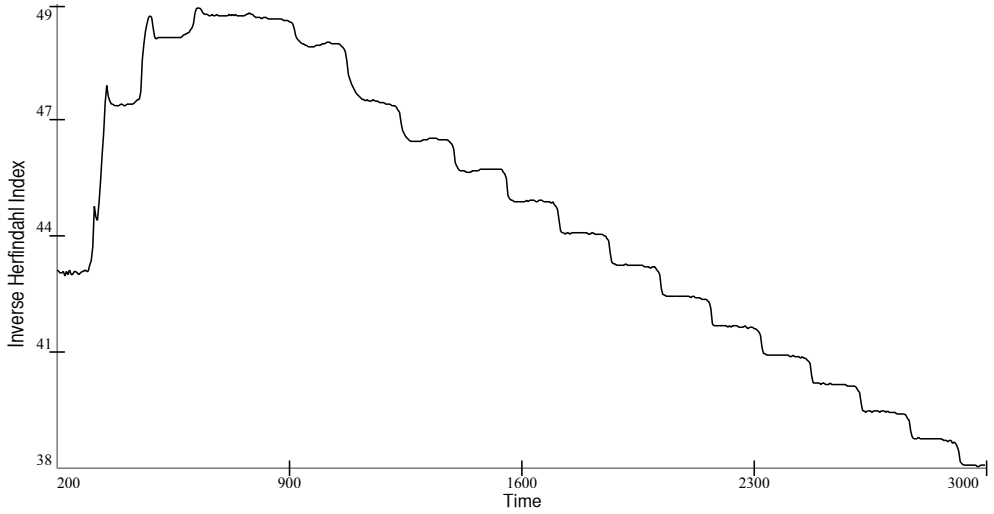

Figure 2: Time series of the inverse Herfindahl index of the market shares of firms in the consumable sector

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explains the cyclical pattern of the relation between market concentration and per capita output in Figure 1.

First, in our model consumers preferences are defined by the hierarchical position in the company they work for, which defines an income class. Second, as firms grow larger they add new management layers forming new classes with consumers with higher income, lower selectivity with respect to price and higher selectivity with respect to quality. While wealthier classes attempt to distinguish themselves purchasing goods of higher quality (higher quality selectivity), existing classes imitate their behaviour, reducing their own price selectivity and increasing their own quality selectivity[13]. As a result, firm growth, the emergence of new consumer classes, and the imitation of the less affluent classes monotonically increases the demand for higher quality and price products and reduces the demand for "cheap" goods. This explains the step relation in Figure 1: each step is induced by a change in consumer class composition, which in turn increase the selection pressure for firms with respect to product quality. It also explains the positive effect that firm and employment growth has on market concentration: a growing economy, with growing firm size 'produces' more sophisticated consumers with higher income. It is important to note that more than seventy percent of the demand comes from the first two classes, the most numerous by construction. Therefore, it is their preferences and selectivity that are crucial in driving the results (for instance via imitation). In the next two sections we will investigate the effect of market concentration on growth.

As shown in Figure 2, however, unlike the demand for higher quality goods, the emerging market concentration follows a non-monotonic change. We explain this prop-

[13]Reducing at the same time the amount of goods purchased, given their budget constraint.

erty in Figure 3 where we plot the distribution of the market shares of firms in the consumable market, ordered by decreasing quality, for different time steps of the simulation. On the vertical axis we measure the firm's market share. On the horizontal axis are the firm ordered by the quality of their output, with the highest quality firm closest to the origin. We remind that the mark-up rate is positively related to the price quality. Therefore firms closer to the origin are likely to ask for a higher price.[14] Each distribution corresponds to a different time step.

As noted in Figure 2 around the 900th step firms have very similar market shares. As we move towards the initial and the final steps the distribution of firm's size is significantly more skewed. In particular, in the periods before 900 firms with lower prices have an advantage of higher quality competitors, due to the relatively high share of consumers seeking low-quality, low-price products. Due to the emergence of new income classes (as the economy grows) and to their imitation by the bulk of the demand, during the latest stages of the simulation no consumer is particularly selective on price and all have acquired some selectivity with respect to quality. Therefore, product of lowest quality and price see their market shares disappear, whereas firms with the highest quality exploit the preferences of the top managers with very high incomes and attract increasing numbers of middle- and low-income workers who imitate the life-style of their more affluent peer.

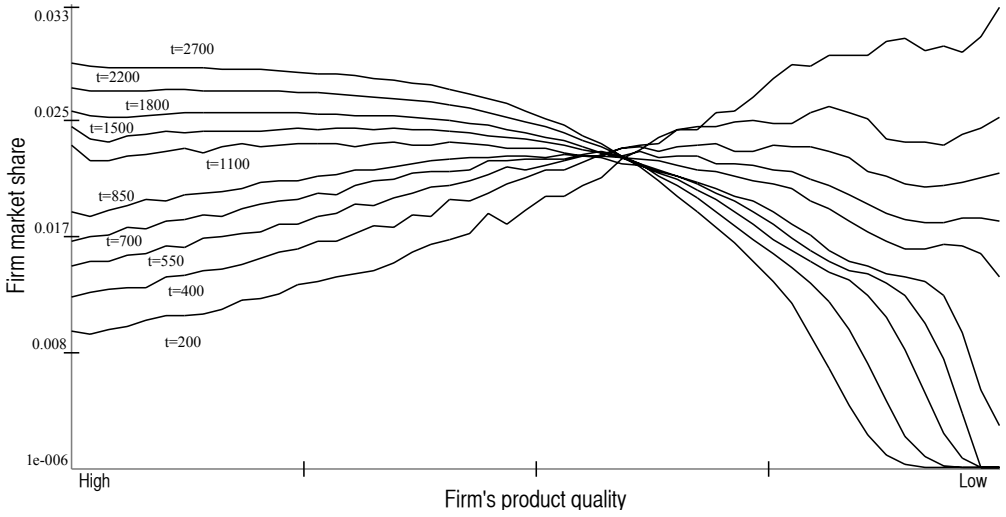


Figure 3: Market share distribution of firms in the consumable market at different times periods. Firms are ordered by a decreasing levels of quality (leftmost has the highest quality) on the horizontal axis. Market shares on the vertical axis.

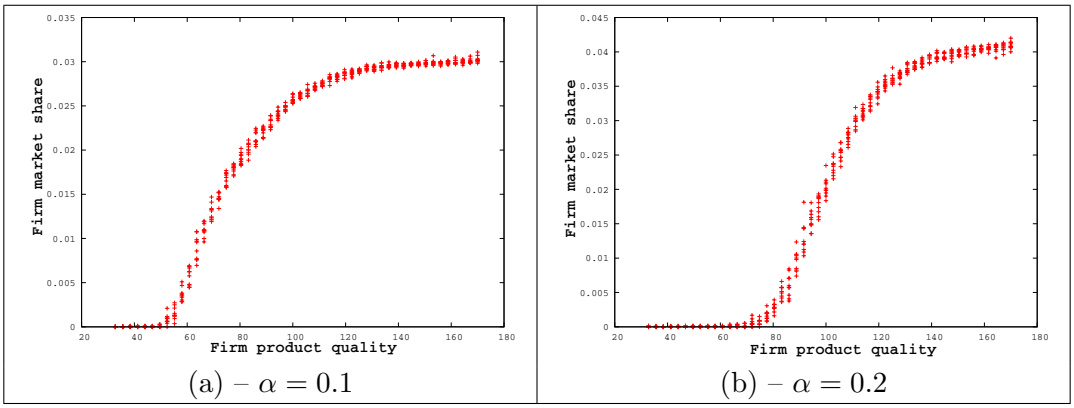
Indeed, different patterns of preferences imitation, mark-up rates, and product disparity may influence the pattern of economic growth through the market structure. This is what we explore in the following sections.

[14]The reason why this may not be the case is that the price is crucially determined by variable costs, which depend on firm size and capital investment.

4.2 Imitation Pressure in Consumption Patterns

We explore the effect of a faster imitation of consumption patterns (α). In the 'benchmark' configuration the consumer selectivity of an income class z with respect to minimal quality ($\upsilon_{q,z}$) (maximal price ($\upsilon_{p,z}$)) increases (decreases) by 10% with respect to the selectivity of the next income class ($\upsilon_{q,z+1}$ and $\upsilon_{p,z+1}$) – every time a new, wealthier, class and consumption patterns emerges.[15] We compare the benchmark case with results obtained with faster imitation (20%), representing societies where low income classes are faster in adopting consumption habits observed in richer classes (for a given income growth). The implications are that, for a given increase in firm size, consumers become more rapidly less selective with respect to price, and more selective with respect to the product quality, reducing market concentration in the early stage and increasing it in the later stages of growth. As observed earlier, the first three classes form the bulk of the demand, and it is their preferences that determined the results of the model.

In Figure 4 we compare the market share distribution of firms ranked on the horizontal axis by increasing quality for the benchmark case (graph a – $\alpha = 0.1$) and for the case with faster imitation (graph b – $\alpha = 0.2$) in the last period of the simulation. We plot results from ten different runs to control for randomness. The figure clearly shows that with faster imitation rates the distribution of firm size (market shares) is significantly more skewed, as expected, with a higher number of firms exiting the market.



(a) – $\alpha = 0.1$ (b) – $\alpha = 0.2$

Figure 4: Distribution of firms market shares (vertical) for increasing product quality (horizontal). Panel (a): benchmark consumer imitation rate (10%). Panel (b): faster consumer imitation rate (20%).

We then study whether the rate of consumer imitation has a systematic effect on market concentration and income growth. We performed 100 simulation runs with configurations set with a different value of the parameter α ranging from 10% to 20%. In Figure 5 we plot the relation between the IHI and output per capita.

Compared to the benchmark case (bottom right in Figure 5), the increasing concentration generated by faster imitation of consumer preferences for conspicuous consump-

[15] See eq. 3.

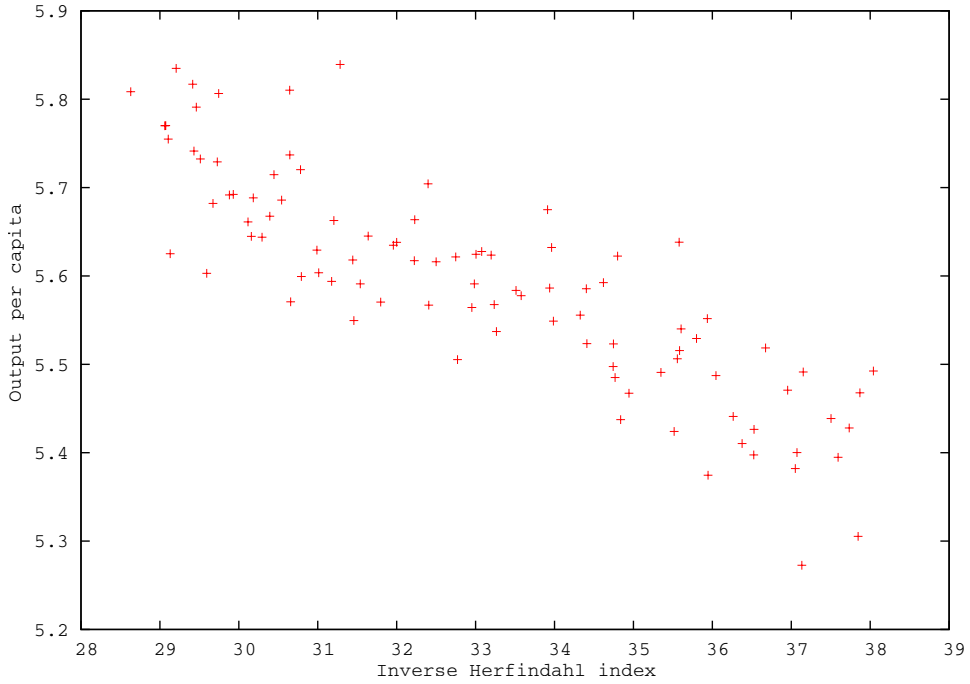


Figure 5: Inverse Herfindahl index versus output per capita for different rates of consumer imitation.

tion has two main effects. First, a significant increase in the demand for higher quality goods, due to the large share of total income of the lower income classes (as shown in Figure 4). Second, a significant increase in demand for new capital vintages, due to the relatively more skewed distribution towards large firms.

The results suggest a mechanism by which societies where lower income classes, through redistribution and social mobility, have access to the basket of top classes may lead to stronger economic performance.

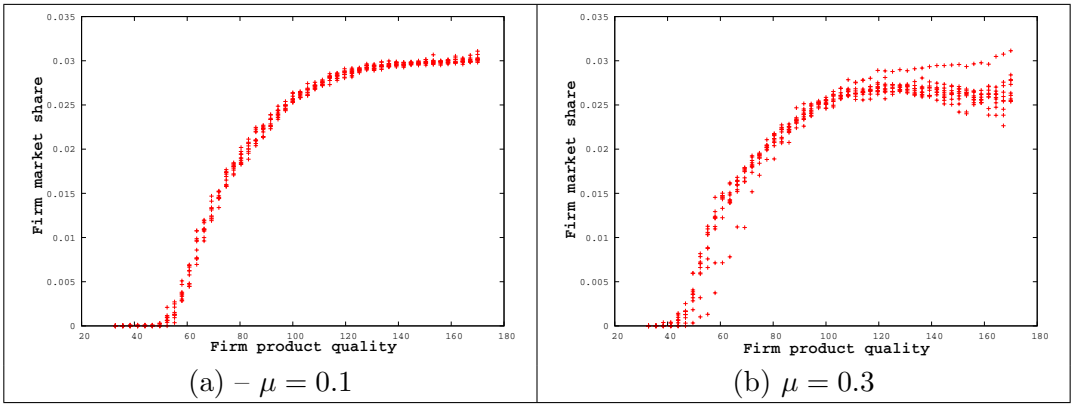
4.3 Markup and Distribution

In this section we assess the effect of different pricing regimes in the presence of consumer imitation, product variety and consumer selection, in closed economy. How do higher mark-up rates influence the choice of consumers from different income classes, the emergence of new classes, and the relation between market concentration and income growth. Prices in our model are set as a mark-up charged on top of labour costs (see equation 3), with mark-up rates proportional to quality levels. We compare the benchmark case (10%) with results obtained with a higher maximum mark-up rate (30%), representing societies where firms are able to extract more profit and have more resources for

investment and to redistribute to shareholders.[16]

The implications are that, for a higher mark-up rate, *ceteris paribus*, the low income class select more on the basis of price than on the base of product quality, despite the imitation process. Moreover, the overall demand is lower.

In Figure 6 we plot the market shares of firms ordered on the horizontal axis by increasing quality. In panel (a) the benchmark case (maximum $\mu = 0.1$) and in panel (b) the case with high mark-up (maximum $\mu = 0.3$). First, (b) shows larger differences in the distribution for different simulation runs, suggesting a stronger effect of labour cost through size and productivity, with respect to quality, in determining the price. Second, market shares significantly change for the extreme values of quality, ad remain quite similar for central values. In general, with higher mark-up rates lower quality firm experience higher sales, and high quality firms experience lower sales, compared to the benchmark configuration with lower mark-ups. The net effect is that with higher mark-ups there is lower concentration (lower IHI).



(a) – $\mu = 0.1$ (b) $\mu = 0.3$

Figure 6: Distribution of firms market share (vertical) for increasing product quality (horizontal). Panel (a): lower mark-up rate (10%). Panel (b): higher mark-up rate (30%).

The effects of the lower market concentration on output per capita is significantly negative. In Figure 7 we plot this relation for the last simulation period. Compared to the benchmark case (top left in Figure 7), for an increasing mark-up the economy experiences a higher market segmentation between rich and poor consumers, with an overall lower concentration. Higher prices depress demand, and therefore per capita output in two ways: (i) directly, by reducing the demand; (ii) indirectly, by reducing market concentration.

Within the limits of our model, we conclude that a higher market power and price levels decrease market concentration by hindering the consumption of higher quality goods to lower income classes, and separating different consumer niches. As a conse-

[16]We recall that given the maximum rate, the mark-up is proportional to product quality, as described in equation 3. In other words, changing the maximum rate we affect the absolute rates but maintain their proportionality to quality.

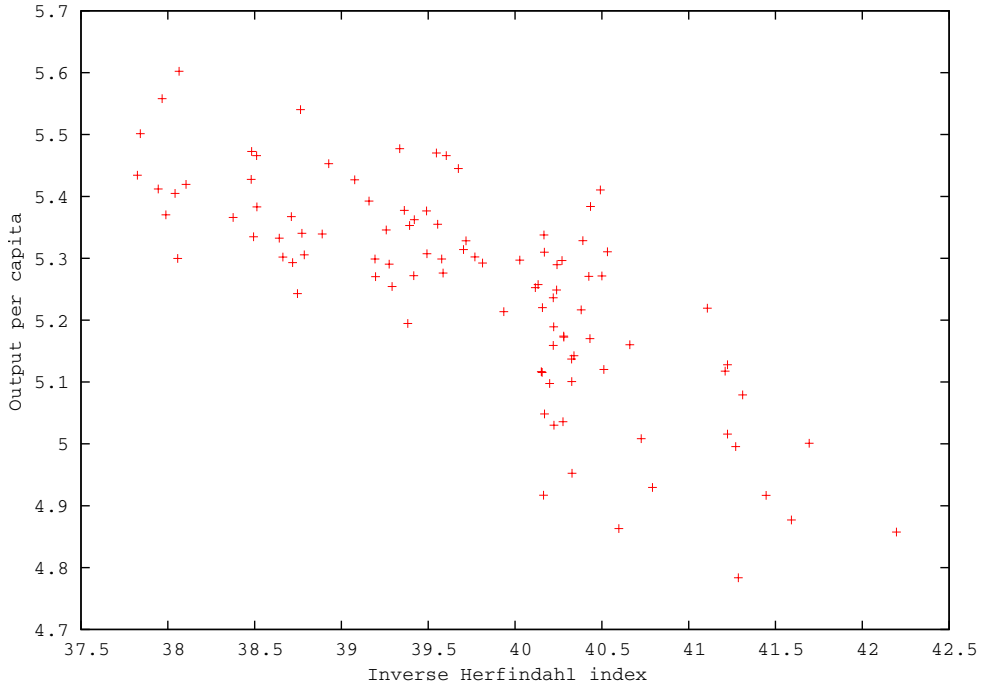


Figure 7: Inverse Herfindahl index versus output per capita for different mark-up rates.

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quence, the economy experiences lower investments in new capital vintages and lower innovation, and economic growth.

4.4 Product Disparity

In this section we investigate the effect of product disparity. We compare the benchmark configuration, characterised by a range of product quality between 30 and 170, with an economy with a narrower range of the quality assigned to the producers of the consumable good – between 50 and 150. This is like considering an economy where there is less market segmentation, goods are more similar, and therefore consumers are less selective with respect to quality differences, for a given selectivity parameter (there are relatively more firms producing a similar good). The implication is that there is fr less consumer selection, and therefore market concentration.

We first plot the market shares of firms ordered on the horizontal axis by increasing quality, for ten independent simulation runs (Figure 8). As expected, the distribution of firm size (market shares) is significantly less concentrated than in all other cases, including the benchmark. No firm exit the market, and most selection occurs over price (which reduces as the economy grows and low income classes adopt more conspicuous consumption patterns).

In Figure 9 we plot the relation between market concentration (IHI) and per capita

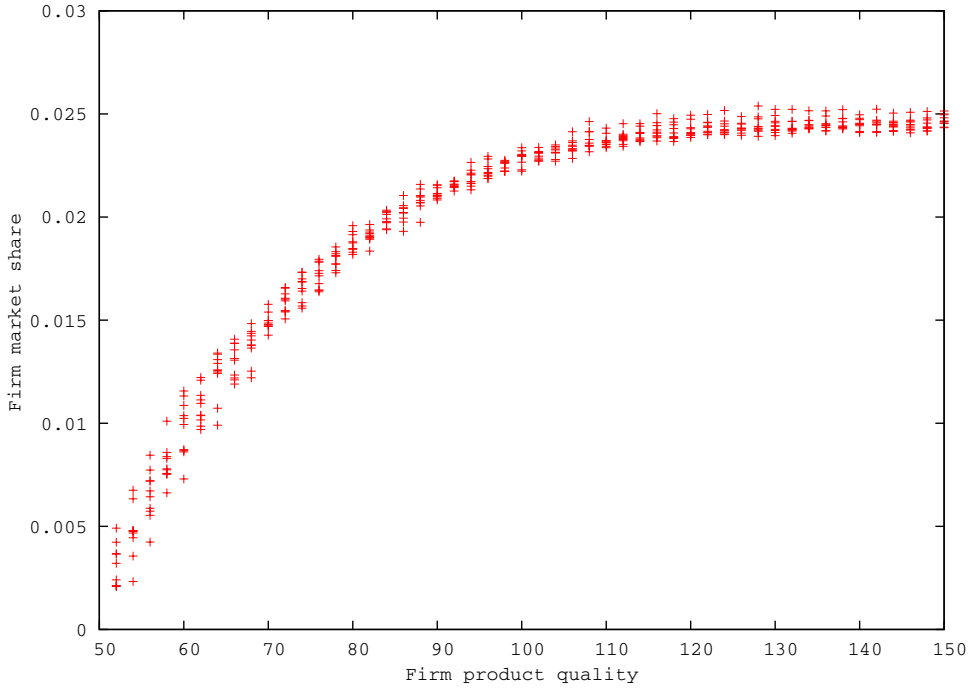

Figure 8: Distribution of firms market share (vertical) for increasing product quality (horizontal). Low quality disparity.

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output. The figure shows the results from 100 simulation runs each with a different range of product quality (going from 160 – benchmark – to 100). Compared to the benchmark case (middle left in Figure fig:iHQR), there is not much difference in output growth. The effect of increasing disparity is is much less pronounced than in the the earlier case of increasing mark-up, and disappears for an IHI higher than 40.

The results imply that, although market concentration sharply increases for increasing heterogeneity in the quality of final goods, in our model disparity alone, with no changes in prices[17] and no changes in the pattern of consumption of poorer income classes, have no significant effect on the relation between heterogeneity and growth.

5 Conclusions

A growing body of literature is exploring macro-economic models based on the complex interaction between microeocnomic agents with realistic behavioural properties. The main advantage of these model is that they allow to analyse emerging evolutionary macro economic properties as the outcome of simple interactions, without assuming any equilibrium dynamics.

[17] As discussed earlier we maintain the same distribution of mark-up, with any quality distributions.

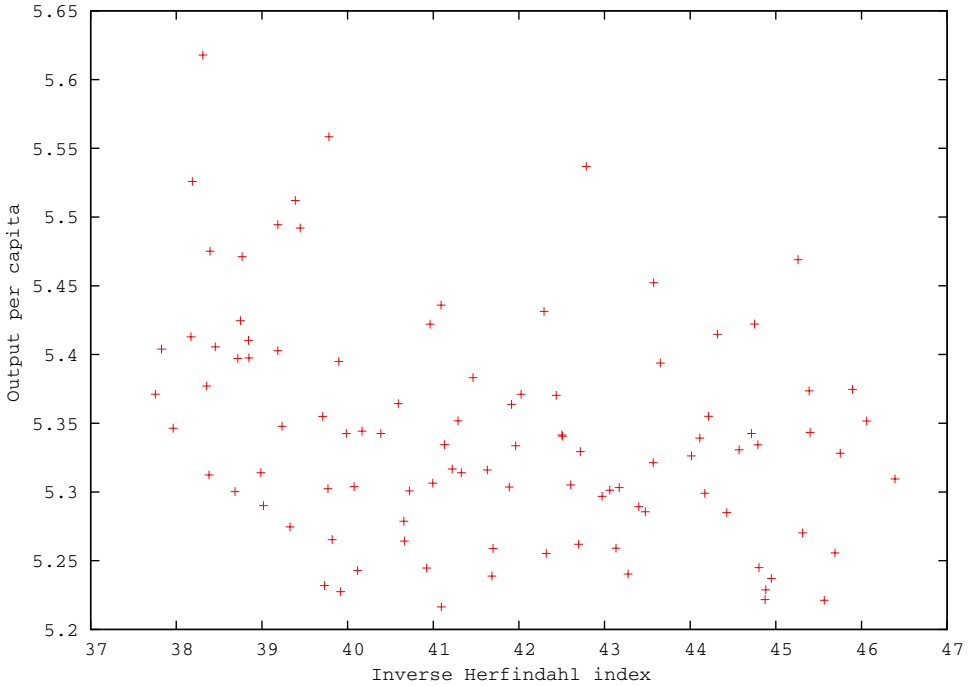

Figure 9: Inverse Herfindahl index versus output per capita for different levels of dispersion of the product quality.

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This paper exploits an agent based model replicating a number of interrelated aspects of structural change Ciarli et al. (2010). We have extended the model to consider an explicit relation between the quality of products and their price, and to allow for dynamic consumer preferences, allowing members of low income classes to imitate the purchasing behaviour of higher income classes. Exploiting these extensions we have studied the relation between market concentration through the process of economic development, mainly as a function of demand dynamics.

Whereas most of the structuralist literature focusses on the demand effect on growth and structural change via the distribution of income (size and price effects), we considered less studied structural changes (consumer preferences, firm size and capital vintages), and focussed on the effect of the distribution of both income and preferences (although we limited the analysis to the latter) on the structure of the market in the consumable sector. And we studied the effect of different market structures on productivity and income growth via technological change.

The model reproduces some basic properties in terms of market concentration, firm size, distribution of wages, and income. We showed that market concentration is significantly correlated with per capita output growth, above a given level of final demand. We next used the model to investigate the relation between market concentration and output growth for varying consumers imitation behaviour – allowing lower income classes

to share the same preference of higher income classes, pricing behaviour, and product quality distributions.

We found that in two cases, where the increased concentration is due to relatively lower mark-up rates and to consumers changing rapidly their preferences, higher output per capita is found to correlate with concentration. Hence, in historical conditions where margins are moderate and consumers can purchase goods of higher quality (in a closed economy model), we can expect relatively higher economic growth. As in other structural models this occurs because of consumers access to different goods. High mark-up rates prevent consumers from lower income classes to access high quality goods, segmenting the market, reducing concentration and there fore capital investments. High imitation rates, conversely, enables the largest part of the population to access high quality good, inducing higher concentration and capital investment. This does not happen for the disparity of goods uniquely on the supply side. Reduced concentration due to lower disparity is not significantly related to higher outputs growth.

The model has a number of limitation, in particular the absence of a financial and a labour market, which restrict growth, and the absence of innovation via entry. We leave these features for future work, building on the current results.

Even with these limitations our model establishes a number of relations on economic development and structural change, which are difficult to show in a model that assumes away the complexity of market interactions and firm organisation. In order to inform economic development policies we suggest further explorations of the hypotheses raised here.

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A Tables

Parameter	Description	Benchmark Value	Data
$\overline{i_2}$	Maximum quality level	170	Analysed: [170-150]
$\underline{i_2}$	Minimum quality level	30	Analysed: [30-50]
$\bar{\mu}$	Maximum markup	0.1	Analysed: [0.1-0.3] Data: [0-0.28]; [0.1, 0.28]; [0.1, 0.39][a]
$\underline{\mu}$	Minimum markup	0	Data: [0-0.28]; [0.1, 0.28]; [0.1, 0.39][a]
δ	Capital depreciation	0.001	[0.03, 0.14]; [0.016, 0.31][b]
ω	Minimum wage multiplier	1.25	[1.6, 3.7][c]
b	Executives wage multiplier	2	[1.25-2][d]
ν	Tier multiplier	5	[3-7][d]
$1-\gamma$	Smoothing parameter of income for expenditures	0.2	[.04, .14]; [.06, .19][e]
ςi_j	Error in the consumer's evaluation of characteristics	$j=1$: 0.05; $j=2$: 0.1	–[f]
δ_ς	τ inter-class multiplier	0.2	[-0.8, 2.4] Mean: 0.18[g]
$\upsilon^{min}=\upsilon_{q,1}$	Highest = first tier quality selectivity	0.1	See Lorentz et al. (2014)
$\upsilon^{max}=\upsilon_{p,1}$	Lowest = first tier quality selectivity	0.9	See Lorentz et al. (2014)
α	Imitation of higher classes quality and price selectivity	0.9	Analysed: [0.9-0.8]
z	Parameter innovation probability	0.01	–[h]
σ^a	Standard deviation productivity shock	0.01	See Ciarli et al. (2012)
ρ	R&D investment share	0.7	–[i]
F	Final good firms	50	–
G	Capital good firms	15	–

[a]Marchetti (2002); De Loecker and Warzynski (2009); Joaquim Oliveira et al. (1996). [b]Nadiri and Prucha (1996); Fraumeni (1997) non residential equipment and structures. We use the lower limit value, (considering one year as 10 simulation steps) to avoid growth in the first periods to be determined by the replacement of capital. [c]Ratio with respect to the average wage (not minimum) in OECD countries Boeri (2009). [d] Simon (1957). [e]Krueger and Perri (2005b); Gervais and Klein (2010). [f]Empirical evidence not available to the best of our knowledge. Parameters set using the qualitative evidence in Zeithaml (1988). [g]Change in price elasticity for food product categories (Zheng and Henneberry, 2011). [h]Set to a value that ensures that innovation in the capital sector occurs. [i]Empirical evidence with respect to profits not available to the best of our knowledge.

Table 1: ***Parameters setting***. *Parameter's (1) name, (2) description, (3) value, and (4) empirical data range when its effect is not analysed in section 4*