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

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Abstract

We study the relation between variety, market concentration, and economic growth, along different phases of economic development which entail a number of changes to the structure of production and consumption in the economy. We focus on three aspects of structural change, which are connected and are correlated to variety, market concentration, and economic growth: (i) product quality; (ii) firms' mark-ups; and (iii) imitation of consumer preferences for price and quality. We model the interactions among several aspects of structural change such as firm size and hierarchical structure, innovation in capital vintages, the emergence of social classes, income distribution, and consumer preferences across and within classes. We find that market concentration has a significant and positive impact on economic growth only in the presence of sufficiently large demand. The strongest effects emerge in the presence of a more skewed firm size distribution and firms producing higher priced and higher quality goods. We find also that this effect is influenced strongly by different aspects of structural change. Changes in the behaviour (or income) of the less wealthy income classes is crucial as is investment in new capital vintages, and the emergence of diverse income classes with heterogeneous consumption preferences. In contrast, we find that supply side product variety, *cæteris 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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1 Introduction

The main aim of this paper is to study the relation between variety, market concentration, and economic growth, along different phases of economic development involving changes to the structure of production and consumption in the economy. We focus on three aspects of structural change which are linked and are related to variety, market concentration, and economic growth: (i) product variety, measured as disparities among the quality of final goods; (ii) firm differentiation based on mark-ups related to the quality of goods, which segments the access to high quality goods; and (iii) consumer preferences related to price and quality based on a process of imitation by less wealthy income classes of the preferences of wealthier income classes. All three aspects influence the selection of firms and, therefore, market concentration, in ways that differ in the different phases of economic development, and which, we argue, generate different patterns of demand. Differences in the timing of concentration and whether it is induced by dispersion on the demand or supply side, might affect economic growth differently. We discuss these differences in the next section.

To investigate the relation between variety, market concentration, and economic growth we use a model of the interactions among several aspects 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. In our model, the economic structure goes through different phases, ranging from Malthusian stagnation to sustained exponential growth. Also, in our model, growth is the result of a Kaldor-Young dynamics: an outcome of cumulative causation generated by productivity growth and domestic demand growth and change.

Our paper contributes to several theoretical literatures and, especially, work on structural change (Cimoli, 1988; Verspagen, 1993; Cimoli and Porcile, 2009; Saviotti and Pyka, 2008), unbalanced growth (Murphy et al., 1989b,a), and the relation between innovation, income distributions and growth (Zweimüller, 2000; Föllmi and Zweimüller, 2006). Our model differs from these model in several respects, and our work contributes in three main ways.

First, we go beyond purchasing power and saving propensity (level of demand); instead, we study the role of the distribution on consumption preferences (distribution of demand). We focus on the effect of consumer selection on market concentration and study three different channels through which consumer selection determines market concentration: heterogeneity of the quality of goods across firms; heterogeneity of prices across firms; and consumer demand elasticity with respect to the price and quality of goods.

Second, we consider the interaction between the concentration of demand and the concentration of supply, which, in our model, are endogenously related. The organisation of production into different layers of managers and workers, generates classes with different income and consumption preferences. Therefore, changes to the organisation determine the distribution of income and of consumption preferences. The firm's organisation and capital vintages generate cost heterogeneity. In addition, firms produce goods

of different quality. Heterogeneous consumers choose goods from these firms. Depending on their elasticity with respect to price and quality, each class of consumers selects a subset of firms, which determines market concentration. The skewness of the distribution of market shares, in turn, conditions the firm's organisation (e.g., some firms remain small, with a few layers of management, others grow large and have multiple management levels).

Third, we investigate this interaction in a model in which the structure of the economy changes endogenously along different phases of economic development (see Section 2.2).

We find that market concentration has a significant and positive impact on economic growth only in the presence of sufficiently large demand (in a Schumpeter Mark II pattern (Malerba and Orsenigo, 1995)). Otherwise, concentration has no significant effect. For demand to play such a catalytic role, if firms are highly differentiated in terms of product quality, less affluent consumers must converge towards the consumption of the more affluent classes. We find the strongest effect on the model when the distribution of firm size becomes more skewed and is concentrated on firms producing higher priced goods. We find also that this effect is strongly influenced by different aspects of structural change. As already noted, changes in the behaviour (or income) of the less wealthy classes is crucial; also important is investment in new capital vintages and the emergence of diverse income classes with heterogeneous consumption preferences. In contrast, we find that supply side product variety, *cæteris paribus*, has no significant effect on growth.

In Section 2, we discuss the theory underlying the model's growth process and the relation between market concentration and economic growth. We refer to the relevant literature and argue for the need for a complexity approach to the study of structural change. In Section 3 we describe the model, focusing on the main aspects of interest in the context of 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. Section 5 offers some conclusions.

2 Motivations and Related Literature

2.1 Concentration, Structural Changes, and Economic Growth

To our knowledge, the literature contains no systematic investigations of the relation between market concentration and economic growth and little is known about how this relation is affected by the timing of market concentration – in different phases of economic development – and by the different mechanisms inducing demand and supply side concentration. There are some studies that examine the relation between sectoral concentration and economic development and propose that economies first diversify and then specialise again (Imbs and Wacziarg, 2003).[1]

[1]Recent studies show that high-income economies are more diversified than low and middle income economies (Hidalgo et al., 2007); however, we do not investigate this aspect in the present paper.

Most industry models argue that market growth induces entry and, therefore, deconcentration even if the incumbents increase their output (Spence, 1981). However, Hall (1984) shows that when growth can be anticipated and in the presence of learning (or, as in our model, increased productivity and output) growth leads to higher concentration.

The large literature on sectoral systems of innovation (Malerba and Orsenigo, 1995; Dosi and Nelson, 2010) shows that, in some industries, innovation is driven by large incumbent firms Schumpeter (1942), while in others it is driven by the entry of new small firms (Schumpeter, 1934). Arrow (1962) argued for an intermediate position: some competition is necessary to incentivise investment, but too much competition does not allow the accumulation of sufficient profit to fund innovation. More recently, Malerba et al. (2007) shows that market structure is related to demand dynamics and the formation of niches.

Growth model are silent about how market concentration influences growth. In the Unified Growth Theory (UGT) model proposed by (Desmet and Parente, 2012), productivity growth is related to increased firm size; small artisan firms are replaced by large capitalist firms. Market concentration increases investment and economies of scale, which has a positive effect on economic growth. The Schumpeterian model proposed by (Possas et al., 2001) shows an inverse causal structure: growth in latent productivity (the technological frontier) increases concentration. However, the relation suggested is similar: market concentration is positively related to economic growth. Peretto (1999) models a two sector economy in which an intermediate sector that invests in Research and Development (R&D) and shows increased productivity is at the heart of an endogenous growth process. In the presence of more concentration in the intermediate sector and increasing firm size, investment in R&D also increases, with a positive effect on economic growth.

In line with the structuralist tradition, in our model, economic growth is the result of positive feedbacks between demand (level and composition) and productivity dynamics. Increased demand can be the result of a reduction in price – following increased productivity – or an increase in the number of workers. Population growth is a result of firm growth due to increased output or to consumer selection and market concentration. When a firm grows, the number of workers increases more than proportionately, due to the need to hire executives to manage the lower tier workers. That is, for given level of output, in our model, an economy with many small firms hires fewer workers than an economy with a few large firms.

Productivity increases when consumer goods firms replace old capital vintages with new, more productive, capital vintages. For this to happen, the following conditions must hold. First, demand must outstrip the firms' productive capacity either because of an increase in final demand or, for a given level of demand and capital depreciation, the firm's market shares have increased due to consumer selection. Second, the demand for new capital must be sufficient to allow capital goods firms to make a profit and allow investment in hiring R&D workers. Third, the investment in R&D must be successful. Given that R&D investment, by nature, is uncertain, the higher the investment, the higher the probability of increased productivity.

In other words, demand trickles down from final consumer to capital good supplier. This trickle down process varies with the condition of the economy and various parameters, which we study in this paper. Productivity trickles up from capital producers to final consumers and affects their buying decisions in relation to both level and supplier selection. In turn, their buying decisions affect further productivity increases. However, if demand grows without inducing productivity growth, we observe a stage of Malthusian stagnation (per capita income does not grow). Sustained economic growth occurs only when the level or selection of demand induces substantial investment and R&D expenditure.

Market concentration mediates between demand and productivity dynamics. On the one hand, higher market concentration induces some firms to grow larger, involving larger capital investment, and the hiring of more workers compared to a less concentrated economy. In our model, these events have multiple effects. First, following a Schumpeter Mark II innovation pattern (Malerba and Orsenigo, 1995), firms in the capital good sector have a higher probability to innovate successfully and to increase their productivity. Second, final demand grows relatively more, inducing more investment in an autocatalytic process. Third, final demand is more segmented, which may increase concentration in the succeeding time steps. Fourth, successful investment in new, more productive capital vintages may increase demand and market concentration in the succeeding periods, while the higher labour costs associated with more layers of management may reduce market concentration in the succeeding periods.

On the other hand, if the market is highly concentrated from the early stages of economic development, when demand is low, only a few firms grow, which does not generate sufficient demand for capital good suppliers to innovate and constrains future recruitment of workers, demand, output, and productivity.

There are several structural conditions that shape the way market concentration mediates between demand and productivity dynamics. We examine three: distribution of the quality of final goods, related distribution of the price of final goods, and the evolution of consumer preferences.

In our model consumer classes with distinct consumption preferences emerge endogenously as firms grow. Wealthier classes prefer high quality goods and less wealthy classes prefer less expensive goods. The less wealthy classes (i.e., factory workers) generate most of the demand. In the model consumer preferences change, imitating the preferences of wealthier consumers. Thus, the preferences of the whole population shift from price to quality if the economy grows and new classes are generated. Thus, market concentration changes along different phases of economic development and its effects on growth are also likely to change. For example, Chenery et al. (1984); Rosenberg (1972) discuss the crucial role of standardisation of production and the homogenisation of consumer preferences during the industrial revolution, in large economies such as the US. The final effect of market concentration on economic growth depends on the complex interactions between these different aspects of structural change, in ways that are not predictable from the outset. This is the focus of our paper.

2.2 Modelling the Complex Relations between Structural Change and Economic Development

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). However, the process of economic development observed over the last three centuries can be interpreted best as the interaction among sundry structural changes.

Economists have discussed, in detail, the role of incumbent sectors in shaping patterns of productivity and output growth in relation to technology, industrial organisation, income distribution, and the demand for the goods and services they generate (Baldwin, 1956; North, 1959). Using data on 100 countries for 30 years after the end of the second world war, Chenery and Syrquin (1989) suggest that sectoral reallocations are induced by significant changes to private consumption and investment shares, with consumption moving towards less basic needs. Several stylised facts emerge from the history of the first industrial revolution such as: increasing firm size and greater concentration of production in large, capital intensive firms (Desmet and Parente, 2012); increased use of technologies embedded in capital goods (Kuznets, 1973); increased variety of consumer goods (Berg, 2002); emergence of a bourgeois class and greater income inequality (McCloskey, 2009); and growth in population and market size (Voth, 2003). Most of these aspects of structural change interact and, similar to a complex system, the properties emerging from these interactions – for instance, in terms of economic growth and sectoral shifts – cannot be deduced from the properties of a single aspect (Beinhocker, 2006). Individuals interact directly (Schelling, 1978), which has consequences for the diffusion of information and individuals' and organisations' behaviour. Individuals access local information, compare a limited set of alternatives, and have limited ability to form expectations and to compute probabilities (Simon, 1969). Heterogeneous shocks and behaviour do not necessarily cancel out in the aggregate, such as in income distribution (Gabaix and Landier, 2008), firm growth rates (Bottazzi and Secchi, 2006), innovations (Silverberg and Verspagen, 2007), firm sizes (Simon and Bonini, 1958), and other social and natural phenomena (Mitzenmacher, 2004), and heterogeneity persists through time (technology, productivity, profits, growth) (Dosi et al., 2010a). These differences enable processes of cumulative causation and path dependence, which, in the development literature, are analysed as poverty traps (Easterly, 2006). Since we are interested in analysing development dynamics (rather than comparative statics), we must focus on change, not equilibria. Our interest is in the absence of equilibria, in how societies in general, and their components, evolve from one condition of relative stability to the next, through structural change.

Models accounting for micro interactions (Kirman, 2010), bounded rationality (Simon, 1969; World Bank, 2015), heterogeneity, and out-of-equilibrium evolutionary dynamics cannot have closed form solutions.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 these interactions, rules of behaviour and micro parameters. The interactions can occur across different levels – micro to macro. Therefore, we analyse aggregate dynamics such as economic output and its distribution as emergent properties which emerge from the behaviour of the individuals and organisations in the economy.[2]

2.3 Related Literature

Our analysis draws on a wide scholarship in different aspects of the model in this paper. It fits mainly within the evolutionary tradition of economic growth (Nelson and Winter, 1982; Silverberg and Verspagen, 2005; Cimoli, 1988; Metcalfe et al., 2006) and, particularly, models analysing the effect of demand on growth (Dosi et al., 1994), combining structuralist and evolutionary theories (Cimoli, 1988; Cimoli and Porcile, 2009; Verspagen, 1993), combining evolutionary and Keynesian theories (Dosi et al., 2015, 2013, 2010b), and investigating the relation between variety and economic growth (Saviotti and Pyka, 2008, 2004).

We draw on the work of Pasinetti (1981) on structural dynamics and the relevance of changing consumption patterns and vertically related sectors. More generally, our theoretical work is inspired by the structuralist school in economic development (Cornwall and Cornwall, 1994; Hirschman, 1958; Kaldor, 1966; Palma, 2008).

Our paper is related to unbalanced growth models such as Murphy et al. (1989b,a), in which workers can be employed in two consumer good sectors: agriculture and manufacturing. Consumers receive an income from working in one of these two sectors or from rents. As in most growth models, manufacturing is assumed to be the sector with increasing returns. Investment in manufacturing requires demand for manufactured goods, and therefore wages in the agriculture sector to be above the living wage. This can arise due to two necessary, but not sufficient conditions: productivity increasing technological change in agriculture, and a redistribution of income from landowners to farmers. Our model differs from Murphy et al. (1989b,a) in several respects. First, radical methodological differences subsume a number of assumptions related to micro foundations, agents' rationality, heterogeneity, and out-of-equilibrium analysis, discussed above. Second, we do not distinguish between agriculture and manufacturing. In our model, firms in the consumer sector produce goods of different quality, which can apply to any sector: agriculture, textiles, high-tech, or services. However, we include an intermediate sector, which produces capital goods for the consumer good sector and is the source of increased productivity. Third, we abstract from the physical limits to production, but production capacity – workers and capital – require time to build. Fourth, in our model there is no need for *rentiers*: income differences emerge from the organisation of production as a result of wage differences.

In addition to Murphy et al. (1989b), several other models have been proposed to investigate how demand influences economic growth through income and preferences.

[2] A number of computational models (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) have been developed to analyse economic growth and other macro properties.

New trade theory introduces consumer preferences for product variety (Krugman, 1980) and a few models show that economic growth is driven by escaping consumer satiation (Aoki and Yoshikawa, 2002; Bertola et al., 2006; Patriarca and Vona, 2009). Saviotti and Pyka (2008, 2004) model the relevance of increasing product variety for sustained economic growth.

Only few studies analyse the relation between product innovation, inequality, and growth, modelling consumers with heterogeneous preferences. Extending Murphy et al. (1989b), Zweimüller (2000) proposes a model in which poor consumers purchase mainly basic goods, and rich consumers purchase mainly luxury goods. The results suggest that redistributive policies increase economic growth by inducing more innovation activity, stimulated by larger demand. Using non-homothetic preferences, and relaxing 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 high price for rich consumers, and the 'market size effect' with low income inequality – innovators face larger demand.

3 The model

The model is an extension of the model described in Ciarli et al. (2010) and Ciarli et al. (2012), where a detailed description can be found.[3] Here, we briefly discuss the main structure and dynamics of the model. In the following sections we highlight the aspects of the model that differ from Ciarli et al. (2010), and on which the investigation in this paper depends.

We model a closed economy composed of three sectors: a final good sector populated by F firms indexed $f \in \{1; 2; ...F\}$; a capital goods sector populated by G firms indexed $g \in \{1; 2; ...; G\}$; and a household sector populated by $N(t)$ consumers/workers split into $H(t)$ classes indexed $z \in \{1; 2; ...; \Lambda(t)\}$ (Figure 1).

Firms f produce a non-homogeneous good for z consumer classes using labour and capital in fixed proportions; capital good firms g use only labour. Labour is organised hierarchically: in addition to shop-floor workers ($z = l = 1$), firms above a minimal size require a hierarchy of executives ($Z = l > 1$) to organise their production.[4]

All firms (f and g) pay a minimum wage to their shop-floor workers ($w^1_{f|g}$), and a multiple of the lower tier wage to their higher tier workers ($w^l_{f|g} = b^{l-1} w^1_{f|g}$). Executives also receive bonuses from non-invested profits ($\psi^l_{f|g}$). Wages and bonuses received by workers in a production tier l form the income of the corresponding class z. Income is spent to purchase final goods.

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

[4] We represent firms as hierarchies of workers and managers, where each manager coordinates a number of workers in a lower hierarchy, and earns a multiple of their wage.

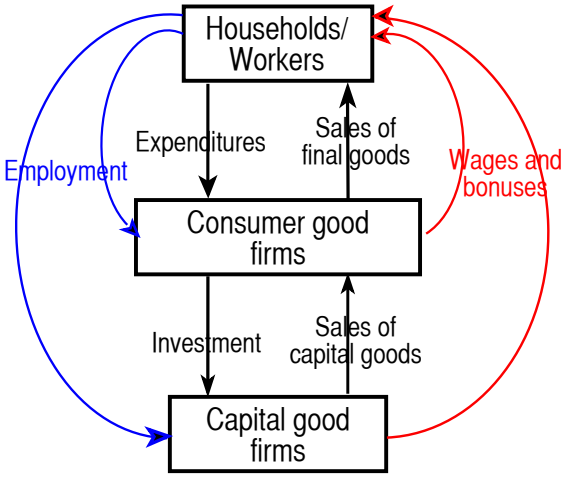


Figure 1: ***Overall structure of the model and flow of goods and money***

Households in the same income class $z = l$ are assumed to share the same consumption preferences for good price and quality, representing Engel's law. Workers in the top income classes have high elasticity with respect to product quality ($\upsilon_{q,z}$) and low elasticity with respect to product price ($\upsilon_{p,z}$). Workers in less wealthy classes, with high elasticity with respect to price and low elasticity with respect to quality, over time, imitate the preferences of wealthier consumers.

The number of income classes $H(t)$ is determined endogenously in the model. A new income class emerges when the size of one firm reaches a given threshold, which requires a new managerial layer l.

Firms f purchase new capital goods from capital good producers g when they need to increase their production capacity. Firms g spend part ρ of their cumulated profits from on hiring engineers for R&D. R&D investment probabilistically increases the productivity of the capital goods produced. Firms f choose among g producers depending on the price and productivity of the capital, and on the estimated time required to produce it.

While firms g produce on demand, firms' f output (Q_f) is determined by estimating (adaptively) the expected demand, including the desired level of inventories (S_f). The difference between actual demand and output are compensated by inventories wherever possible, or by maintaining a backlog of orders to be filled from future production.

Both f and g compute prices as a mark-up on the unit labour costs. Final good producers charge a differentiated mark-up, proportional to the quality of their product.

The model makes a number of simplifying assumptions in order to focus on the interactions among the different aspects of structural change. We do not include a labour or a financial market and we assume a closed economy. We also assume no entry of new firms.

Figure 2 describes the model's main dynamics during one time step. During a single time step each agent updates its states on the basis of the state in $t - 1$ and of the relevant events occurring within that time step.

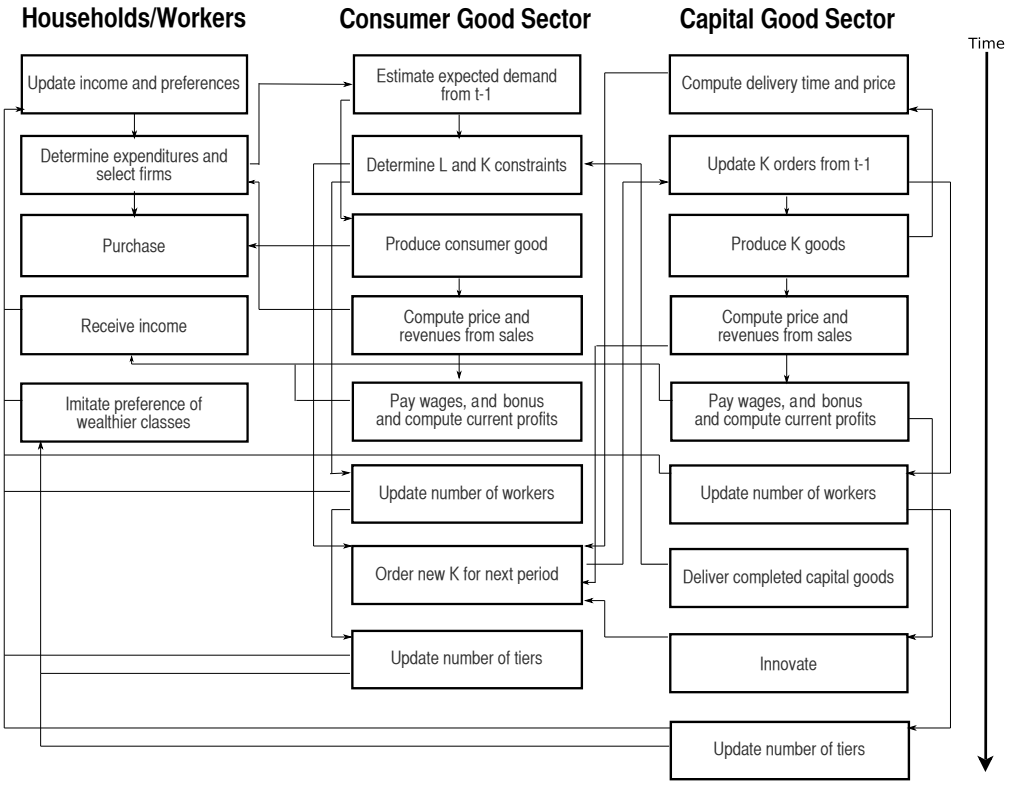


Figure 2: ***Schedule of the operations performed in the three sectors during a time step***

After updating preferences and income from $t-1$, *households* determine the amount of their expenditure, select the best firm, and purchase the final good. At the end of the period, they collect the income paid by employers, which will be used to determine the next-period expenditure level, and, if a new class/tier has emerged, they imitate wealthier classes.

Final good firms estimate their expected demand on the basis of the previous period sales. They produce output that satisfies the expected demand constrained by their production capacity. If there is a difference between demand and production capacity, they advertise new vacancies and issue new orders for capital goods. If the number of workers in the top tier exceeds a parameter ν, a new tier is added to the firm, resulting in a new consumption class. Given the cost of labour and the quality of the good produced, firms set a price. After collecting sales the firm pays wages and bonuses, and cumulates profits. If it chooses to invest in capital goods, it selects the capital good provider from the capital good sector on the basis of the productivity and price of the capital vintage, and the wait time.

Capital good firms update their orders, and estimate delivery times for new orders of capital goods. Given the labour input, these firms work on the vintages under production and, if necessary, create additional vacancies. If the number of workers in the top tier

exceeds a parameter ν, the firm adds a new organisational tier which results in a new consumption class. Given the cost of labour, the firm sets the price. When the capital good is completed, it is delivered to the buyer. Finally, if the firm has accumulated profits, the R&D department will embark on innovative work, which may result in higher productivity of the capital vintages produced from $t+1$.

Product Characteristics

Firms in the final goods market produce a non-homogeneous good which differs in quality ($i_{2,f}$) and price ($i_{1,f}(t) = p_f(t)$). The quality is assigned at the outset and is linearly increasingly with respect to the firm index $f \in \{1; 2; ...F\}$ from $\underline{i_2}$ to $\overline{i_2}$. $\underline{i_2}$ and $\overline{i_2}$ will be used to study how the distribution of variety affects the economy's development pattern. Higher quality products are more sophisticated and should be considered luxury goods. Lower quality products are less sophisticated and satisfy basic needs. Changes in the distribution of quality and in the disparity of the goods on the market are one of the facets of structural change considered here. Rather than investigating the emergence of new goods, we investigate the changing composition of demand and supply.

Prices are set independently by each firm as a mark-up rule ($\mu_f(t)$) on unit labour costs $c_f(t)$:[5]

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

We assume that firms producing a higher quality good are in a position to charge a higher mark-up.[6] Thus, the mark-up is proportional to product quality, with the minimum mark-up $\underline{\mu}$ corresponding to minimum quality $\underline{i_2}$ and the maximum mark-up $\overline{\mu}$ corresponding to maximum quality $\overline{i_2}$. Given $\underline{\mu}$ and $\overline{\mu}$, the mark-up level is proportional to the quality of the 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 of the quality range $\left[\underline{i_2}, \overline{i_2}\right]$. This ensures that we can compare economies with different product disparities, without introducing 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 different purchasing power (defined below), as proposed in the model in Valente (2012). Preferences define the characteristics of the basket of selected goods; purchasing

[5]This assumption is supported by empirical evidence, starting with Hall and Hitch (1939) and confirmed by Blinder (1991) and Hall et al. (1997). For a recent review of price-setting behaviour in the Euro area, see Fabiani et al. (2006).

[6]There is evidence across industries (De Loecker and Warzynski, 2009) and within industries (Atkin et al., 2015; Corrocher and Guerzoni, 2009; Deltas et al., 2011; Verboven, 1999), that firms that produce higher quality good charge a higher mark-up.

power (income) determines the level of demand for the firms producing a good with the selected characteristics (demand is shared equally among all selected firms).

Consumers have limited information on the true quality and price of products.[7] The choice is made with respect to a *perceived* value drawn from a normally distributed random function centred on the true values. A purchasing routine of bounded rational consumers is at the heart of the model. The consumer's preferences (identical for all members of the same 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. The most selective consumers with respect to quality purchase only goods that have a quality similar to the best good in the market. The most selective consumers 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 virtually any good, irrespective of price (quality) differences among firms. If a given product does not meet the threshold on either price (too high) or quality (too low), then the product is discarded. If all the products are discarded on this basis, then the best is chosen. In the case that more than one product exceeds both thresholds, then the consumer chooses one randomly, with a uniform probability.

We assume that price selectivity decreases with a class income and that quality selectivity increases with a class income. These differences can be thought of as representative of Engel's law (satiation of 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 related to quality. The following classes are defined with preferences which are increasingly less selective with respect to price and more selective with respect to quality. υ^{max} (υ^{min}) denote 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 which 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

[7] Evidence on the difficulty for consumers to assess product quality and price is discussed by Celsi and Olson (1988); Hoch and Ha (1986); Rao and Monroe (1989) and Zeithaml (1988).

class of infinitely wealthy consumers has 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 firm selection.

In addition to Engels curves representing the shift from basic inexpensive goods to luxury expensive goods as income grows, we also model the imitation of consumers in the less wealthy classes of the preferences of consumers in higher income classes. Consumption is an act that has strong social implications, as Veblen (2005) famously noted. In many, if not all, examples of modern industrial growth, increasing income and productivity have been accompanied by the adoption by lower income consumers of the behaviours of higher social status consumers. The concept of "aspirational" consumer is well known in the marketing literature and has been studied also by economists (Cowan et al., 1997). For example, Kaus (2013) shows that rapid social change renders imitation of consumer styles more visible. In our model we assume that the emergence of a new, wealthier class which adopts more conspicuous consumption preferences (more selective with respect to quality and less selective with respect to price), consumers from all other existing classes shift their 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 imitation of an immediately higher income class. In Section 4.2 we study the effect of α on the 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 firm size distribution, with some firms growing larger. Firms that grow larger require additional workers and capital goods, resulting in greater firm heterogeneity (therefore, selection). On the one hand, additional workers require an additional supervisor, which requires an additional tier of management. 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, the firm's output price.[8] Given the assumption that wealthier classes choose more sophisticated

[8]For a discussion of firm size and labour costs see also Brown and Medoff (1989); Criscuolo (2000); Bottazzi and Grazzi (2010).

goods, firms that produce goods of higher quality may start to gain market share. This may change firm selection and the distribution of firms. However, the more populous classes – those at the bottom of the organisational pyramid which select firms on the basis of the good price – account for the bulk of consumption. Therefore, the composition of the final goods industry will reflect the composition of the demand – which, in turn, is influenced by the composition of the final goods industry.

On the other hand, new capital vintages may be more productive compared to the firm's and its competitors' current capital stock. Capital investment has the effect of increasing firm productivity and, therefore, reducing output prices. Below, we discuss labour demand, firm organisation, and capital investment and productivity.

Given the number of workers $L^1_{f|g}(t)$ required to produce the firm's output in time t ($Q_{f|g}(t)$) – in both the final goods (f) and the capital goods (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 of any manager at any level in the organisational pyramid (Simon, 1957). Then, when the number of second tiers managers reaches ν ($L^2_{f|g}(t) = \nu$), the firm hires one third tier manager ($L^3_{f|g}(t)$) to organise production, and so on for as long as the number of managers in the highest tier grows beyond ν. In other words, we model firms with classical 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. Then, the total number of workers in the economy is given simply by: $L_{f|g}(t) = L^1_{f|g}(t) \sum_{l=1}^{\Lambda_{f|g}(t)} \nu^{1-l}$.[9] We assume inertia in the labour market as explained in Ciarli et al. (2012, section 2.2.2): because labour markets do not clear instantaneously and because there is no perfect match between labour demand and supply, firms adjust their labour input gradually to the level required to satisfy demand.

As discussed widely in the literature, we assume that individuals working in the higher tiers of the organisation earn a multiple b of the wage of 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 $w^1_{f|g}(t) = \omega w_m(t-1)$, that is, 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 first is determined on the basis of a wage curve (Blanchflower and Oswald, 2006; Nijkamp and Poot, 2005), and then is 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 only to wages (Atkinson, 2007). Firms distribute to executives (from $l = 2$ above) cumulated profits $R^D_{f|g}(t)$ that are not

[9] We show that the level of demand depends on the income level of each income class.

used for capital investment – in the final goods sector – or R&D – in the capital goods sector. The share of profits distributed to each tier of executives is proportional to the wage differences, and is the same 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 assume also that consumer preferences are strongly related to worker employment status.

Capital Investment and Productivity Growth

Firms in the final goods sector differentiate themselves with respect to competitors, based on a given quality and price, which depends on variable labour costs. Labour costs depend on the number of executive tiers – the higher the number of workers, the greater the diseconomies of scale due to the organisational structure, for a given ν – and on the productivity of the capital stock $A_f(t)$. The firm's productivity depends on the firm's investment and 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.[10] 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 denotes a single vintage; δ is the capital depreciation rate; and g denotes the capital good firm from which the capital vintage was purchased in time $t = \tau$.

To simplify, we assume that a firm f invests in a new capital vintage whenever capital capacity falls below its demand.[11] The investment is 5% larger than the capital needed to meet the demand, in order to absorb future fluctuations. 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 with the selected g. Finally, depending on g's production capacity and the number of orders in line, the capital good is delivered and added to the stock. We assume that when a firm

[10] In the first period firms have a single vintage.

[11] This assumes that firms take no risk, which, although counter-intuitive, does not have any effect on the aggregate results of our model.

places an order it uses the cumulated profits – which then are no longer available for sharing among 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 the reaction of firms final goods to changes in demand (composition). More crucially, if the market is very concentrated, capital good firms receive a small number of very large orders. This is due to two features of our model. First, the few successful firms in the final goods market see their demand increasing while they wait for delivery of a previously ordered capital vintage. Second, the few capital producers that receive bulk orders invest massively in R&D (more below), increase their productivity, and become more attractive, unless their production queue is too long.

Therefore, market concentration in the capital good sector reflects the market concentration in the final good sector. We next discuss R&D and innovation in capital vintages and how they 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 final goods sector in period t, plus the orders still in production. The demand determines the number of shop floor level workers hired in each period ($L_g^1(t)$).

Firms in the capital goods sector devote a share ρ of the profits cumulated in the past to R&D through the employment of engineers (Llerena and Lorentz, 2004).[12] 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 the extent to which a successful innovation improves the productivity of the capital vintages produced (Nelson and Winter, 1982). We follow the standard Schumpeterian growth models and model innovation as a stochastic process (Aghion and Howitt, 1998; Silverberg and Verspagen, 2005; Dosi et al., 2010b). First, the probability that an investment in R&D will succeed and produce an 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 might affect the innovation probability.

Second, if the innovation is successful, the productivity of the vintages produced starting from $t+1$ is a stochastic improvement with respect to the vintages that the firm was producing up to the current 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 local knowledge depends on the firm's past technological achievements. The improve-

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

ment 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 increases.

Note that, in our model productivity increase from investment in R&D is cumulative: (i) the higher the investment ($L_g^E(t)$) the higher the probability of innovating; (ii) the more innovations achieved 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 the resources invested in R&D even more as long as the higher prices and the longer waiting queues of larger successful firms do not cancel out the gains from higher productivity. As a consequence, market concentration in the capital good sector should induce more innovation, as in a 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 final demand (Chiarella et al., 2000; Dosi et al., 2015). Expectations are formed as a result of demand from consumers in the different classes in $t-1$. The difference between current and 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 ($A_f(t-1)$), while we assume a fixed capital intensity (D_f). Complete determination of the output is illustrated in equations 1-4 in Ciarli et al. (2012). Also, we assume no constraint on 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 the number of tiers. In particular, workers above the first tier do not participate in production and, therefore, by definition, reduce productivity. The number of workers per output depends on the productivity of the capital vintages. The higher the capital investment of a firm f, the higher its productivity, and the lower its costs and price. Finally, the profits ($\pi_f(t)$) used for future investments or distributed as shares to executives are simply the difference between the value of sales and the firm's variable costs.

Production in the intermediate sector ($Q_g(t)$) is determined by the orders from the final goods sector and is just-in-time (Cooper and Haltiwanger, 2006; Doms and Dunne, 1998). The firm's only input is labour 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 numbers of workers and 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 Demand

Demand for firms in the intermediate sector is determined by the capital investment of firms in the final goods sector, as already discussed. We close the model with the demand for firms in the final goods sector. Above, we discussed at length how consumers in different classes choose among the goods offered by firms. Here, we need only to define how much each class spends.

The income of each class of workers z is based on the sum of the wages w and of the bonuses ψ for all workers, in all firms in both sectors (f, g), in the corresponding organisational tiers $l = z$:

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

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

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

where γ is the smoothing factor. We assume that there is a market that collects excess income into savings if income is higher than current consumption, and releases savings if income is lower than consumption. We assume that this consumption smoothing is equal across classes.

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

In Section 4 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 product disparity distributions, different patterns of adaptation of consumer preferences, and different pricing strategies.

4 Results

First, we discuss the main model properties and then analyse how they are influenced by three parameters accounting for: (i) imitation of 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 and price (static). We analyse the properties numerically, by simulating the model dynamics 100 times to control for different random events. The model is initialised using a "benchmark" configuration of the parameters and initial values that is congruent with empirical observation (Table 2).

In line with earlier work (Ciarli et al., 2010, 2012; Lorentz et al., 2016), the model shows an endogenous growth path that initially is linear (Malthusian stagnation) and becomes exponential after the transition to sustained economic growth (Kaldorian growth) (Galor, 2010).[13] In this paper, we focus on the relation between market concentration and economic growth, along these different phases of economic development during which the economy undergoes a number of changes to the structure of production and consumption. Figure 3 plots this relation. The horizontal axis is the Inverse Herfindahl Index (IHI) for firms' market shares. The IHI ranges between 1 (one firm dominates the market, i.e. high concentration) and F (all firms have the same market share, i.e. low concentration). On the vertical axis we measure two growth related variables: per capital output and weighted average productivity of the capital used by firms in the final goods market.

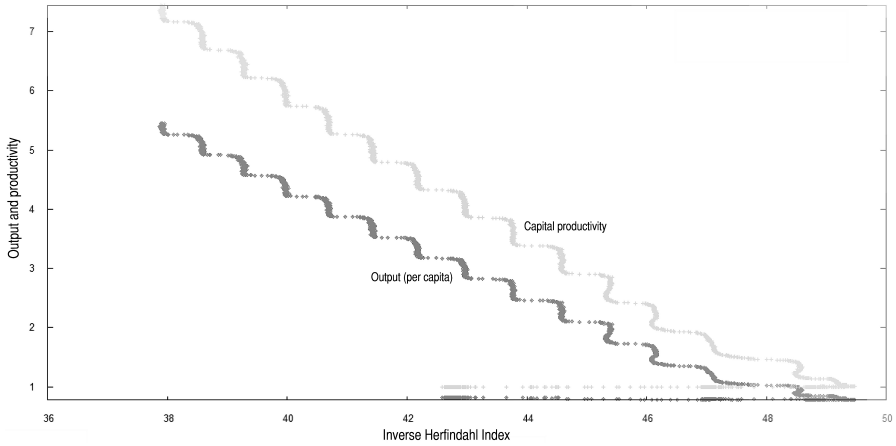


Figure 3: ***The effect of market concentration on output: two phases***. *Average weighted productivity of the capital used by firms in the final goods market (top series) and output per capita (lower series) – vertical axis – plotted against the IHI of the market shares of firms in the final goods sector – horizontal axis.*

Figure 3 depicts two different relations, corresponding to the two stages of economic growth. During the first phase of Malthusian stagnation, changes in market concentration are not related to per capita output and average productivity (all observations horizontally aligned to the x-axis correspond to this phase). In the second phase of

[13]Results are not shown for reasons of space, but are available to the interested reader.

Kaldorian growth, average capital productivity and per capital output increase cyclically with market concentration (lower IHI).[14]

The explanation for the positive relation between market concentration and productivity is capital investment. As firms' sales grow, their capital requirements increase, and they purchase new capital vintages from firms in the intermediate sector. Capital good firms increase R&D investments, further increasing the productivity of new vintages. The sales of firms in the final goods market increase because of the level or the concentration of final demand, or both. The level depends on the number of workers and on the price of the final good, and increases the output of all firms *cæteris paribus*. While demand concentration depends on consumers' selectivity – and, therefore, on the composition of workers – and on the price and quality of the firm's output, and increases the output of selected firms, which become relatively more productive if they invest in new capital vintages. Both the level and the concentration of demand are necessary conditions for the economy to experience sustained growth.

The reason why, in the Malthusian phase, there is no relation between market concentration and growth is that the level of demand is too low for firms with higher market shares to invest in new capital vintages. Profits are redistributed rather than invested, and firms in the intermediate market are idle. In this phase firms compete only on price. As firms with an initial cost advantage attract more customers and grow larger, their labour costs increase and they become less competitive. Figure 4 plots the IHI time series. Initial market concentration is accompanied by no investment in new capital vintages, no increase in productivity, and a levelling out of the differences among firms. However, after a period of quasi perfect market competition, during which labour and demand increase, the market begins to concentrate on firms producing higher quality, which now need to investment in new capital vintages to meet that demand. This is the transition from the Malthusian to the Kaldorian growth regime. During this phase we observe the positive relation between market concentration, productivity, and per capita output.

Market concentration has a significantly different effect on economic growth in the two phases because of the complex interplay between different aspects of structural change: changes in the level of demand and composition, changes to firm competitiveness and growth, and changes to the market structure. In our model consumer preferences are defined by their hierarchical employment position, which defines an income class. As firms grow, they add new management layers, forming new classes with consumers with lower selectivity with respect to price, and higher selectivity with respect to quality. Consumers in existing classes imitate their behaviour, reducing their own price selectivity and increasing their own quality selectivity. As a result, the demand for higher quality and higher price goods increases monotonically, and demand for "cheap" goods decreases monotonically. Each step in Figures 3 and 4 is due to a change in the consumer class

[14]The fact that output per capita is lower than productivity depends on the diminishing returns to scale due to the increasing number of managers required to coordinate larger organisations. Part of the productivity gains accrued from technological innovation are spent on compensating for decreased productivity caused by the increased number of workers engaged on managerial tasks.

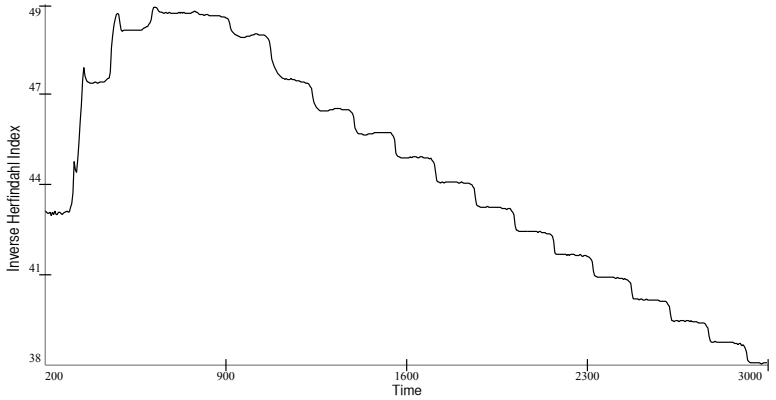


Figure 4: ***Time series of the inverse Herfindahl index of the market shares of firms in the final goods sector***

composition and an increase in the selection pressure for firms with respect to product quality.

Unlike demand for higher quality goods, market concentration follows a non-monotonic change (Figure 4) due to these changes in consumer preferences. Figure 5 plots the market share distribution of firms in the final goods market (y-axis), ordered by decreasing quality (x-axis), for different time steps in the simulation. We recall that the mark-up is positively related to quality. Therefore firms closer to the origin are likely to charge a higher price.

As depicted in Figure 4, around the 900^{th} step firms have very similar market share. As we move towards the initial (200) and the final (2700) steps the distribution of firm size becomes significantly more skewed. In particular, in the previous periods, 900 firms with lower prices have an advantage over high quality competitors, due to the relatively high share of consumers seeking low-quality, low-price products. However, because of the low level of demand, this selection has no impact on productivity Due to the emergence of new income classes (as the economy grows) and due also to imitation, during the last stages of the simulation consumers are more selective with respect to quality than price. Therefore, the lowest quality and lowest price products see their market share disappear, whereas firms with the highest quality output exploit the preferences of top managers and attract increasing numbers of middle- and low-income workers, who imitate the life-styles of more affluent workers.

Eventually, the growth in firm size due to the level and composition of demand, changes in the consumer and labour structure, and firm selection explains the positive effect of firm and employment growth on market concentration and productivity, via capital investment. A growing economy, with firms that are increasing in size, 'produces' more sophisticated consumers with higher incomes. As already noted, level of demand is crucial for selection to play a role: more than 70% of demand comes from the first two classes of workers, who imitate the preferences of more affluent classes.

In Sections 4.2, 4.3 and 4.4 we investigate how different rates of preferences imitation

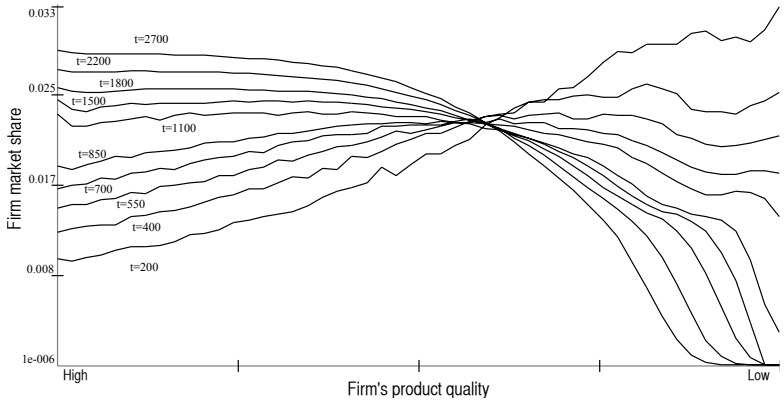


Figure 5: ***Market share distribution of firms in the final goods market in different times periods***. *Firms are ordered by decreasing level of quality (those to the left are the highest quality) along the horizontal axis. Market shares are represented on the vertical axis.*

(concentration of consumer preferences), mark-up rates (price dispersion), and product disparity (quality dispersion), can influence the pattern of economic growth via changes to the market structure.

4.2 Imitation Pressure in Consumption Patterns

We explore the effect of faster imitation of consumption patterns (α). In the 'benchmark' configuration, 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 pattern emerges.[15] We compare the benchmark case with results obtained for faster imitation (20%), representing societies where low income classes more rapidly adopt the consumption habits observed in richer classes (for a given income growth).

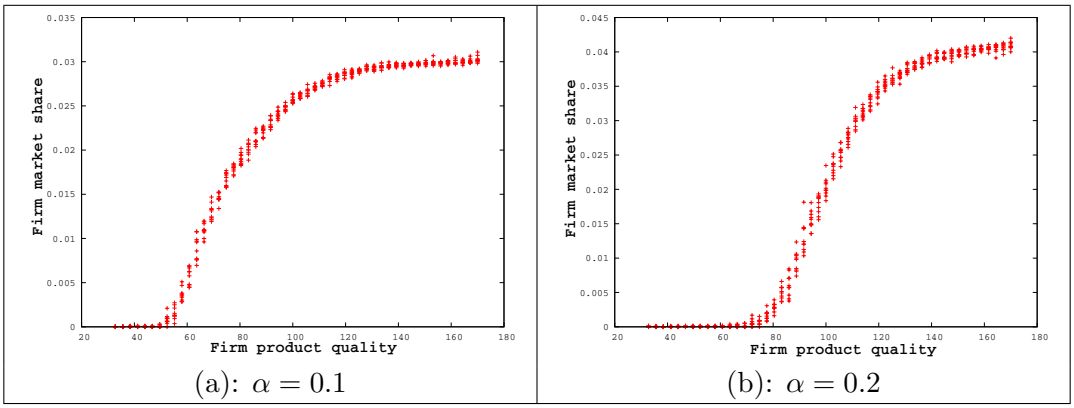
The implications are that, *cœteris paribus*, consumers become less selective more rapidly with respect to price, and more selective with respect to quality, reducing the selection pressure in the early stages of development, and increasing it in the later stages of development.[16] The reason why this is crucial is that, in our model, the first three income classes form the bulk of the demand, and their preferences have a significant impact on the results.

Figure 6 compares the market share distribution of firms ranked on the horizontal axis by increasing quality for the benchmark case (panel a: $\alpha = 0.1$) and for the case with faster imitation (panel b: $\alpha = 0.2$) in the last period of the simulation. We plot the results from 10 different runs to control for randomness. Figure 6 shows clearly

[15] See eq. 3.

[16] This is because during the early stages consumers with low wages reduce selectivity with respect to price more rapidly, whereas in the later stages all consumers become more selective with respect to quality.

that with faster imitation rates the firm size (market share) distribution, as expected, is significantly more skewed, with a higher number of firms exiting the market.



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

Figure 6: ***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%).*

Next we investigate 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 parameter value α ranging from 10% to 20%. Figure 7 plots the relation between the IHI and output per capita.

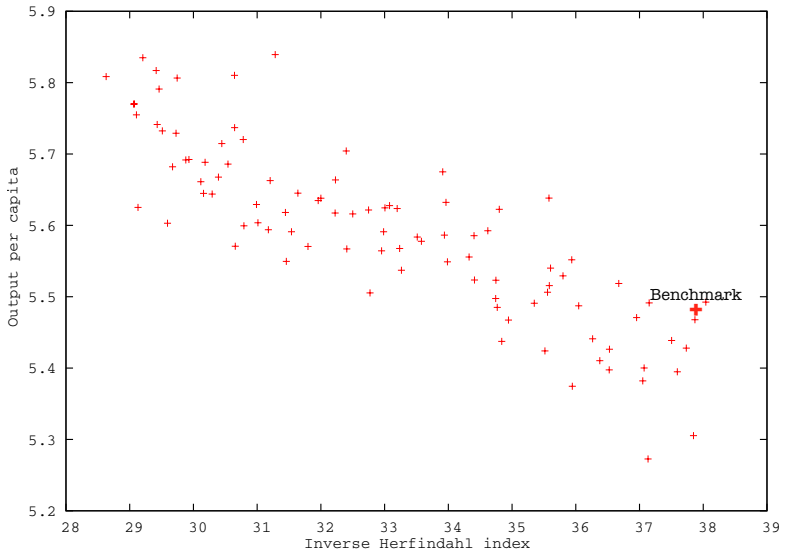


Figure 7: ***Inverse Herfindahl index versus output per capita for different rates of consumer imitation***

Compared to the benchmark case (bottom right in Figure 7), the increasing concentration generated by faster imitation of consumer preferences for conspicuous consump-

tion has two main effects. First, a significant increase in the demand for higher quality goods due to the large share of the total income of the lower income classes (as shown in Figure 6). 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 the top classes, can lead to stronger economic performance.

4.3 Markup, Price Dispersion, and Income Distribution

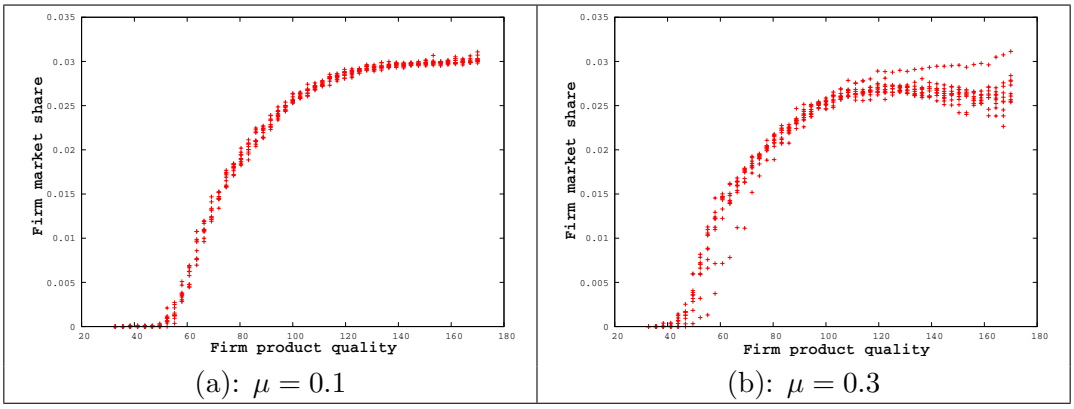
In this section we explore the effect of price dispersion as an outcome of firm's pricing strategies. Prices in our model are set as a mark-up on unit labour costs (see equation 3), where the mark-up rate is proportional to product quality. In the benchmark configuration the maximum mark-up is 10%. We compare this with results obtained for a maximum mark-up of 30%, representing societies where firms producing high quality goods are able to extract higher profits to redistribute to shareholders. With a maximum mark-up of 30%, for a given distribution of product quality, there is a higher price dispersion.

The implications are counter-intuitive: for a higher mark-up rate, *cæteris paribus*, firms are more heterogeneous with respect to price, the market is more segmented, and the distribution of market shares at the end of the simulation is less skewed. Consumers in the first income classes select firms based more on price than on quality, for a given imitation rate. Due to the significantly larger demand of the less wealthy income classes in our model, in the initial stages of development low-quality and low-price firms attract most of the demand, and market concentration is higher than in the benchmark case. As more income classes emerge, more consumers can afford high-cost goods, and market concentration in the last simulated periods is lower than in the benchmark case.

We show this in Figure 8 where we plot the market shares of firms, ordered on the horizontal axis by increasing quality. Panel (a) depicts the benchmark case (maximum $\mu = 0.1$) and Panel (b), the case with high mark-up (maximum $\mu = 0.3$). Market shares significantly change for extreme values of quality, reducing for high quality, and increasing for low quality, squeezing the distribution towards central values. How does a higher concentration in the early stages of development and a lower concentration in the late stages of development affect economic growth?

Figure 9 plots this relation for the last simulation period. The effect of lower market concentration on output per capita is significantly negative. Compared to the benchmark case (top left in Figure 9), for an increasing maximum mark-up, the economy experiences higher market segmentation between rich and poor consumers, reduced demand for high quality goods, and an overall lower market concentration. Higher prices depress demand and, therefore, per capita output, in two ways: (i) directly, by reducing demand; (ii) indirectly, by reducing market concentration.

Within the limits of our model, we conclude that the ability to charge higher prices decreases market concentration by hindering the consumption of higher quality goods to lower income classes, and separating different consumer niches. As a consequence, the



(a): $\mu = 0.1$ (b): $\mu = 0.3$

Figure 8: ***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%).*

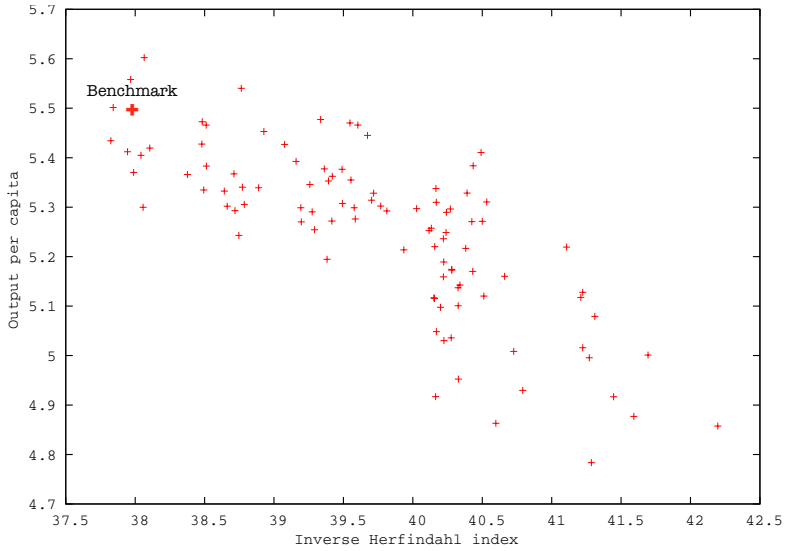


Figure 9: ***Inverse Herfindahl index versus output per capita for different mark-up rates***

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

4.4 Product Quality Dispersion

We investigate the effect of higher dispersion in product quality. We compare the benchmark configuration – product quality ranging between 30 and 170 – with an economy with a narrower range of the quality assigned to the producers of the final good – between

50 and 150, representing societies with lower product variety.

The implications are, *cæteris paribus*, lower market segmentation, and less selective consumers with respect to quality, reducing consumer selection and, therefore, market concentration in the final stage of development (when the demand for high quality goods increases) – with respect to the benchmark case.

We plot the market shares of firms ordered on the horizontal axis by increasing quality (Figure 10). As expected, the market share distribution is significantly less skewed than in all other cases, including the benchmark. All firms have positive market shares, and most selection is related to price.

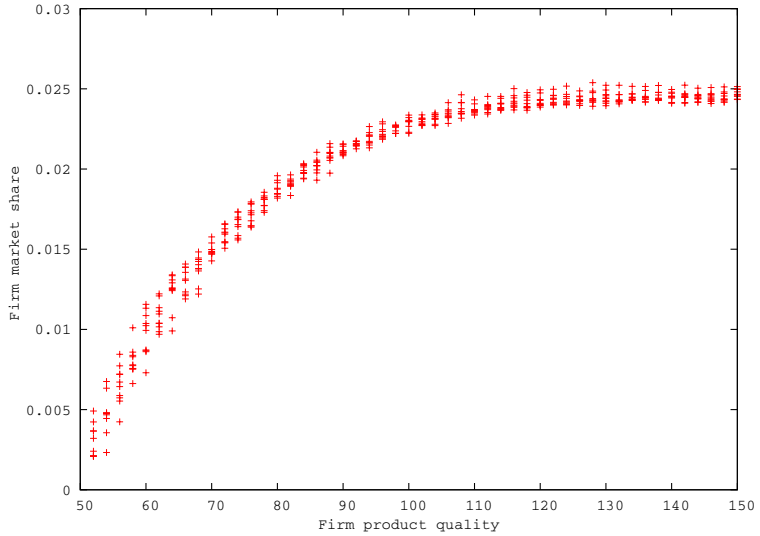

Figure 10: ***Distribution of firms market share (vertical) for increasing product quality (horizontal). Low quality disparity***

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Figure 11 plots the relation between market concentration (IHI) and per capita output.[17] Compared to the benchmark case (middle left in Figure 11), reducing final market concentration through reduced product variety does not significantly change output growth, even though market concentration at the end of the simulation is significantly lower (from 38 firm in the benchmark case to more than 46 firms, on average, in the case of lower product variety). The effect of increasing disparity through product quality is much less pronounced than in the case of increasing disparity through the mark-up.

The results imply that, although market concentration increases sharply for increasing heterogeneity in the quality of final goods, in our model disparity alone, with no changes in prices[18] and no changes in the pattern of consumption of less wealthy income classes, has no significant effect on the relation between variety and growth.

[17]Figure 11 depicts the results from 100 simulation runs each with a different range of product quality (from 40-160 to 100-100).

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

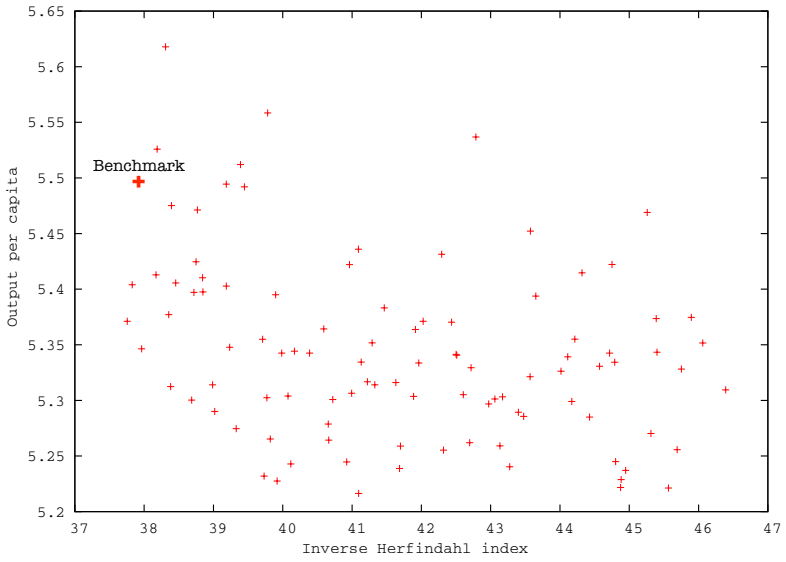

Figure 11: ***Inverse Herfindahl index versus output per capita for different levels of dispersion of the product quality***

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5 Conclusions

A growing body of literature is exploring macro-economic models based on the complex interaction between microeconomic agents with realistic behaviour properties. The main advantage of these models is that they allow analysis of emerging evolutionary macroeconomic properties as the outcome of simple economic behaviour, without any assumption of equilibrium dynamics.

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

While most of the structuralist literature focuses on the effect of demand on growth and structural change via the distribution of income (size and price effects), in this paper we considered less well studied structural changes (consumer preferences, firm size, and capital vintages), and focused on the effect of the distribution of preferences and product variety on market concentration in the final goods sector. We studied the effect of market concentration on productivity and income growth via technological change. In particular, we analysed how market concentration, generated in different phases of the development process – initial Malthusian stagnation and eventual Kaldorian sustained growth – by different types of heterogeneities – preferences, price, and quality, impact differently on

	Dispersion	Selection/Concentration[4]		Output
		Malthusian	Kaldorian	
Preferences	$\uparrow^{1}$	$\uparrow/\uparrow$	$\downarrow/\downarrow$	$\downarrow$
Price	$\uparrow^{2}$	$\uparrow/\uparrow$	$\uparrow/\downarrow$	$\downarrow$
Quality	$\uparrow^{3}$	$\longleftrightarrow/\longleftrightarrow$	$\uparrow/\uparrow$	$\longleftrightarrow$

Footnote: [1]lower imitation of wealthier class preferences; [2]wider distribution of mark-up rates; [3]wider distribution of product quality; [4]we distinguish between the initial stage of development (Malthusian stagnation) and the final stage of development (Kaldorian sustained growth).

Table 1: ***Summary of results.***

economic growth.

The model reproduces some basic properties related to market concentration, firm size, wages distribution, and income. We showed that market concentration is correlated significantly with per capita output growth above a given level of final demand. We also exploited the model to investigate the relation between market concentration and output growth for varying consumer imitation behaviours, price dispersion, and product quality dispersion.

We found that, as the result of very different mechanisms, higher dispersion in consumer preferences – due to slower imitation of wealthier classes, and in price – due to higher mark-up rates, caused a higher concentration during the initial phases of development and a lower concentration during the last phase of development (Table 1), and significantly lower output growth. In contrast, higher dispersion of product quality is related to no change in the initial phase and to a higher concentration in the last phase of development, but only mildly to output growth.

It is only when the increased concentration is due to relatively lower mark-up rates and to consumers changing their preferences rapidly that higher output per capita is correlated with market concentration. When there are moderate profit margins accompanied by access to goods of higher quality by less wealthy consumers (in a closed economy model), we would expect relatively higher economic growth. As in other structural models, this is the result of consumers having access to a larger variety of goods. However, high mark-up rates prevent less wealthy consumers from accessing high quality goods, thereby segmenting the market, and reducing concentration and capital investment. In contrast, high levels of imitation induces the majority of the population to access high quality good, inducing higher concentration and higher capital investment.

This mechanism of higher concentration and increased output does not occur if market concentration is generated only through product variety on the supply side. It needs to be accompanied by access to higher quality by less wealthy income classes, via imitation and, possibly, via redistribution.

The model has some limitations, in particular, the absence of a financial market and a labour market restraining growth, and the absence of innovation via firm entry. We leave the inclusion of these features for future work, building on the current results.

Nevertheless, our proposed model provides evidence of several relationships between economic development and structural change, which are difficult to demonstrate in a model that assumes away the complexity of market interactions and firm organisation. We would suggest further empirical investigation of the hypotheses in this paper in order to formulate more effective economic development policies.

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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. (2016)
$\upsilon^{max}=\upsilon_{p,1}$	Lowest = first tier quality selectivity	0.9	See Lorentz et al. (2016)
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 1 year as 10 simulation steps) to avoid growth in the first periods being determined by the replacement of capital. [c]Ratio with respect to the average (not minimum) wage in OECD countries Boeri (2009). [d] Simon (1957). [e]Krueger and Perri (2005b); Gervais and Klein (2010). [f] To the best of our knowledge, there is no available empirical evidence. Parameters are 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 innovation activity in the capital sector. [i]To our knowledge, there is no available empirical evidence on profits.

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

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