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The Effect of Demand-Driven Structural Transformations on Growth and Technological Change*

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Abstract

The paper analyses the effect of the dynamics of consumption preferences on the dynamics of macro–economic growth. We endogenously derive micro–dynamics of consumption behaviour as a result of the increase in the number of income classes. The different degrees of inertia in the adjustment of consumption levels to income changes affect firm selection and the dynamics of market structure, which is ultimately responsible for different regimes of macro–economic growth. We find, firstly, that higher heterogeneity in consumption preferences amplifies and accelerates market dynamics, leading to a swift shift from a Malthusian to a Kaldorian growth pattern. Secondly, consumption smoothing mainly affects the timing of such a take–off. Inertia in consumption delays the occurrence of a Kaldorian engine for growth.

Keywords: Consumption; structural change; income distribution; technological change; growth
JEL: O41, L16, C63, O14

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1 Introduction

The recent years have witnessed an unprecedented global recession, triggered by a financial burst over consumption credit in the US. This has revamped the importance of analysis of the effect of micro–level consumption choices on aggregate dynamics of growth. Economic theory is urged to re-define the analytical priorities in this direction. However, both mainstream and heterodox theories have produced a meagre number of contributions on the effect of consumption micro–behaviour on aggregate growth, with the notable few exceptions that we review below (e.g. Dosi et al., 2010).

The aim of this paper is to analyse the effect of specific aspects of consumption micro–behaviour on the macro–dynamics of growth and labour productivity. In particular, we look at how endogenously determined changes in *consumption preferences* and in *consumption smoothing* to earnings, affect growth patterns.

To do so, we build upon the model proposed in our previous work (Ciarli et al., 2010, 2012), which is purportedly equipped to endogenously derive the dynamics of consumption preferences. These latter are modelled in terms of consumers selectivity of price and quality, that is the degree to which different consumers rank their priorities and trade–off in terms of (high) quality and (low) prices. The model allows to track down the transmission of consumption smoothing on the aggregates. More in particular, the model explicitly bridges changes in the organisation, technology and wages composition at the firm–level and changes in the consumption preferences associated to different working/earning classes (income distribution).

While our previous work analysed the general macro–properties of our model (Ciarli et al., 2010)[1] and those emerging from the micro–dynamics of supply–side characteristics (Ciarli et al., 2012), here we concentrate on how changes in the consumption behaviour are transmitted by the complex interrelation of micro to macro mechanisms to firm selection and market structure and result in different macro–properties.

The scholarship on the effects of demand on growth has proposed models that focus on income–led changes of consumption preferences affecting the rate of product innovation taking place in a final good sector (Aoki and Yoshikawa, 2002; Föllmi and Zweimüller, 2008; Matsuyama, 2002). Some of these contributions analyse the relation between income distribution and growth based on the change in demand for differentiated goods, albeit their analytical apparatus does not allow to treat firm selection and the dynamics of market structure as a result of changing preferences. Other contributions look at the effect of the emergence of new sectors as output variety and growth (Saviotti and Pyka, 2008, 2004).

Within the evolutionary stream of literature, a few contributions have analysed how consumption 'needs' evolve (Witt, 2001, 2008), some drawing upon interdisciplinary evidence and theory (Swann, 1999; Babutsidze, 2012; Valente, 2012), which also account for the psychological drivers of the consumption behaviour. [2] To our knowledge, evolu-

[1] We summarise and discuss in Section 3 the different growth patterns identified by the benchmark configuration.

[2] Although in the present paper we do not focus on the psychological drivers of consumption behaviour, the results of this literature are implicitly taken into account when modelling the consumers selectivity.

tionary and agent–based models have missed the opportunity to tackle specific aspects of consumption behaviour that affect growth through their impact on firm selection and market structure.

Scholarship on consumption smoothing mainly comes from labour and macro economists and looks at whether and how changes in earning and income distribution affect consumption choices. A substantial part of this literature has focused on empirical testing of the Life-cycle Permanent Income Hypothesis (PIH) (Ando and Modigliani, 1963; Hall, 1978). In a recent and comprehensive survey, Meghir and Pistaferri (2011) review the empirical evidence around the PIH, finding that the majority of the evidence in developed countries support it. Faced with anticipated or actual income shocks, households might react with *ex-ante* or *ex-post* strategies to prevent shocks from dramatically affecting their consumption choices. Both ex-ante and ex-post behavioural responses depend on the amount of risk that actors are able to transfer to, for instance, private insurance or public schemes, so that standard models of inter–temporal consumption predict that current consumption adjusts very little to persistent income shocks. The PIH has substantially influenced the policy debate, mostly undermining the role and effectiveness of Keynesian policies and more in general the Keynesian apparatus, by modelling and empirically showing that the (aggregate) consumption function only depends on permanent life–cycle income.

Evolutionary models have never entered this debate, failing to consider the feedback mechanisms underpinning income and consumption choices. In this paper we implicitly use the parameter behind the PIH, consumption smoothing, although we do not pretend to either provide support or reject the PIH,[3] rather we analyse the emerging macro properties associated to different levels of consumption smoothing.

The specific analysis and findings proposed in this paper originally contribute to both the streams of literature above in that they specifically focus on the micro–level mechanisms underpinning the demand–side of structural change and analyse the macro–properties emerging from the model. We focus in particular on the two aspects of consumers behaviour that are central to these literatures, that are consumer preferences – modelled in terms of endogenously determined *selectivity* to different benchmarks of price and quality – and consumer smoothing. Our model allows to look at how the changes in consumers preferences affect the selection of firms, their size distribution and therefore the market structure that characterises different growth phases. Results of the simulations conducted for different levels of consumption selectivity and smoothing are discussed against our benchmark growth dynamics summarised in Section 3.

In the benchmark macro–dynamics results we identify two distinct growth phases. A first, transitional, Malthusian phase is characterised by low productivity growth and a low, albeit stable, output growth driven by factors accumulation. When a wealthier class of managers emerges as a result of increases in firms size and market concentration, innovation and capital–led increases in aggregate labour productivity spur a take–off and shift the economy into a second phase, whereby a Kaldorian engine lifts the Malthusian

[3]One of the reasons for this is that our model does not include an explicit financial market, so that we are not able to explicitly model inter–temporal consumption choices.

stagnation.

Within these different growth patterns, economies experience structural changes of consumption behaviour (selectivity and smoothing), which might or might not affect the emerging macro–properties of economic systems. The analysis of these is central to this paper.

The model shows that *consumer selectivity* substantially affects macro-economic properties, i.e. aggregate growth and labour productivity. First, we find that the higher the selectivity of consumers, the higher and more significantly affected is output growth. Second, it is worth emphasising a relevant and unique emergent macro-property generated by our model, briefly mentioned in Section 3 and rarely considered in the growth literature: in the presence of high consumption selectivity during the Malthusian phase, we observe the co-existence of lower aggregate productivity and higher output growth, which we discuss at length in Section 4. This pattern changes dramatically after the take-off and the shift to the Kaldorian phase, when capital firms innovate and produce more productive capital vintages: in the presence of higher consumer selectivity, aggregate productivity does not experience negative shocks and, eventually, starts growing at significantly higher rates, alongside aggregate output.

Interestingly, when looking at the effect of *consumption smoothing* on the emerging macro-properties of the model, we find that higher consumption inertia mainly affects the *timing* of the take–off and the shift to the Kaldorian regime, rather that the actual rate of growth. This evidence is confirmed when we analyse the association of different levels of consumption inertia with patterns of income distribution, which remain unaltered in dimension.

Overall, the paper offers a long-due zoom into the effects of specific characteristics of demand on the emerging macro-dynamics of output and productivity, drawing upon a model specifically equipped for looking into the complex and interrelated aspects of micro structural changes in consumers and firms behaviour and firm selection on macroeconomic results (Ciarli et al., 2012). Interestingly and unprecedentedly, we find results that allow us to contribute to the (meagre) scholarship that has dealt with the effects of preferences and consumption smoothing on growth.

In this respect, our model is closely related to the recent attempts to study macro–economic policies in an agent-based framework using insights form the Schumpeterian and Keynesian traditions. In line with Dosi et al. (2010), we take a step forward with respect to the neo–Keynesian micro foundations as well as relax the assumption of the ability of economic agents to optimise, as in contributions included in Dawid and Fagiolo (2008).

The remainder of the paper is organised as follows. Next section describes the model. Section 3 presents the main dynamics of the self-sustained growth regime generated through the numerical simulation of the model. Section 4 discusses the effects of heterogeneous preferences and consumption smoothing on the distinct growth regimes identified above. Finally, Section 5 summarises the rationale behind the model, discusses the results and, most importantly, proposes few lines of research which the various extensions of the model might usefully contribute to.

2 An Evolutionary Model of Structural Change

We model a closed economy including two production sectors (capital goods and final good producers) and the aggregate demand. The productive sectors are composed by a fixed number of firms producing heterogeneous goods. Demand is represented by the set of households who earn their income by working in firms from both sectors, and consume goods produced by firms in the final good sector. Firms in the final good sector need capital goods, which are purchased from firms in the capital good sectors, which only use labour as production factor.

Labor organisation within firms in both sectors is hierarchically organised. The base of the organisational pyramid includes shop floor workers, who carry out the actual production process. The rest of the organisation is based on the assumption that for any given number of employees it is necessary to have a coordinating manager. Thus, the organisation of labor implies intrinsic (static) diseconomies of scale, as to expand production it is not sufficient to increase the number of shop floor workers, but also the number of organisational layers, generating increasing unitary costs, for shop floor workers productivity being equal.

Firms of the capital good sector produce a single capital good with a specific embodied level of productivity. Innovations occurring in the capital good sector – i.e. improvement of the embodied level of productivity – are the only source of technological change and productivity gains in the final good sector – and in the economy as a whole.

The household sector is populated by workers/consumers. These are grouped in different income classes characterised by different income levels and preferences with respect of the characteristics of the final good, price and quality. Income classes, and their related preferences, are assumed to depend on the hierarchical position within the firms employing the workers.

Overall, the model represents three *non-Walrasian* markets (Colander et al., 2008; Dosi et al., 2010): final good, capital good, labor. Households spend their income to buy from firms in the final good market. Supply is constrained by a firm's production capacity (including stocks buffering short term differences) and demand depends on households available income.

In the capital good market, capital producers use labor to produce capital goods ordered by firms in the final good sector. Demand for capital depends on the obsolescence of existing machines and decisions to increase production (and productivity) levels. New capital goods embody the most recent innovations offering increasing levels of labor productivity.

The labor market is represented only implicitly. We assume no long term divergence between supply and demand of labor, although short term inertia allows for prolonged periods of disequilibrium. Minimum wage, used to determine wages for all hierarchical levels, increases with inflation and excess demand for workers.

We model a closed economy with no financial sector. However, the model contains a fairly detailed representation of the mechanisms aggregating individual decisions by firms and households/workers so to produce sophisticated macro-level properties. In particular, the model allows to generate different growth patterns, and to analyse the conditions associated to each state. Overall, the model can be considered as a general platform that allows analysis of interconnected events and explanations that in more complex systems would be difficult to distinguish.

The implementation of the model have been described in several previous works (Ciarli et al., 2010, 2012). In what follows we provide a brief survey of the individual elements of the model, focusing in particular on those at the core of the endogenous structural changes generated by the model, particularly those that are relevant for generating the original results presented in this paper, the behavioural link between income and consumption choices, the preference structure and the role of expectations in firms' operative production decisions.

2.1 Final Good Sector

The final good sector is composed by a fixed number of firms offering a product whose quality is differentiated across firms and exogenously fixed. Firms produce using labour and capital, use a mark-up rule to set the price of their product, and distribute wage and bonuses. We use the index f to indicate a firm and t to indicate the time period.

2.1.1 Production

Firms first estimate the demand in period t. The quantity demanded to each firm is subject to consumers choice in $t-1$, which depends on random volatility and long term trend changes due to different composition of the demand (Section 2.3).

We assume that firms are not able to predict the future demand for their good in each time period. They use adaptive expectations based on the gap between past estimations and current demand to adjust their output minimising the gap between current production and sales – i.e. inventories. The level of current production is the result of the firms' expected demand and of available labour and capital inputs. Formally, a firm's estimation of its own demand for the current period, $Y_f^e(t)$ is computed as:

$$Y_f^e(t) = a^s Y_f^e(t-1) + (1-a^s) Y_f(t-1) \tag{1}$$

where $Y_f(t-1)$ is the lagged value of actual demand, and the parameter a^s, defined in the [0,1] range, accounts for a more or less conservative behaviour with respect to expectations.

Second, firms define the desired production level ($Q_f^d(t)$) as the difference between the expected demand and the available inventories, or accumulated backlogs ($S_f(t-1)$):

$$Q_f^d(t) = \max\left\{(1+\bar{s})Y_f^e(t) - S_f(t-1); 0\right\} \tag{2}$$

where $\bar{s}$ is the desired ratio of inventories to insure towards unexpected increases in the current demand.

Finally, actual production $Q_f(t)$ is a function of the desired production, labour, and capital constraints:

$$Q_f(t) = \min\left\{Q^d_f(t); A_f(t-1)L^1_f(t-1); D_f K_f(t-1)\right\} \tag{3}$$

where $L^1_f(t-1)$ are the available workers from period $t-1$, $A_f(t-1)$ is the labour productivity embodied in the capital vintages, $K_f(t-1)$ is the available capital from period $t-1$, and D_f is the fixed capital intensity ratio.[4]

2.1.2 The Labour Structure

Following previous empirical and theoretical work (Simon, 1957; Lydall, 1959; Waldman, 1984; Abowd et al., 1999; Prescott, 2003), we assume that firms are composed by distinct hierarchies of labour. We assume that only shop-floor workers enter the production process, while workers in higher layers of the hierarchy manage the production process. That is, line managers do not operate the machineries. However, managers do contribute to the labour cost of the firm. With reference to the literature we also assume that there is a maximum number of employees that each manager is able to coordinate. As a consequence, when firms increase in size they may require to higher more layers of managers. Assuming constant the number of lower level employees that each manager coordinates, ν, the total number of workers in each layer l is given by:

$$L^l_f(t) = \nu^{1-l} L^1_f(t) \tag{4}$$

The model assumes that for a given $A_f(t-1)$ the productivity of shop-floor workers is constant, and the relation between output and shop-floor workers is linear. Conversely, the number of managers increases exponentially with respect to production (or, equivalently, number of shop-floor workers) due to the need of managing more workers and firm's operations. This introduces decreasing returns to scale with respect to labour (Idson and Oi, 1999; Criscuolo, 2000; Bottazzi and Grazzi, 2010).

The demand for shop-floor workers is a function of the desired production level, subject to two distinct adjustments. First, we assume that firms maintain a share of excess labour (u^l) as an insurance against unexpected increase in future demand. Second, we assume that hiring and dismissing workers is subject to frictions: only a portion ϵ of the desired change to the labour force can be carried out in a time period. The formal representation of the number of shop-floor workers (layer 1) is then:

$$L^1_f(t) = \epsilon L^1_f(t-1) + (1-\epsilon)\left[\left(1+u^l\right)\frac{Q^d_f(t)}{A_f(t-1)}\right] \tag{5}$$

2.1.3 Capital and Investment

As firm purchase new capital vintages when commanded by an increase in the desired production, the level of the capital stock productivity is computed as the average productivity across all vintages available, discounted by their depreciation:

[4] In line with large empirical evidence, starting from the seminal work by Kaldor (1957).

$$A_f(t) = \sum_{h=1}^{V_f(t)} \frac{k_{h,f}(1-\delta)^{t-\tau_h}}{K_f(t)} a_{g,\tau_h} \tag{6}$$

where a_{g,τ_h} is the productivity embodied in the h vintage acquired in the period τ_h. The variable $k_{h,f}$ is the amount of capital (measured in terms of units of output) whose contribution is discounted at the depreciation rate δ. The stock of available capital $K_f(t) = \sum_{h=1}^{V_f(t)} k_{h,f}(1-\delta)^{t-\tau_h}$ is the sum of vintages of the units of capital purchased in the past and still in production, considering an exogenous rate of depreciation.

A new capital vintage is ordered by a firm when the desired production cannot be achieved with the current stock. The firm chooses a capital good supplier (Section 2.2) and places an order for the quantity needed. We assume that the choice of the capital supplier depends on three characteristics of the capital vintage suppliers: price of the capital vintage, its productivity and the number of time periods it takes for the supplier to produce it (time to build).

Capital investment introduces increasing economies of scale which may compensate the decreasing economies of scale due to the increase in labour costs with firm size.

The cost of the new capital vintage is paid at the time of delivery using the funds cumulated in the previous periods as a fixed share of revenues.

Whenever no capital investment is made the revenues are partly distributed to managers (not to shop-floor workers) as bonuses in addition to their regular wages.

2.1.4 Wages, Prices and Profits

We assume that shop-floor workers are paid a multiple ω of the minimum wage. The minimum wage is computed as a function of (un)employment (using wage curves (Blanchflower and Oswald, 2006) and Beveridge curves (Nickell et al., 2002)), and varies proportionally to the aggregate productivity growth, and inflation (Boeri, 2012).

Managers receive two distinct sources of income: a fixed wage and bonuses – derived from non-spent extra-profits, when available. The managers' wage is a multiple b of that paid to shop floor workers, with the multiple proportional to the hierarchical level occupied:

$$w_f^l(t) = b^{l-1} w_f^1(t) \tag{7}$$

Wages thus increase exponentially with the size of the firm (Simon, 1957; Lydall, 1959).

The price of the final good is determined on the basis of a mark-up on top of unit variable cost (Fabiani et al., 2006). A share of the resulting profits – price time current sales minus total labour costs – is redistributed as bonuses, unless the firm needs to invest in new capital. If the firm does not invest in new capital the non-distributed profits are cumulated over time to be used for future capital investments. We implicitly assume that firms have access to a non-modelled financial sector. When profits become negative due to a large capital investment, no bonus payment may occur until profits become positive again (and are not used for further capital investments).

2.2 Capital sector

The capital good sector is composed by firms producing units of capital vintages. Capital good firms produce using only labour, and engineers for Research and Development (R&D). The capital vintages produced are characterised by a level of labour productivity that depends on the amount of R&D. The demand for capital good firms results from the capital investments of the final good firms. We indicate capital good firms with the index g.

2.2.1 Production, Organisation, and Demand

We assume that capital good firms fulfil the orders received by the final good firms on a 'first-in-first-out' basis (Cooper and Haltiwanger, 2006), always working on the oldest order in their book of orders.

The labour organisation does not differ from the final good firms (Section 2.1.2): only shop-floor workers are counted as productive input, but their organisation requires a hierarchy of managers, depending on firm size.

Since the production capacity is typically smaller than needed to produce a capital order in one period, capital producers need several time periods to complete an order (Amendola and Gaffard, 1998). Capital producers maintain a backlog of orders that they use to estimate the time of delivery for prospective buyers.

The demand for one capital goods firm depends on the final firms' capital investments, as well as the outcome of their selection of capital suppliers. We assume that capital suppliers with a lower price and producing vintages with higher labour productivity are morel likely to be selected. However, capital suppliers with a long backlog of orders, are less likely to be selected.

2.2.2 Technology, R&D and Innovation in Capital Vintages

Capital producers attempt to increase the productivity of the produced vintages by investing in R&D. These investments are financed by the cumulated past profits not distributed as bonuses.

Innovation is modelled in a two stages random process standard in the evolutionary literature (Nelson and Winter, 1982). First, we assume that the success of the R&D investments increases with the number of engineers hired ($L_g^E(t)$), which depends on the invested profits: larger firms are able to maintain larger research labs (Llerena and Lorentz, 2004).

More formally, the probability that a capital supplier successfully innovate is a function of the number of engineers hired in $t-1$ and a parameter ζ:

$$P_g(t) = 1 - e^{-\zeta L_g^E(t-1)} \tag{8}$$

In other words, to obtain a successful innovation it is necessary to cumulate sufficient profits, which in turn depends on the demand from the final good firms for new capital and to satisfy this demand also requires firms to have built a sufficiently large production workforce. Both conditions require time to be fulfilled, representing the slow cumulation of innovative expertise.

Second, a successful innovation offers the opportunity to improve the labour productivity of new vintages. Assuming that only gradual technological improvements are possible, the magnitude of the change in the productivity embodied in the new capital goods $a_{g,\tau}$ is drawn from a normal distribution centred on the current level of productivity:

$$a_{g,\tau} = a_{g,\tau-1}\,(1 + max\{\varepsilon_g(t);0\}) \tag{9}$$

where $\varepsilon_g(t) \sim N(0;\sigma^a)$ is the random size of productivity increment. The advances in the vintages' embodied productivity are higher, the larger the variance of the stochastic process of innovation σ^a.

When a producer of capital goods hits an innovation the improved productivity is embodied in all capital goods produced and delivered from the moment of its discovery.

2.2.3 Wages, Prices and Profits

The determination of wages, prices and profits is similar to the one described for final good producers. Firms pay wages to managers proportional to their position in the hierarchy as multiples of the shop-floor workers' wage. Prices are determined by a markup on unit variable costs, labour. Profits are cumulated over time and used to distribute bonuses to managers or to hire new engineers.

2.3 Households

The focus of this paper is on the role of the demand side on long run growth. We model two particular aspects of consumption behaviour: consumer preferences for different classes of workers, and consumption smoothing. First, in our model preferences are endogenous to the extent that individuals working at different layers of the firm receive a different wage and bonuses (Section 2.1.4), and pertain to a different consumption group or class. The total amount of available income in a class is given by summing the total number of wages and bonuses paid to its workers. In other words, we assume that preferences depend on the "social" status determined by a consumer class. A class of consumer is identified with the index z.

As a consequence, changes occurring at the supply side of the economy, through firm size and wage distribution, are reflected in a different distribution of consumption across classes with different preferences and income levels. Growing differences among classes, in turn, affect market concentration and therefore firm growth, which are a function of consumers' selection of goods and firms.

Second, we allow workers to insure future level of consumption by smoothing changes in income through time (Krueger and Perri, 2005). The extent to which consumers smooth income variations determine the speed at which shocks on the supply side in one period are reflected in future changes in firm's demand.

2.3.1 Consumer Preferences and Purchase Decision

The purchasing behaviour assumes that consumers have limited information and are boundedly rational (Simon, 1982), and is modelled after the evidence collected from behavioural psychologists and adapted in industrial economics models (Valente, 2012).

In each period consumers rank available alternatives according to the available dimensions (price and quality, in our case). Crucially, the available products are evaluated according to whether they are above or below a given threshold. We refer to this threshold as the level of selectivity. Very selective consumers purchase only the best product, or the cheapest product in the market. Non selective consumers purchase products with any quality or any price available in the market.

For example, suppose that a consumer is purchasing milk on the local market. Different producers offer milk with a different price and a different quality, milked from different animals. Now assume that the consumer can taste the product from the different producers. Let's assume that she realises that the best milk is the goat milk. Among the goat milk producers she finds the one that tastes best to her. However, some of the other goat milk she tasted are quite close in taste. In fact, some of the sheep and cow milk she finds on the market is also not much worst than her preferred goat milk. Then the consumer asks for the price of the different milks. It turns out that the goat is the most expensive. Assume that among the goat milk the prices are quite similar, but the cow milk costs the half. In our example if the consumer is not very selective with respect to quality, she will probably be ready to buy any of the goat milks - i.e. choosing among the ones closer to her tastes discarding only the product with the lowest quality. If she is almost indifferent, non-selective at all, she will probably be ready to buy also some of the sheep and cow milks - i.e. considering also some of the products with a low quality. If she is very selective, she will be ready to buy only the goat milk she likes best. Same with respect to price. If the consumer is not very selective with respect to price, she will be ready to buy any of the cow milks - i.e. discarding only the most expensive products. If not selective at all, she might be willing to buy even some of the goat milks - i.e. considering also some of the most expensive products. If she is very selective, she will buy the cheapest among the cow milks. Finally, if a consumer is selective with respect to both price and quality, she purchases the best of the cheapest milks.

The purchasing routine, therefore, provides an intuitive and clear definition for preferences: the tolerance to accept deviation from the best option. If we aggregate from one consumer to the whole class – where different consumers may have different tastes for milk and different sources of information, but they all have the same level of selectivity – we can safely assume that consumers will purchase all goods that are above the quality and price threshold. That is, all goods that are cheap enough *and* that are of good enough quality.

Consumers' selectivity is modelled as the percentage of difference from the value considered as the best in the market in a given period. That is, 70% selectivity level with respect to quality means that a product with a quality equal to 80% of the best quality product is not discarded as inferior. The same product would be considered as inferior by a consumer with a selectivity level of 90%. Similarly for price.

We assume that classes are characterised by different values of the selectivity parameters. Workers at the shop-floor level are not at all selective with respect to quality, but very selective with respect to price. As income increases and we move towards higher managerial classes, the selectivity towards quality increases and the selectivity towards price decreases.

We assume that the preferences of the bottom class and of the top asymptotic class[5] are symmetric. We assign the parameter υ^{max} as the selectivity of the shop-floor workers with respect to price and the selectivity of the top asymptotic managerial class with respect to quality. And viceversa, we assign the parameter υ^{min} as the selectivity of the shop-floor workers with respect to quality and the selectivity of the top asymptotic managerial class with respect to price. The parameters controlling the level and distribution of the selectivity for intermediate classes are assigned according to the following equations:

$$\upsilon_{p,z+1} = (1 - \delta_\varsigma)\upsilon_{p,z} + \delta_\varsigma \upsilon^{min} \tag{10}$$
$$\upsilon_{q,z+1} = (1 - \delta_\varsigma)\upsilon_{q,z} + \delta_\varsigma \upsilon^{max} \tag{11}$$

where $\upsilon_{x,z}$ is the selectivity with respect of the characteristic $x = p, q$, price (p) and quality (q), z is the index for the class, assuming z to increase for higher income classes, $\upsilon_{p,z=1} = \upsilon^{max}$, and $\upsilon_{q,z=1} = \upsilon^{min}$. When υ^{max} and υ^{min} are close, the classes differ marginally with respect to consumption patterns. Increasing the difference between the two values produce larger differences in the preferences of the extreme classes.

Most importantly, when υ^{max} is close to 1, shop-floor workers (i.e. the largest part of the population in our model) are very selective with respect to price difference and select only those firms that manage to produce at a lower price. They discard any other competitors even for a small difference with respect to the lowest price.

2.3.2 Consumption Smoothing

A crucial assumption in our model is that consumption expenditures in a given time period do not necessarily equal total income. The literature has long accepted that consumer spending is driven by long-term consumption smoothing (Krueger and Perri, 2005) because of (social) habits as well as financial decisions.

More formally, current consumption is a function of past consumption levels $C_z(t-1)$ and present income $W_z(t)$:

$$C_z(t) = \gamma C_z(t-1) + (1-\gamma)\, W_z(t) \tag{12}$$

Parameter $(1 - \gamma)$ is the speed at which consumers adjust their consumption for a change in income. When $\gamma > 0$ households change the current level of consumption only partially with respect to past levels, assuming that an implicit banking system

[5] The top asymptotic class corresponds to an hypothetical class. As the number of hierechically constructed managerial class rises with the size of the firms, the preferences of the highest managerial class approches those of this top asymptotic class.

compensates for the difference between consumption and income. For $\gamma = 0$ any change in income is reflected in a change in consumption. In the first scenario business cycles are smoothed by consumers, in the second case, they are amplified.

Notice that we are implicitly assuming the existence of a market for savings collecting excessive income when this is higher than consumption and releasing savings when income is not able to match consumption. The implicit financial sector is neutral in redistributive terms across savers and, over the long-term, matching in- and out-flows of savings.

Finally, the model computes separately the consumption decisions for each consumer class, and total sales for each firm are obtained summing up the current demand from each class that has selected that firm.

3 Two-Phases Growth and Technological Regimes: Evidences from Numerical Simulations

In this section we present the results obtained by simulating the model initialised on the basis of the benchmark configuration (parameters described in Table 1 in the Appendix)[6]. The parameters are calibrated to the empirical level, when available. The effect of the remaining parameters is discussed in the following sections and in our previous work (Ciarli et al., 2012). Micro level parameters are set identical for all firms, apart from product quality which is randomly drawn.[7]

The purpose of this section is to describe in detail the model behaviour, focussing on the mechanisms of income growth and productivity. These mechanisms will be used to explain the effect of the demand micro behaviour on aggregate income growth in the next section.

Figure 1 displays output growth patterns endogenously emerging from the model, similar to what we find in Maddison's empirical description of the long-run growth of Western Europe and its 'offshoots' (Maddison, 2003; Hulten, 2009). As in other Unified Growth Theory (UGT) models (Galor, 2010), we reproduce two distinct growth stages, with the turning point around period 1200, following a transition phase between period 800 and 900. During the first phase the output is characterised by a stable low growth with small fluctuations. The growth of income is accompanied by population growth and induces firms growth. Following Galor (2010), we call this the Malthusian stagnation phase. During the second phase the economy takes off and experiences sustained exponential growth.

The transition phase is characterised by shocks that affect *aggregate* productivity (Fig. 2), causing a fall and a quick recovery of it, and a stagnant capital productivity

[6] The model was implemented, run and analysed in Laboratory for Simulation Development (LSD) (Valente, 2008). The code of the model is available upon request.

[7] Each result is the average over 100 replicates to control for the influence of random events. We show the 95% confidence interval in Figure 1. To ensure a better visualisation, we do not report the CI for the following figures, though they all show the same level of robustness. These are available from the authors on request.

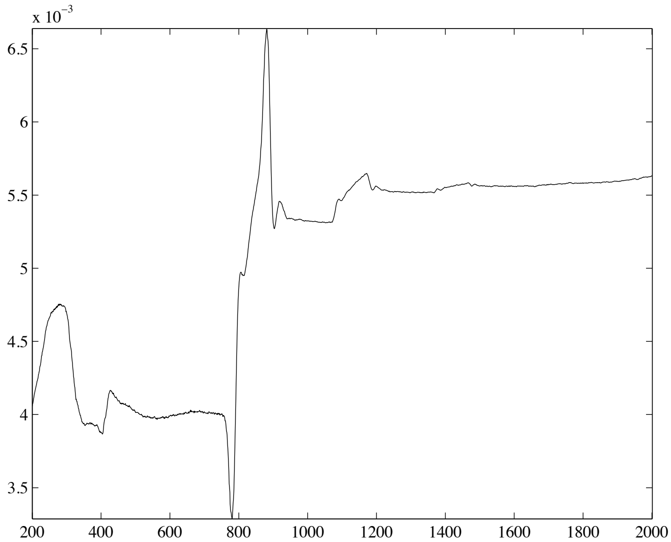

Figure 1: ***Growth rates of the economy output across time****; data from 10 periods moving averages computed over punctual growth rates. For each time step the series reports the average value across 100 replications.*

(Fig. 3). These shocks are responsible for the shift to the second phase of sustained exponential growth (Fig. 1).

First, in our model firms enjoy constant returns to scale only if higher labour does not require an additional level of management (Section 2.1.2). Beyond ν shop-floor workers (assumed identical for all firms), the firm hires a new layer of managers, increasing labour costs but not its production capacity. Second, as a consequence of the initial firms homogeneity, even shop-floor workers, who are very selective with respect to price, share their consumption almost equally across all firms, which offer similar products at the same price. Indeed, because shop-floor workers are assumed to be not very selective with respect to quality, the small differences among product qualities are not relevant for firm selection in this phase.

When firms, initially growing at similar rates, change their organisation and hire new managers, just before period 800 (Fig 2), aggregate productivity falls right afterwards. Raising prices temporarily reduces demand and output growth, while introducing variety among firms in terms of price.

The emergence of a new class of wealthier consumers leads the economy to quickly recover, while price–variety among firms increases market concentration. Those firms which enjoy a sudden increase in demand and larger market shares start investing in new capital goods, significantly increasing demand in the capital good sector.

As capital producers accumulate sufficient profits to hire engineers, they experience sustained investment in R&D. After period 1100, some of these investments are successful and capital producers start delivering capital vintages with higher labour productivity (Fig 3). This causes swift exponential growth and a shift to the second stage, whereby

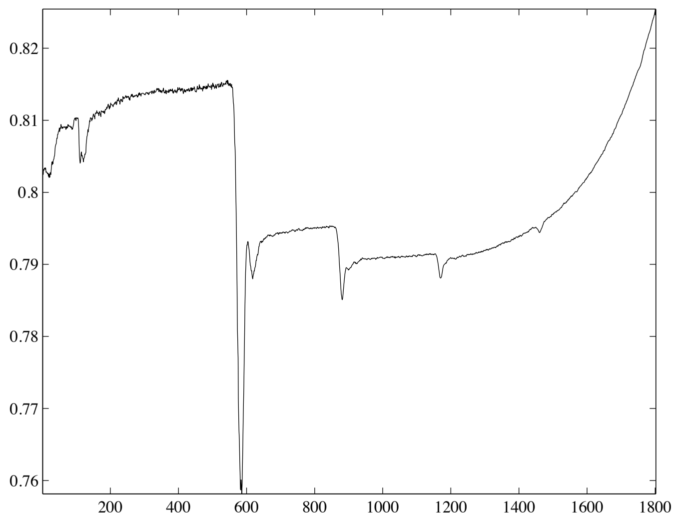

Figure 2: ***Aggregate Labour productivity across time steps***. *For each time step the series reports the average value across 100 replications*

a 'Kaldorian' engine lifts the 'Malthusian' stagnation.

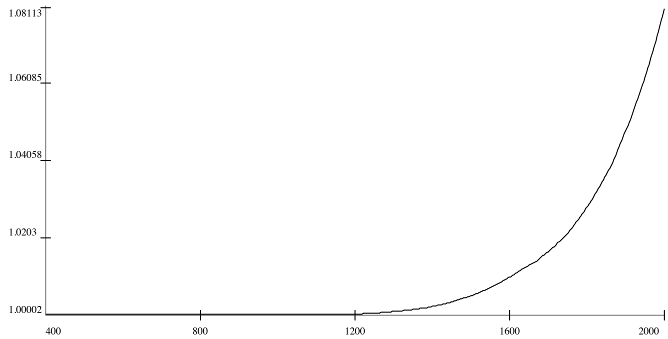

Figure 3: ***Average capital productivity*** *weighted by delivered capital goods. Average value across 100 replications*

When capital producers reach a sufficient level of cumulated production and profits, they can afford to finance R&D, thus generating innovations and more productive capital goods. This induces further price reduction, higher firm differentiation, selection and growth, and the emergence of wealthier classes, which sustain demand and output growth in a cumulative causation process, as that described by Kaldor and Myrdal (Myrdal, 1957; Kaldor, 1966, 1981).

In the 'Kaldorian' phase, aggregate productivity growth becomes exponential, as the increasing returns, to be ascribed to labour productivity of new capital vintages, outrank the diminishing returns due to the higher number of managers in more complex organisations.

The specific properties of the model, such as, for example, the timing of the 'take-off' from the Malthusian growth phase to the Kaldorian phase, depend on a combination of parameters. Some of these are analysed in (Ciarli et al., 2012).

4 The effect of demand-driven structural changes on technological change and growth

Standard economic theory posits that firms are homogeneous and consumers choice is only determined by price and quantity, regardless the producer to which consumers resort to. Consumers choice should therefore not have any macro-economic effect, since losses and gains due to micro-differences should cancel each other out at macro level. Instead, the non-linear nature of the model, both in aggregative and dynamic terms, produces relevant macro consequences originating from micro consumers behaviour.

In this section we investigate the main demand side effects of the model, focussing on the consumption behavioural parameters. First, the selectivity with respect to price and quality differences of consumers belonging to different (endogenous) income classes. Second, the consumers attitude towards consumptions smoothing against changes in income.

4.1 Macro-effects of Consumers Preferences

In this section we focus on consumers preferences, that are the selectivity with respect to the combination of price and quality of the goods. It is important to know that consumer selectivity dos not affect the *quantity* of goods purchased.

As discussed in Section 2.3.1 consumers have different levels of selectivity regarding the goods' price and quality. Highly selective consumers choose only the goods with the lowest price (lower income classes) or the highest quality (top income classes). Non-selective consumers, instead, discard only goods with a very high price or a very low quality.

In what follows we show results obtained by varying the parameter affecting the extreme values of selectivity: υ^{max} and υ^{min}. Since we impose that $\upsilon^{max} + \upsilon^{min} = 1$, we refer for convenience to υ^{max} only.

Figure 4 shows total (log) output at the end of the simulation ($t = 2000$) against increasing values of υ^{max} (for 100 replications to control for deviations from the average). The results suggest that high selectivity has a large and significant - in fact more than proportional - impact on output [8]. The model thus clearly shows that consumer selectivity, through its effect on firms' market shares, significantly affect macro-economic properties, i.e. aggregate growth and labour productivity.

What are the mechanisms through which consumers selectivity affects output growth?

[8] Due to space constraints, here we do not report a detailed analysis of the robustness check against randomness. However, we find that the within–time variance across all simulations for all value of υ^{max} is at least 10^3 times larger than the variance across the 100 simulation run for the same value of υ^{max}. The data available form the authors.

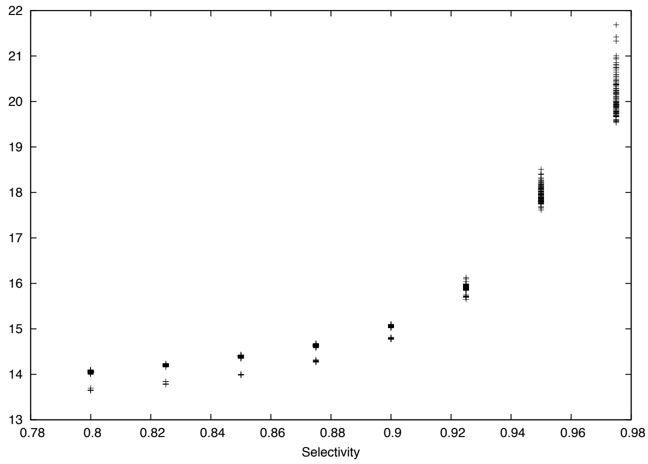

Figure 4: ***Log output vs*** υ^{max}. *Data from 100 independent runs for each value of* υ^{max} *at* $t = 2000$

In Figure 5 we plot the time series of output growth for different values of υ^{max} (average across 100 runs to control for randomness). From the previous discussion we know that the series are ranked according to the level of selectivity: the higher υ^{max} the higher is the growth rate at any simulation period.

First, we note that the pattern for most series replicates the one observed in the benchmark case (Figure 1), that is a sequence of shocks due to firms reaching the size at which they have to add new layers of management.

Second, Figure 5 shows that for higher levels of selectivity the volatility of these shocks is amplified. Simulations results with low selectivity indicate that economies experience a very smooth transition phase but they do not achieve the same high growth rate of economies with extremely selective consumers.

We next turn to the time series of aggregate labour productivity – measured as total output divided by the number of workers – in Figure 6. First, during the Malthusian phase, economies characterised by higher selectivity and higher output growth experience lower aggregate productivity. This apparently contradictory results is explained by recalling that in this phase growth is sustained only by factors accumulation: more workers increase the demand. Additional layers of management hired by larger firms, in the absence of increases of productivity of capital vintages, result in negative returns to scale, albeit they keep sustaining demand.

This pattern changes dramatically after the take-off and the shift to the Kaldorian phase, when capital firms innovate and produce more productive capital vintages: aggregate productivity does not experience negative shocks and, eventually, starts growing at significantly higher rates for economies with higher consumer selection.

Before turning to the next section, it is worth emphasising a relevant and unique emergent macro-property generated by our model – briefly mentioned in Section 3, rarely considered in the growth literature: the co-existence of low aggregate productivity and

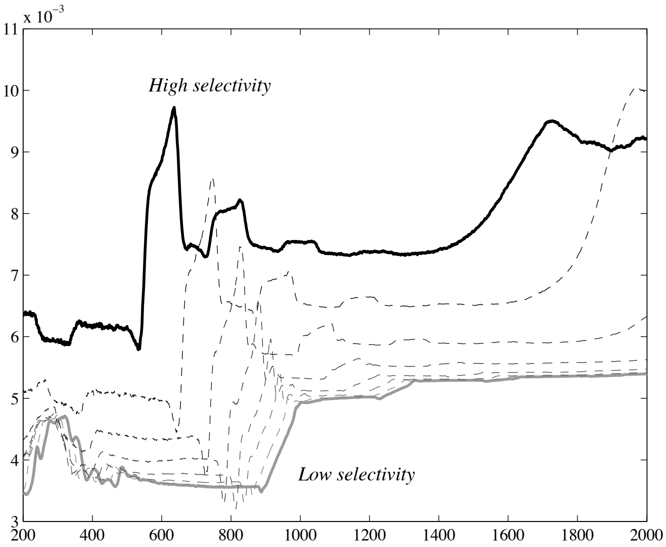

Figure 5: ***Time series of the output growth rate for different values of*** υ^{max}**..** *Average over 100 independent runs for each of the 8 values of* υ^{max}

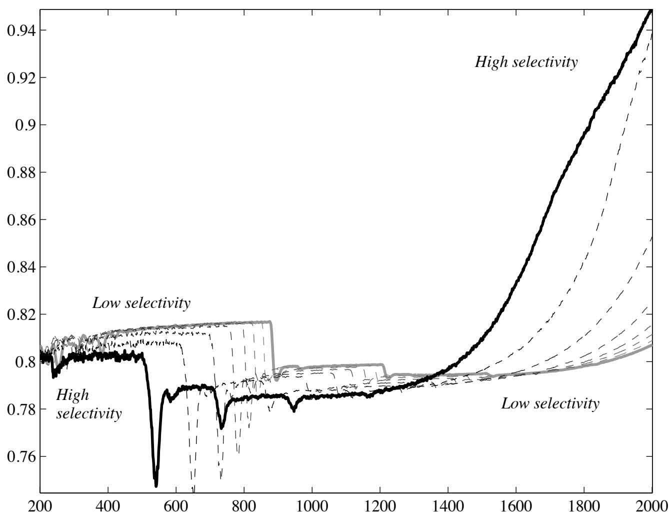

Figure 6: ***Time series of the aggregate labor productivity for different values of*** υ^{max}**.** *Aggregate productivity is measured as total output divided by the number of workers. Average over 100 independent runs for each of the 8 values of* υ^{max}

high output growth during the Malthusian phase.

In Figure 7 we plot the values of the inverse Herfindal index, which measures market concentration of final good firms. High levels of the inverse Herfindal index denotes a low concentration – many firms of similar size – whereas low levels denotes a high concentration – dominance of a few large firms serving most of the market.

As expected, highly selective consumers cause higher market concentration: in market with intense selection of firms, price–competitive firms have larger market shares than in markets with weak selection. This implies that with high selectivity some firms grow large and others remain small, whereas with low selectivity, firm size is homogeneous.

In our model large firms hire managers, which are not productive but are costly. For a given average firm size in a market, the less concentrated is the firms's size distribution, the lower is the number of managers. Therefore, for a given output, the higher is the market concentration, the lower the aggregate labour productivity (measured as output per worker).

In the Malthusian phase a larger number of workers, with higher wages, increases demand, and therefore output, which in turn lead firms to grow. However, increasing firm size in a concentrated market leads to a further price difference: firms that are growing in size because they were more competitive with respect to price slowly lose competitiveness because of the additional labour costs. This explains why we observe shocks in the market concentration, which are transmitted to aggregate output.

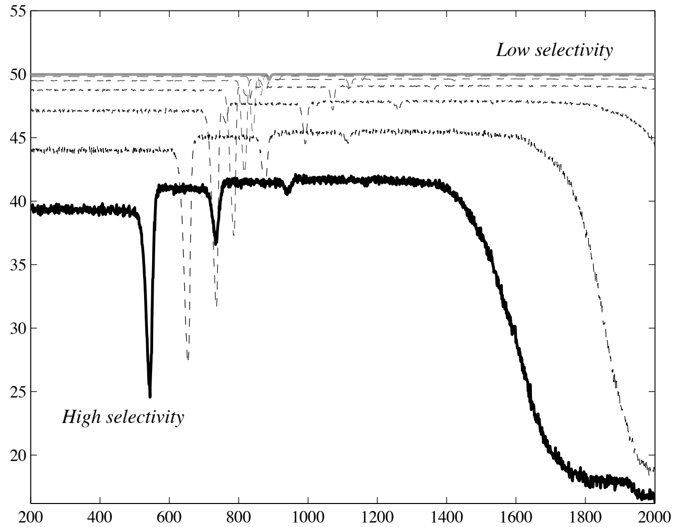

Figure 7: ***Time series of the market concentration for final good producers.*** *Concentration is measured with the inverse Herfindal index. Average over 100 independent runs for each of the 8 values of* υ^{max}.

In the Kaldorian phase, higher concentration in the final good market implies higher capital investments, because the most competitive firms have the largest market shares and are in continuous need of growing their capital endowment. As a consequence, they spur innovation in the capital good sector, which in turn sustains the exponential growth.

To summarise, first, we find that consumers selectivity significantly affect economic growth. Second, this happens because selective consumers increase market concentration. In the Malthusian growth regime, selection sparks growth as economies made of a few large firms generate comparatively more demand than economies with many small firms. In the Kaldorian regime, selection feeds demand to large firms that invest more in new capital vintages, sustaining a productivity–led growth.

4.2 Consumption smoothing

In this section we analyse the effect of different degrees of consumption smoothing with respect to changes in income. To recall, in our model (Section 2.3.2) the consumption in period t for a given class of consumers is equal to a share $\gamma \in [0, 1]$ of their consumption in period $t - 1$, plus a share $(1 - \gamma)$ of the payments received in t.

The implications of this assumption is straightforward. Changes in wages only have a partial impact on consumption. If, however, a change in income persists long enough, consumers eventually modify their consumption level until the next change. In sum, for high levels of γ consumption adjusts to income with a high inertia, whereas for $\gamma \to 0$ there is almost no inertia in adjusting consumption to income.

In figure 8 we plot the effect of inertia in adapting consumption levels to income (γ) on the growth of output in the last period of the simulation ($t = 2000$). For each value of γ (around the benchmark case [0.7, 0.9]) we run 100 simulations to control for the dispersion around the mean due to random effects.

Concerning the main question of this paper, that is whether the features of demand affect long run income growth, we find that consumption smoothing behaviour does affect both the rate of output growth and the timing of changes in the growth pattern. The effect on the rate of output growth is very small though, ranging between 4.5% and 6.5%.

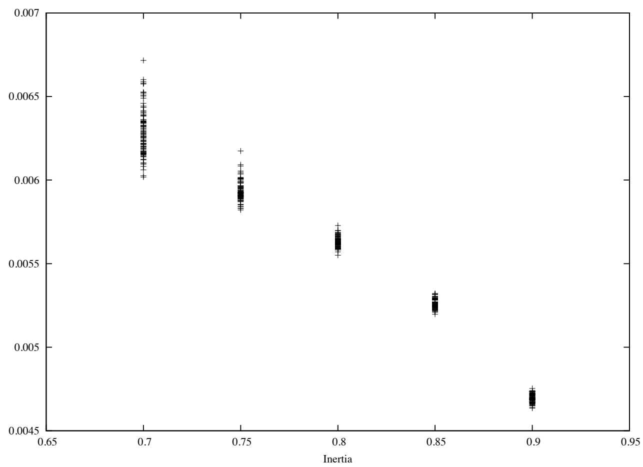

Figure 8: ***Output growth rates vs. inertia levels (γ).*** *Results from 100 simulations for each value of γ at at $t = 2000$.*

Concerning the timing we find more nuanced results. Figure 9 shows the time series of output growth, averaged over 100 runs, for the same value of γ. As already noted, the lower series are the result of higher inertia and the higher series the result of lower inertia.

First, for higher inertia, as expected, the economic cycles are wider. As γ decreases, the faster speed of adjustment of consumers leads firms to an equally faster growth of sales.

Second, the temporary recession experienced by the economy before the take-off is reduced.

Third, the faster is consumers reaction to income changes, the earlier the economy experiences the take-off.

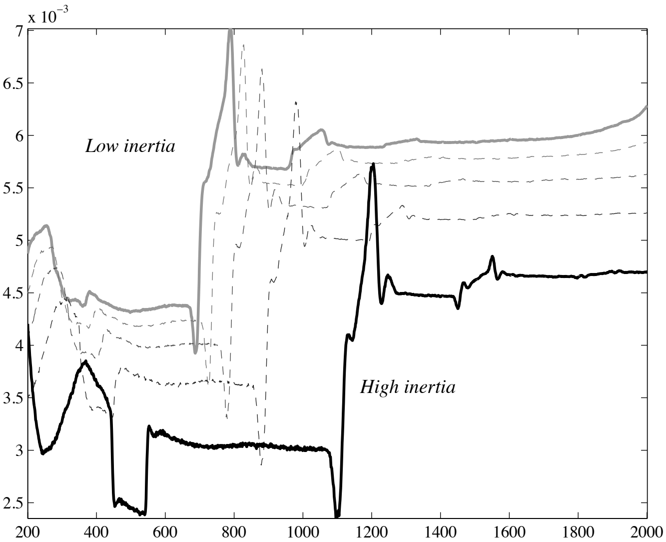

Figure 9: ***Output growth rates moving averages for different values of*** γ. *Average over 100 independent runs for each of the 5 values of* γ.

Analysis of the time series also allows for a more detailed explanation of the association between higher growth rates and low consumption inertia. As noted in Section 3, in the Malthusian regime the engine of growth is factor accumulation: increasing number of workers lead to higher consumption and higher sales. Higher consumption smoothing reduces in all periods the level of sales with respect to scenarios with lower smoothing. Further, lower sales imply that a lower number of workers is employed. The lower number of workers/consumers further reduces output growth and delays the investment of capital good firms in R&D. In other words, the overall mechanism leading to the take off and exponential growth is not altered in any other way but its timing.

We also analyse how different levels of consumption smoothing affect income distribution. In Figure 10 we plot the Gini index for different values of γ.[9] The figure shows that economies with different γ undergo the same patterns of growth, albeit with a different time frame, realising the same level of income distribution. These results reinforce the idea that consumption smoothing mainly affects the timing of growth and distribution, rather than their pattern.

[9]Average over 100 independent runs.

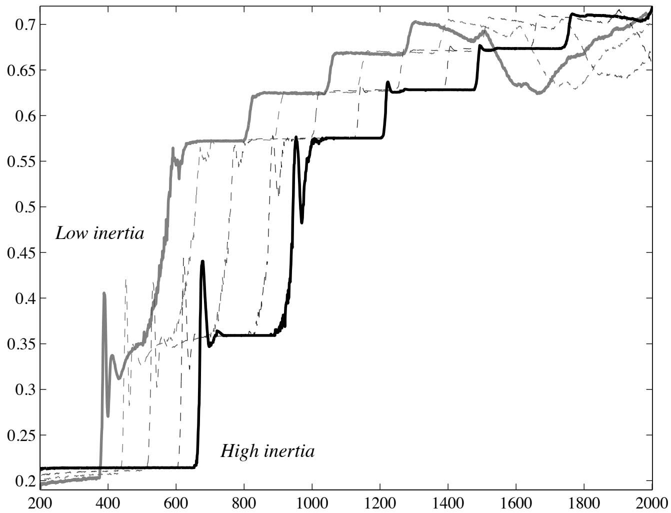

Figure 10: ***Inequality for different values of*** γ. *Measured by the Gini index. Average over 100 independent runs for each of the 5 values of* γ.

The fact that high consumption smoothing does not dramatically affect the growth patterns observed, but only their timing, suggests that the growth engine as represented in our model seems not to be harmed by stable consumption patterns. We could dare to put forward that initiatives meant to reduce consumption volatility, such as to sustain income during recessions, would have a direct positive welfare effect, at no detriment to long-term growth prospects.

5 Concluding remarks

The very recent years have witnessed an unprecedented recession in the Global North, mainly triggered by a financial burst over consumption credit in the US. Economic theory is therefore urged to re-define its analytical priorities and make sense of – among other things – the transmission mechanisms from the micro–level consumption behaviour to the macro dynamics of growth (and employment). Yet, as it is often the case, real–world issues are not able to shake the unwavering hysteresis of economic interests and scholars, so that the effort to identify determinants of and ways out from the recession is sluggish.

We have seen that both mainstream and heterodox theories have produced a meagre number of contributions on the effect of consumption micro–behaviour on aggregate growth, with some notable few exceptions (e.g. Dosi et al., 2010).

This paper has provided an original step forward in this direction, by focusing on specific aspects of demand–side structural changes, related to micro–level consumption decisions, as affecting macroeconomic growth and labour productivity via firms selection and market structure dynamics. We were able to do so by building upon the 'platform' model proposed in our previous work (Ciarli et al., 2012) and adding to the few contributions in the evolutionary tradition that have explicitly taken into account the role of demand (e.g. Saviotti and Pyka, 2008; Dosi et al., 2010; Lorentz, 2014).

Unlike these, we have explicitly looked at consumption smoothing and discussed our results with respect to the macro and labour economics contributions that have tested the Life–cycle Permanent Income Hypothesis. Also, we have explicitly linked consumption preferences to income distribution on the one hand – as consumer selectivity is assumed to be linked to income classes – and to firm selection on the other hand, as consumption choices in terms of price and quality are indeed responsible for firms growth and market structure dynamics.

Results from the numerical simulations around the parameters representing the above aspects interestingly point to two main effects:

- Higher consumer selectivity amplifies the mechanisms conducive to higher output and labour productivity growth, most especially in the Kaldorian phase, whereas in the initial Malthusian phase, higher selectivity leads to the interesting co-existence of higher output growth (compared to the benchmark Malthusian phase), and lower labour productivity growth;

- Higher consumption smoothing, instead, does not seem to majorly affect the rate of output growth, but only the timing of the shift between the Malthusian and the Kaldorian phases.

Considering that selectivity levels are linked to income classes, a very interesting line of future research might well look into the effects of inequality on growth. This should allow to engage with the development economics literature and especially those contributions that have looked at whether and how poverty traps hamper or delay economies' take–off (Abramovitz, 1986; Acemoglu and Robinson, 2006) or morally unacceptable levels of inequality are responsible of starting off processes of growth (Aghion et al., 1999; Bilancini and D'Alessandro, 2008).

Further, there are very interesting directions that future research might take, related to debates in both theoretical and policy literature on the relevance of Keynesian recipes to relaunch economies – especially in recession.

The original suggestion of the irrelevance of smoothing. i.e. that consumption does not strictly adjust to income shocks (Duesenberry, 1952, 1958), has been used as a way to dismantle the core theory behind the Keynesian multiplier, by claiming that if the consumption function is based on the permanent income, linked to the consumption life-cycle of households, than Keynesian policies have little or not effect (Ando and Modigliani, 1963). The empirical literature has indeed shown that consumption and income changes do not appear to be closely synchronised, which would be a necessary consequence of consumption smoothing. However, the lack of synchronicity does not necessarily confirm the existence of smoothing. Indeed, depending on the measurements used, consumption volatility may even appear to be larger than income volatility (Deaton and Muellbauer, 1980b,a). A possible explanation for this evidence is that consumption indeed closely tracks income, but consumers respond to income shocks with a long delay. Evidence in this respect is not unanimous, and further research is needed, also to provide a solid base to government–based interventions in support of consumption.

In this latter respect, it would be worth considering that increasing inequality is associated to a higher number of low income households, which lack access to credit and for which insurance against income shocks is more difficult to get. Thus, we might observe a decreasing smoothing while societies become more unequal, a currently robust trend in the recent years, which became more pronounced with financial markets becoming stricter on credit supply. The overall consequence of this is a decreasing smoothing over periods (and for social classes) experiencing falling income, which is indeed a gloomy prospect. This tendency may be countered by stabilising policy measures specifically designed to reduced volatility of consumption, increasing benefits when income fall and reducing them when income grows. An example of this stabilising policy is the food stamp program in the US which imposes a lower bound to consumption when income falls below a threshold.

Overall, scholars in the evolutionary tradition should devote analytical effort on the effects of consumption choices and income inequality on growth prospects, primarily because their analytical apparatus are more flexible and assumptions less constraining than their mainstream counterparts. Similarly, results on these topics should allow engaging more directly in policy debates on the opportunity and effects of government interventions to get us all out from recession.

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A Tables

Parameter	Description	Value	Data
$\underline{i_2}$	Minimum quality level	98	See Ciarli et al. (2012)
$\overline{\overline{i_2}}$	Maximum quality level	102	See Ciarli et al. (2012)
$\bar{s}$	Desired ratio of inventories	0.1	[0.11 - 0.25][a]
u^l	Unused labor capacity	0.05	0.046[b]
u	Unused capital capacity	0.05	0.046[b]
$\bar{\mu}$	Markup	0.2	[0-0.28]; [0.1, 0.28]; [0.1, 0.39][c]
δ	Capital depreciation	0.001	[0.03, 0.14]; [0.016, 0.31][d]
$\frac{1}{D}$	Capital intensity	0.4	D = [1.36, 2.51][e]
ϵ	Labor market friction	0.9	0.6; [0.6, 1.5]; [0.7, 1.4]; [0.3, 1.4][f]
ω	Minimum wage multiplier	1.11	[1.6, 3.7][g]
b	Executives wage multiplier	2	See Ciarli et al. (2012)
ν	Tier multiplier	5	See Ciarli et al. (2012)
γ	Consumption smoothing	0.8	Analysed
ςi_j	Error in the consumer's evaluation of characteristics	$j = 1$: 0.05; $j = 2$: 0.1	–[h]
$\upsilon^{min} = \upsilon_{2,1}$	Highest = first tier quality tolerance	0.1	Analysed
$\upsilon^{max} = \upsilon_{1,1}$	Lowest = first tier quality tolerance	0.9	Analysed
ζ	Innovation probability	0.01	–[i]
σ^a	Standard deviation productivity shock	0.01	See Ciarli et al. (2012)
ρ	R&D investment share	0.7	–[j]
ω^E	Engineers' wage multiplier	1.5	[1.2, 1.4][k]
a^s	Adaptation of sales expectations	0.9	–[l]
δ_ς	τ Inter-class multiplier	0.2	–[l]
F	Final good firms	50	–
G	Capital good firms	15	–
H_z	Consumer samples	50	–

[a]U.S. Census Bureau (2011); Bassin et al. (2003). [b]Coelli et al. (2002). [c]Marchetti (2002); De Loecker and Warzynski (2012); Joaquim Oliveira et al. (1996). [d]Nadiri and Prucha (1996); Fraumeni (1997) [e]King and Levine (1994). [f]Davis et al. (2013); Jung and Kuhn (2011); Andrews et al. (2008); DeVaro (2005). [g]Ratio with respect to the average wage in OECD countries Boeri (2012). [h]Empirical evidence not available to the best of our knowledge. Parameters set using the qualitative evidence in Zeithaml (1988). [i]Set to a value that ensures that innovation in the capital sector occurs proportionally to the number of engineers, but not at all attempt. [j]Empirical evidence with respect to profits not available to the best of our knowledge. [k]Relative to all College Graduates and to accountants Ryoo and Rosen (1992). [l] Empirical evidence not available: the parameters has little influence on the results presented here.

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*

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