Bureau d'économie théorique et appliquée (BETA) UMR 7522

Documents de travail

« Structural Changes and Growth Regimes »

Auteurs

Tommaso Ciarli, André Lorentz, Marco Valente, Maria Savona

Document de Travail n° 2017 – 19

Juin 2017

Bureau d'Économie Théorique et Appliquée
BETA - UMR 7522 du CNRS

BETA Université de Strasbourg
Faculté des sciences économiques et de gestion
61 avenue de la Forêt Noire
67085 Strasbourg Cedex
Tél. : +33 (0)3 68 85 20 69
Fax : +33 (0)3 68 85 20 70
Secrétariat : Géraldine Del Fabbro
g.delfabbro@unistra.fr

BETA Université de Lorraine
Faculté de droit, sciences économiques et de gestion
13 place Carnot C.O. 70026
54035 Nancy Cedex
Tél. : +33(0)3 72 74 20 70
Fax : +33 (0)3 72 74 20 71
Secrétariat : Sylviane Untereiner
sylviane.untereiner@univ-lorraine.fr

http://www.beta-umr7522.fr

Structural Changes and Growth Regimes*

Tommaso Ciarli [†] André Lorentz [‡] Marco Valente [§] Maria Savona [¶]

This version: June 15, 2017
First version: June 2016

Abstract

We study the relation between income distribution and growth mediated by structural changes on the demand and supply side. Using results from a multi-sector growth model we compare two growth regimes which differ in three aspects: labour relations, competition, and consumption patterns. Regime one, similar to Fordism, is assumed to be relatively less unequal, more competitive, and with more homogeneous consumers than regime two, similar to post-Fordism. We analyse the parameters that define the two regimes to study the role of exogenous institutional features and endogenous structural features of the economy on output growth, income distribution, and their relation. We find that regime one exhibits significantly lower inequality, higher output and productivity, and lower unemployment than regime two. Both institutional and structural features explain these difference. Most prominent among the first group are wage differences, accompanied by capital income, and the distribution of bonuses to top managers. The concentration of production magnifies the effect of wage differences on income distribution and output growth, suggesting the relevance of the norms of competition. Among structural determinants, particularly relevant are firm organisation and the structure of demand. The way in which final demand distributes across sectors influences competition and overall market concentration. Particularly relevant is the demand of the least wealthy classes. We also show how institutional and structural determinants are tightly linked. Based on this link we conclude by discussing a number of policy implications emerging from our model.

Keywords:Structural change; income distribution; competition; consumption behaviour; technological change
JEL: O41, L16, C63, O14

*We thank participants at the following conferences for comments and suggestions: EURKIND (Valencia, 2016), Schumpeter Society (Montreal, 2016), SPRU50 (Sussex, 2016), and EAEPE (Manchester, 2016). We thank participants in seminars at ECLAC, ECLAC summer school, and Curitiba for comments and suggestions. The paper has greatly benefited from comments and suggestions from Robert Blecker, Francesco Lamperti, Carolina Pan, Gabriel Porcile, Anna Salomons, Engelbert Stockhammer, Ariel Wirkierman, an anonymous reviewer of the SPRU Working Paper Series, and two anonymous referees of this journal. The paper has benefited from funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 649186 – Project ISIGrowth.

[†] SPRU, Science Policy Research Unit, University of Sussex, T.Ciarli@sussex.ac.uk

[‡] BETA - Bureau d'Economie Théorique et Appliquée (UMR CNRS 7522) and Université de Technologie de Belfort-Montbéliard, alorentz@unistra.fr

[§] University of L'Aquila, Italy; SPRU, University of Sussex; Ruhr-Universitaet Bochum; LEM, Sant'Anna School for Advanced Studies, marco.valente@univaq.it

[¶] SPRU, Science Policy Research Unit, University of Sussex, M.Savona@sussex.ac.uk

1 Introduction

An increasing number of studies suggest that most OECD economies have changed growth regime around the 1980's (Freeman and Soete, 1997; Fagerberg and Verspagen, 1999; Petit, 1999; Boyer, 2010). Some of the regularities that suggest a change in the growth regime across a range of countries are in order.

Atkinson (2015), Atkinson and Morelli (2014), and Piketty (2014), among many others, suggest that income inequality has been rising since the 1980's, after a few decades of decline. While there are important differences in the level of inequality among countries with different welfare states, the pattern has been similar across OECD countries.

Such increase in inequality was accompanied by a number of related changes, also common across a range of OECD countries. Inequality seem to be driven by the increased share of wealth concentrated in the 10% and the 1% of the population with the highest incomes (Alvaredo et al., 2013; Atkinson et al., 2011; Atkinson and Morelli, 2014). Since the 1970's the increase in inequality was preceded, and is currently accompanied, by a regular decline of labour shares (over GDP) (Karabarbounis and Neiman, 2013; Summers, 2013). Related to this, wage growth and productivity growth, once matched, started to diverge at the end of the 1970's, with the gap between the two increasing constantly (Lazonick, 2014).

Similar to what happened during other episodes of structural change, process innovation in the manufacturing sector is increasingly labour saving: capital goods replace more and more routinised tasks, increasing productivity (Brynjolfsson and McAfee, 2014; Karabarbounis and Neiman, 2013). Labour economists have convincingly shown that this is followed by an increase in the number of low paid jobs, and an increase in the number of high paid jobs (Acemoglu and Autor, 2011), reducing significantly the middle class jobs. Manning (2004), Autor and Dorn (2013), and Mazzolari and Ragusa (2013) also suggest that these changes in the labour market are not independent from changes in the composition of consumption and consumer preferences.

A large component of the increasing difference between the top 10% and the rest is the increased compensations of top classes of workers, with wages, bonuses, profit shares (Atkinson et al., 2011) and stock options (Frydman and Jenter, 2010). Part of these growing differences are explained by the routinisation of tasks, and part by the financialisation of economies and firms (Lazonick, 2014; Lazonick and Mazzucato, 2013; Stockhammer, 2012). The trend which is common to both is the increased size of firms. The evidence shows that firm average size increases with a country per capita income (Poschke, 2015) and market concentration (The Economist, 2016), and is correlated with wage dispersion (Mueller et al., 2015) and CEO pay rise (Frydman and Jenter, 2010). OECD (2017) suggest that recent innovations have increased market concentration and the innovation rents redistributed to shareholders and managers. And Autor et al. (2017) suggest that the fall in labour share is related to increase in market concentration and firm size which is also due to change in consumer behaviour, innovation, and lower rates of creative destruction. As suggested by The Economist, "part of what is perceived as a global trend towards greater disparity in wages may actually be the result of the biggest firms employing a greater share of workers".

In this paper we study the relation between income distribution and growth mediated by structural changes on the demand and supply side. We study how the relation changes for distinct growth regimes (Boyer, 1988; Petit, 1999; Coriat and Dosi, 2000) characterised by endogenous differences in (i) labour relations – compensation, profit shares, and the elasticity of wages with respect to productivity and inflation; (ii) norms of competition – entry barriers and market selection; and (iii) income related norms of consumption – consumption shares and consumer preferences. We focus only on structural determinants of income inequality, and we do not consider leaving any redistributive policy.

We define two regimes. *Regime one* characterised by relatively more equal labour relations, more competition and lower selection, and smaller difference in consumption behaviour; and *regime two* relatively more unequal, with relatively more protection for incumbents but higher market selection, and larger differences in consumption behaviour. Although we do not aim to replicate any specific historical period, one may think of regime one as a Fordist regime and regime two as a post-Fordist regime. Instead, we compare the two regimes using results from a multi-sector model that associates the different regimes to different dynamics of structural changes. We then study which of the three aspect that in our model define the regimes is more relevant in explaining the relation between income distribution and growth, by means of a parametric analysis.

We find that a Fordist regime (one) exhibits significantly lower inequality, higher output and lower unemployment than a Post-Fordist regime (two). We distinguish between institutional and structural determinants of these differences, although we also suggest that the two types of determinants are strongly related. Institutional determinants are used to differentiate the two regimes with respect to labour relations, norms of competition, and norms of consumption. We find that, keeping all other features of the regimes fixed, wage differences play the most important role in increasing inequality and limiting output growth. Returns on capital and bonuses to managers magnify the effect of wage differences by increasing the wealth of high wage earners with respect to low wage earners. The role of the minimum wage, instead, is substantially weaker. The concentration of production also magnifies the negative effect of labour relations on income distribution and output growth, suggesting the relevance of the norms of competition. However, in our model we find two opposite effects. On the one hand concentration through entry barriers increases inequality and reduces output growth. On the other hand, concentration via market selection reduces inequality, but has no effect on output. Finally, the norms of consumption have no significant effect on either income distribution or output.

Structural determinants, instead, are emerging properties in our model. First, in the absence of redistributive policies, an increase in average firm size have a direct effect on increasing income inequality. Changes in the structure of production amplify the effect of institutional difference in wage setting. Second, the structure of the demand also plays a crucial role. Sectors that attract the largest share of consumption of low income classes tend to be also significantly less concentrated in our model than sectors that sell mainly luxury goods. The structure of demand also influences competition: sectors that constitute the largest expenditure shares of the low income classes face fiercer competition, more selective consumers with respect to price, and therefore tend to exhibit a low mark-up. This implies lower profits and dividends which would accrue wealthier classes income. Third, demand plays a crucial role in explaining the differences in output between the two regimes. Even if regime two catches up in terms of productivity, due to the structure of demand the more uneven distribution curtails output growth.

Modelling and Defining Growth Regimes

The interaction between labour compensation, competition, and consumption patterns has been discussed by the regulation theory with reference to different varieties of capitalism (Boyer (1988), Petit (1999) and Coriat and Dosi (2000)).

We propose a model in which we interpret these three aspects as follows.

Labour compensation, the wage-labour nexus. We distinguish three aspects of the wage labour nexus. First, we model firms as hierarchical organisations (Caliendo et al., 2015), where workers are distributed in different tiers with different tasks and wages: at the bottom of the pyramid are clerks and blue-collars, at the top are the CEOs. In between, there are a number of intermediate supervisors and managers. The number of managerial tiers depends on the organisation of labour and on the size of the firm (endogenous in our model). Small firms have less tiers than large firms, *cæteris paribus*. Firm size depends on consumer selection, the level of consumer demand, labour productivity, and the entry of new competitors. Wages are differentiated across tiers, determining income differences between consumer classes. Together, the number of tiers and the wage differences determine the distribution of wages in the population. The larger is the wage multiplier, the larger the difference between tiers. Second, workers in managerial positions receive part of the profits as bonuses or profit shares as part of their compensation, proportionally to their base wage. The larger is the rate of profits distributed as bonuses, the larger are the differences between working classes. Third, the minimum wage is a function of unemployment, average productivity, and inflation. We peg changes in the minimum wage to changes in productivity and prices. The larger the elasticity of the minimum wage to productivity and inflation, the higher the distribution of value to workers, and the higher their purchasing power (level of demand).

Norms of competition. In our model competition and market concentration depend on consumers' selection, firms' differentiation with respect to price and quality, and entry barriers. Consumers' selection and firm's heterogeneity are endogenous in the model. Selection depends on the changes in the structure of consumer classes and on their preferences; firms' heterogeneity depends on firms response to price competition (investing in newer and more efficient capital goods and changing the mark-up) and non-price competition (increasing the quality of their products). We distinguish two aspects of the norms of competition. First, the lower are entry barriers, the higher is the probability that new firms enter in one of the consumer goods sectors and compete. Second, the more selective are consumers' preferences with respect to quality and price, the strongest the selection of firms, and the lower the number of surviving firms.

Norms of consumption. We model two aspects of changes in consumption behaviour. First, consumers in different income/working classes consume a different share of goods from each final good sector in the economy. We assume that less wealthy classes consume mainly basic goods and smaller shares of luxury goods. The opposite is true for the asymptotically wealthiest class. The fastest the change in consumption shares between consecutive classes the more heterogeneous is the demand between income classes at the extremes of the distribution. Second, we model preferences as the selectivity with respect to prices and quality. We assume that consumers in classes with a lower income tend to be more selective on price and less selective on quality, with respect to higher income consumers. These preferences change from one class to the next: the larger is the change, the larger are the differences between classes.

The three dimensions of the growth regimes are endogenously related in our model. Firm size, which determine the organisational tiers and wage difference, depends on the level of the demand and on market concentration. The level of demand depends on the elasticity of the minimum wage to changes in prices. Market concentration depends on the norms of competition and on the concentration of the demand. In turn, consumers demand depends on how they are distributed among classes and on the income of each class, which depends on the organisational tiers and on the wage differences. In other words, the norms of consumption are partly endogenous to the wage-labour nexus; the norms of competition are partly endogenous to norms of consumption; and the wage-labour nexus is partly endogenous to both competitions and consumption norms.

We distinguish two growth regimes. *Regime one* is characterised by lower differences in compensation across hierarchical tiers, a lower share of profits distributed to managers as bonuses, and a higher elasticity of the minimum wage to changes in prices and productivity. In other words regime one assumes a lower personal and functional income inequality. In regime one, market barriers are lower and consumers are less selective with respect to both price and quality. Finally, consumption patterns change at a slower pace and the preferences of middle income classes are closer to those of the lower than to the higher income classes. Such a regime is relatively closer to what the regulation school defines the *Fordist regime*.

Regime two is characterised by larger differences in compensation across hierarchical tiers, a larger share of profits distributed to managers, and a lower elasticity of wages with respect to changes in prices and productivity. Regime two assumes a higher personal and functional income inequality. In regime two market barriers are higher and consumers are more selective with respect to both price and quality. Finally, consumption patterns change at a faster pace and the preferences of middle income classes are closer to those of the richer than to those of the less wealthy classes.

Such a regime is relatively closer to what the regulation school defines the *post-Fordist regime*.

Relevant Literature

To our knowledge, most growth models that discuss growth regimes focus on the long run growth and on the shifts in growth patterns, such as the unified growth theory (Galor, 2007). For example due to changes in birth and education household strategies (Galor and Weil, 2000; Boucekkine et al., 2002), firm growth (Desmet and Parente, 2012), or changes in technology and demand (Ciarli et al., 2012). Empirically, a number of studies investigate structural breaks in growth patterns, particularly focusing on developing countries (Kar et al., 2013; Lamperti and Mattei, 2016; Pritchett, 2000). Jones and Olken (2008) characterise the transition between regimes and find that different countries follow common experience of growth acceleration and declines.

Napoletano et al. (2012) is one of the few papers that attempts to model regimes based on insights from the regulation school. The authors mainly focus on the relation between income distribution and firm investment behaviour (in new process technologies). Taking an evolutionary approach, and focussing on how micro behaviour affect macroeconomic outcomes, they investigate "how different growth regimes emerge out of micro-interactions between heterogeneous agents". The paper discusses two different regimes. One where employment is a consequence of increased demand through investment, spurred by profit inducing productivity enhancing innovation. A second one where investment is not led by profits but by demand expectations, and productivity gains are shared between capital goods and labour. As a result, an increase in productivity also leads to increased demand via both consumption and investment.

Our paper is similar in spirit. We model how different ways of organising microeconomic interactions may lead to different macroeconomic outcomes. We add to the work of Napoletano et al. (2012) by being more explicit in modelling the labour relations, the forms of competition, and the norms of consumption, and how differences in those three dimensions may be described as different regimes, or different forms of capitalism. To our knowledge this is also the first paper that investigates how structural changes are related to different growth regimes, and how they mediate the relation between growth and distribution of income under different regimes.

Focusing on the relation between structural changes and growth regimes this paper contributes substantially to the growing literature on Agent-Based macroeconomics[1] and to evolutionary economic growth models[2]. The paper is closely related to papers that study the interaction between Schumpeterian and Keynesian dynamics using agent based micro foundations (Dosi et al., 2010, 2015, 2013). It is also related to the few multi-sector models that have been offered in this tradition (Saviotti and Pyka, 2008a,b), and to papers that study skills and labour in relation to income growth and distribution (Caiani et al., 2016; Dawid et al., 2008; Deissenberg et al., 2008) and more broadly inequality Cardaci and Saraceno (2015); Dosi et al. (2016); Russo et al. (2016). The paper further develops the work by Ciarli et al. (2010).[3] The model in this paper differs from that of Ciarli et al. (2010) and Lorentz et al. (2016) substantially: we introduce multiple consumer good sectors, industrial dynamics, the financial connections linking households savings to investment, and the focus on medium term growth rather then on the conditions for take-off in the long term.

The rest of the paper is structured in the following way. Section 2 describes the aspects of the model most relevant to the three dimensions of the growth regimes: the wage-labour nexus, the forms of consumption and the forms of competition. The remaining parts of the model are pre-

[1] See for example Leijonhufvud (2006); Colander et al. (2008); LeBaron and Tesfatsion (2008); Buchanan (2009); Farmer and Foley (2009); Delli Gatti et al. (2010); Fagiolo and Roventini (2012); Dosi et al. (2013); Lengnick (2013); Assenza et al. (2015); Dosi et al. (2015); Lorentz (2015); Caiani et al. (2016). See also the recent review in Fagiolo and Roventini (2017), and other papers in this issue.

[2] (Nelson and Winter, 1982; Silverberg and Verspagen, 2005; Cimoli, 1988; Metcalfe et al., 2006; Dosi et al., 1994)

[3] See Lorentz et al. (2016), and Ciarli and Valente (2016) for earlier extensions.

sented in appendix A. Section 3 discusses a number of results: the model properties and validation, the comparison between the two growth regimes, and an assessment of the main institutional and structural aspects that differentiate the regimes. Section 4 concludes summarising the core results and discussing policy implications.

2 The Model

The model provides micro foundations for a number of related structural changes: firm organisation, structure of earnings, sector shares, product technology, process technology, consumer classes, consumption shares, and consumer preferences. The model reflects the principles of cumulative causation driving economic growth in the lines of Kaldor (1972): the expansion of effective demand (final demand and induced investments) is the key factor of economic growth, mediated by changes in technology and other aspects of structural change. We model four sectors: producers of consumer goods (in turn divided into 10 sectors), producers of capital goods, a financial sector, and households. The interplay between demand and supply does not lead to market clearing (Colander et al., 2008; Dosi et al., 2010). In the final good sectors supply is constrained by firms' production capacity (time to build capital goods) and labour capacity (hiring). The expansion of all markets is primarily demand-driven, but the model is circular: demand depends on households' available income and preferences, which change with firms' organisation in all sectors. A system of stocks and backlogs operates as a buffering mechanism coping with short term differences between supply and demand. Figure 1 plots the real and financial flows between the four sectors.

[FIGURE 1 HERE]

The household sector is populated by workers/consumers. These are divided in different income classes, each with distinct earnings, savings, rents, preferences, and consumption shares. The income of each class reflects the hierarchical organisation of labour within firms in both the final and capital good sectors: firms are formed by different layers of workers and executives and workers/executives in the different layers receive a different compensation. Formally, we refer to classes of households/workers with the index $i \in \{0, 1, \ldots, \Lambda(t)\}$. A household is assigned to a specific class on the basis of the hierarchical position occupied as worker. $\Lambda(t)$ corresponds to the highest tier in the largest firm in the economy, determined endogenously on the basis of the number of its employees. We assume that the labour market is perfectly elastic, thus removing any population growth constraint. We compute employment using the endogenous vacancy ratio (Beveridge curve) and the minimum wage via a wage curve.

Firms producing consumer goods populate one of the N final good sectors indexed as $n \in [1;N]$, each serving one of the N consumer's need. The output shares of the final good sectors therefore depends on the structure of households' expenditures. Each firm active in the n^{th} sector is indexed with an index $f \in \{1, \ldots, F(t)\}$. The f^{th} firm of the n^{th} final good sector is referred to with the indices (n, f). Industrial dynamics (entry and exit of firms) determines the number of firms $F(t)$ in each consumer good sector. A firm competes with other firms in the same consumer good sector over the quality ($q_{f,n}$) and the price ($p_{f,n}$) of the produced good. Goods' quality depends on firms' investment in product innovation. The price depends on an endogenously determined mark-up and on the productivity of the capital stock available, which determines the number of employees required to produce a given level of output. A firm's sales depend on the consumption shares across the N sectors of the household in the different classes and on their relative price and quality with respect to competitors. In order to produce, a firm f builds and adapts its production capacity to meet expected demand, inducing investments in capital goods which are supplied by firms in the capital good sector.

Firms in the capital good sector produce capital goods with a given level of embodied productivity. The embodied productivity improves as a result of firm innovation. For simplicity, we assume that all capital goods can be used in any consumer good sector. Capital good producers' sales correspond to the investment of firms in the consumer good sectors. Each firm in the capital good sector is indexed with an index $g \in \{1, \ldots, G(t)\}$. For simplicity, we assume no industrial dynamics in the capital good sector, i.e. there is a constant set of capital good producers.

In all sectors firms labour is organised in hierarchical tiers Simon (1957); Lydall (1959); Rosen (1982); Caliendo et al. (2015). As we move up the tiers the number of employees reduces, following a pyramidal structure, and the compensations increases exponentially. Based on recent literature on firm organisation, we assume that workers in one layer have similar occupations, earn a similar wage (the same in our model). The structure of the layers is based on recent empirical evidence across a number of countries Caliendo et al. (2015); Tåg (2013): average wage increase with firm size and tiers, tiers are added or remove in consecutive order, and the addition is triggered by reaching a given size. With respect to the empirical evidence we add one assumption that is crucial to make the connection with the demand side: as noted above, workers in a given tier are homogeneous not only in terms of occupation and compensation, but also in term of income class and therefore consumption shares and preference. This channel between occupation and consumption has received some attention (Mazzolari and Ragusa, 2013) and would definitely benefit from further research.

The financial sector is a centralised institution mediating between households, supplying liquidity through their savings, and firms in need of liquidity to fund their investments in new capital goods or to cover losses. In return, the financial sector collects profits from firms and redistributes them to households in the form of dividends. From the household's perspective, savings are used to buy financial assets issued by the financial sector, which grant the right to a share of future firms' profits. Hence, the share of the total number of financial assets owned by a households' class, determines the share of profits distributed to that class by firms in the form of dividends. The number and price of financial assets owned by a class depends on the cumulated level of past savings. The total value of the financial sector is given by the liquidity collected through savings and not (yet) lent to firms, and the debt cumulated by active firms in order to purchase capital goods or to cover losses. This value, divided by the total number of financial assets issued in the past, determines the current price of financial assets.

The model makes a number of simplifying assumptions. We abstract from redistributive or any other fiscal policy, and focus on the structural determinants of inequality. We focus only on incremental innovations, which in the medium run are more relevant to growth than radical innovations Garcia-Macia et al. (2015). For simplicity we do not consider the role of skills, and how they might be related to the hierarchical tiers and wages. We also simplify the labour market, by assuming an infinite supply of labour and modelling unemployment at the macro level. For simplicity we also do not consider dimensions that are related to the growth regimes such as the substantial differences in the international division of labour, macroeconomic policies, financial markets, and trade. All these limitations are great opportunities for future work.

We describe how we model each of the three dimensions of the growth regimes in Sections 2.1 (wage-labour nexus), 2.2 (norms of consumption), and 2.3 (norms of competition). The remaining components of the model, indirectly related to the regimes, are presented in Appendix A.

2.1 The Wage-Labour Nexus

In our model we distinguish three main aspects of the wage labour nexus: the wage differences between occupations along a firm hierarchy, i.e. the compensations of workers and different levels of executives – including bonuses; the distribution of profits as dividends on the financial market resulting from the functional distribution of earning within the firms and the saving behaviour of households; and the elasticity of the minimum wage with respect to changes in productivity and prices, shaping the distribution of productivity gains between wages and profits, and workers' purchasing power.

2.1.1 The Wage Structure

Each worker/consumer in class i has a disposable income $D_i(t)$ composed of wages $W_i(t)$, bonuses (from profits) $\Psi_i(t)$, and the dividends on firms' profits $E_i(t)$:

$$D_i(t) = W_i(t) + \Psi i(t) + E_i(t) \ , \forall i \in \{0;1;2;...;\Lambda(t)\} \tag{1}$$

The total wage of a class i is the sum of the wages paid by all firms, in the consumer good sectors and the capital good sector, to the employees in the corresponding organisational tier (by assumption each class corresponds to a tier of workers/executives):

$$W_i(t) = \sum_{n=1}^{N}\sum_{f=1}^{F(t)} w_{i,n,f}(t) L_{i,n,f}(t) + \sum_{g=1}^{G(t)} w_{i,g}(t) L_{i,g}(t) \tag{2}$$

Where $w_{i,n,f}(t)$ is the wage paid to workers in the i's tier by firm f in consumer good sector n at time t; $L_{i,n,f}(t)$ the amount of labour employed by firm f in tier i at time t; $w_{i,g}(t)$ the wage rate paid to workers in the i's tier by firm g in the capital good sector at time t; $L_{i,g}(t)$ the amount of labour employed by firm g in tier i at time t.

$L_{i,n,f}(t)$, the total amount of workers of a tier i employed by firm f in a final good sector n at time t is a function of the firm's planned level of output $Q^d_{n,f}(t)$. Given $Q^d_{n,f}(t)$ firms hire a number of shop floor workers $L_{1f}(t)$ that depends on productivity $A_{n,f}(t-1)$ and on a share υ of extra labour capacity to face unexpected increases in final demand:

$$L_{1,n,f}(t) = \varepsilon L_{1,n,f}(t-1) + (1-\varepsilon)\left[(1+\upsilon)\frac{1}{A_{n,f}(t-1)} min\{Q^d_{n,f}(t); \bar{B}K_{n,f}(t-1)\}\right] \tag{3}$$

where ε is a measure of labour market rigidities allowing firms to reach the desired level of workers only asymptotically over time and $\frac{1}{\bar{B}}$ is a constant capital stock intensity. ε is set to a value which generates unfilled vacancies corresponding to empirical evidence.

Similarly, the number of workers employed by firm g in tier i at time t in the capital good sector is a function of the planned output ($K^d_g(t)$) and of a share υ_g of extra labour capacity:

$$L_{1,g}(t) = (1+\upsilon_g) K^d_g(t) \tag{4}$$

Firms in all sectors also hire 'executives'. For every ν shop-floor workers the firm hires one executive at the second tier. For every ν second tier executives one third level executives is hired, and so on. Following Simon (1957), the number of workers in each tier i, for any firm $k \in \{f, g\}$, given $L_{1,f}(t)$ is:[4]

$$\begin{aligned} L_{2,k}(t) &= \nu^{-1} L_{1,k}(t) \\ &\vdots \\ L_{i,k}(t) &= \nu^{1-i} L_{1,k}(t) \\ &\vdots \\ L_{\Lambda_k(t),k}(t) &= \nu^{1-\Lambda_k(t)} L_{1,k}(t) \end{aligned} \tag{5}$$

where $\Lambda_{k(t)}$ is the total number of tiers required to manage firm k at time t.[5] We assume a fully elastic labour supply and derive unemployment and minimum wage in Section 2.1.3.

[4]The index for sector n is suppressed because we represent both final good sectors and the capital good sector.

[5]Caiani et al. (2016) propose an interesting simplified static version of the firm hierarchical structure, introducing heterogeneous wages within each tier. For simplicity in our model we assume that all workers in a given level earn the same wage.

The wage paid to the workers reflects the hierarchical structure of the labour force within the firm. The wage of the shop-floor worker $w_{1,k}(t)$ is an ω multiplier of the minimum wage $w_{min}(t-1)$. The wage of the immediate next tier of executives is a multiple b of $w_{1,k}(t)$; the wage of the immediate next tier of executives is a multiple b of $w_{2,k}(t)$; and so on. b determines the skewness in the wage distribution in line with Simon (1957) and Lydall (1959):

$$\begin{aligned} w_{1,k}(t) &= \omega * w_{min}(t-1) \\ &\vdots \\ w_{i,k}(t) &= b^{i-1} * \omega * w_{min}(t-1) \\ &\vdots \\ w_{\Lambda_k(t),k}(t) &= b^{\Lambda_k(t)-1} * \omega * w_{min}(t-1) \end{aligned} \tag{6}$$

2.1.2 Profit Shares and Financial Returns

The total amount of bonuses of a class $i > 1$ is the sum of the share of profits redistributed by firms to the corresponding tier:

$$\Psi_i(t) = \sum_{n=1}^{N} \sum_{f=1}^{F(t)} \psi_{i,n,f}(t) + \sum_{g=1}^{G}(t)\psi_{i,g}(t) \text{ , } \forall i \in \{2;...;\Lambda(t)\} \tag{7}$$

Where $\psi_{i,n,f}(t)$ and $\psi_{i,n,f}(t)$ are, respectively, the bonuses distributed by the firm f in the consumer sector n and by the firm g in the capital good sector to the tier of worker $i > 1$ at time t.

Firms in the final good and capital good sectors ($k \in \{f,g\}$) distribute a ratio π of their profits $\Pi_k(t)$ as wage premia to executives:[6]

$$\Psi_k(t) = \pi \Pi_k(t) \tag{8}$$

These are assumed to be distributed proportionally to executives' wage ($i \in \{2;..;\Lambda_k(t)\}$).[7] The share $\psi_{i,k}(t)$ of redistributed profits to the executives of each tier i is computed as

$$\psi_{i,k}(t) = \begin{cases} \frac{w_{i,k}(t-1)}{\sum_{i=2}^{\Lambda_k(t)} w_{i,k}(t-1)} \Psi_k(t) \\ \\ 0 \text{ ; for } i = 1 \end{cases} \tag{9}$$

The savings that are used by firms in the form of loans are repaid to consumers in the form of dividends. The returns on savings of a class i is a share of the sum of dividends distributed by all the firms ($R(t)$) proportional to the share of financial assets owned by the class in the previous period ($U_i(t-1)$):

$$E_i(t) = R(t) * \frac{U_i(t-1)}{\sum_{j=1}^{\Lambda(t)} U_j(t-1)} \text{ , } \forall i \in \{0;1;...;\Lambda(t)\} \tag{10}$$

where $R(t)$ corresponds to the sum of firms' profits in the final good sectors and the capital good sector net of the wage bonuses and the R&D expenses. The saving behaviour of each consumer class is formally described in Section A.2.1.

[6] The index for sector n is suppressed because we represent both final good sectors and the capital good sector.

[7] The aim of this paper is not to explain the rise in executives' compensation. However, the proposed wage and bonus structure conforms the model to a stylised representation of the evidence on firms' compensation structure, and on the recent increase in executive's pay. Some evidence suggest that the rise in CEO pay is mainly linked to stock options (Frydman and Jenter, 2010). Other evidence suggests that the main component of the increase in income of the top 1% are salaries and bonuses (Atkinson et al., 2011). The crucial aspect tat we highlight here is the exponential increase in wages with an organisation's tiers, and the use of profits to amplify this difference. Dividends, which may also be though as stock options, also augment the income of the wealthiest classes relative to the less wealthy, as discussed below. Whether they come from savings or from firm compensation is not crucial in this model.

As a consequence of the saving behaviour, the wealthier is a class, the higher the proportion of income saved and used to purchase financial assets. *Cœteris paribus*, the share of per capita income from dividends increases by income class, proportional to wage differences.

2.1.3 Minimum Wage Dynamics

The third component of the wage-labour nexus, the minimum wage, is a function of unemployment, average productivity, and inflation. We peg changes in the minimum wage to changes in productivity and prices. The larger the elasticity of the minimum wage to productivity and inflation, the higher the distribution of value to workers, and the higher the purchasing power.

The minimum wage $w_m(t)$ is the lowest wage that firms can offer to shop-floor workers. Following evidence on the wage curve (Blanchflower and Oswald, 2006; Nijkamp and Poot, 2005) the minimum wage changes proportionally to the changes in the rate of unemployment $u(t)$, for a given level of productivity and price index. Following empirical evidence on wage negotiations (Boeri, 2012) we assume that the wage curve shifts upwards for given changes in consumer prices ($\triangle P(t)$)[8] or productivity ($\triangle A(t)$).[9]

We assume that negotiations to increase the minimum wage take place whenever consumer prices ($P(t)$) or productivity ($A(t)$) increase by at least, respectively, a factor Ω^P or Ω^A since the last negotiations ($t = \tau_w$). Hence, for a stable unemployment rate, the minimum wages grows proportionally to labour productivity and/or prices. More formally:

$$w_m(t) = w_m(t-1) + \varepsilon_U[u(t-1) - u(t)] + w_m(\tau_w)[\varepsilon_P(t)\triangle P(t) + \varepsilon_A(t)\triangle A(t)] \tag{11}$$

where ε_U is the elasticity with respect to changes in the rate of unemployment, $\varepsilon_P(t)$ and $\varepsilon_A(t)$ are, respectively, the elasticities with respect to changes in the consumer price and labour productivity. $\varepsilon_P(t)$ and $\varepsilon_A(t)$ vary depending on the growth of $P(t)$ and $A(t)$ as follows:

$$\begin{aligned}
\varepsilon_P(t) &= \begin{cases} 0 \text{ if } \triangle P(t) \leq \Omega^P \triangle P(\tau_w) \\ \varepsilon^P \text{ if } \triangle P(t) > \Omega^P \triangle P(\tau_w) \text{ and } \triangle A(t) \leq \Omega^A \triangle A(\tau_w) \\ 0.5 * \varepsilon^P \text{ if } \triangle P(t) > \Omega^P \triangle P(\tau_w) \text{ and } \triangle A(t) > \Omega^A \triangle A(\tau_w) \end{cases} \\
\varepsilon_A(t) &= \begin{cases} 0 \text{ if } \triangle A(t) \leq \Omega^A \triangle A(\tau_w) \\ \varepsilon^A \text{ if } \triangle A(t) > \Omega^A \triangle A(\tau_w) \text{ and } \triangle P(t) \leq \Omega^P \triangle P(\tau_w) \\ 0.5 * \varepsilon^A \text{ if } \triangle A(t) > \Omega^A \triangle A(\tau_w) \text{ and } \triangle P(t) > \Omega^P \triangle P(\tau_w) \end{cases}
\end{aligned} \tag{12}$$

If the increase in either $P(t)$ or $A(t)$ from one time period to the next is small, the minimum wage depends only on the level of unemployment. If either $P(t)$ or $A(t)$ increases by Ω^P or Ω^A since $t = \tau_w$, the minimum wage increases by an amount proportional to the increase in $P(t)$ or

[8] $P(t)$ is the weighted average of the final good firms' prices:

$$P(t) = \sum_{n=1}^{N} \sum_{f=1}^{F(t)} \frac{Y_f(t)}{\sum_{n=1}^{N} \sum_{f=1}^{F(t)} Y_f(t)} p_f(t-1)$$

[9] Aggregate productivity is the ratio between aggregate output and employment:

$$A(t) = \sum_{n=1}^{N} \sum_{f=1}^{F(t)} \frac{Y_{n,f}(t)}{\sum_{n=1}^{N} \sum_{f=1}^{F(t)} Y_{n,f}(t)} A_{n,f}(t-1)$$

$A(t)$, irrespective of unemployment. If both $P(t)$ and $A(t)$ increase by Ω^P or Ω^A since $t = \tau_w$, the minimum wage increases by an amount proportional to half the increase in $P(t)$ and half the increase in $A(t)$.

We estimate the level of unemployment ($u(t)$) using the well established Beveridge Curve, as explained in Appendix A.1.1.

How do we distinguish the two growth regimes with respect to the wage-labour nexus? *regime one* is characterised by lower differences in compensation across organisational tiers (lower b), a lower share of profits redistributed to executives (lower π) and a higher elasticity of the minimum wage to an increase in productivity and/or prices (higher $\varepsilon_P(t)$ and $\varepsilon_A(t)$). The other way round for *regime two*. These differences are summarised in Table 2. Note that in our model there is no Government, and therefore no redistribution of wealth between classes. In other words, the distribution of income in our model is assumed to depend only on the economic structure (which also depends on institutions).

[TABLE 2 HERE]

2.2 Norms of Consumption

We distinguish two aspects of consumer behaviour, which are endogenous to the wage-labour nexus: the pace at which as new and wealthier income classes emerge they change the distribution of their purchases from basic to luxury goods – across the N sectors; and the pace at which, as new and wealthier income classes emerge, their preference – with respect to price and quality – differ with respect to the immediately less wealthy class.

2.2.1 Expenditure Shares

The disposable income $D_i(t)$ (Eq 1) is spent on goods from all N sectors or saved in the central financial institution. In line with the evidence on consumption smoothing we assume that the level of expenditure is a convex combination of the non-saved share of the current level of income $D_i(t)$ and of the past level of expenditure ($X_i(t-1)$):

$$X_i(t) = \gamma X_i(t-1) + (1-\gamma)(1-s_i)D_i(t) \tag{13}$$

where $\gamma \in [0;1]$ is the rate of consumption smoothing and $s_i \in [0;1]$ is the given class's' i saving rate.[10].

Consumers from a class i allocate a share $c_{n,i}$ of expenditures to each final good sector. The sector consumption level for each consumer class is then computed as:

$$C_{i,n}(t) = c_{i,n}X_i(t) \text{ with } c_{i,n} \in [0;1] \text{ ; } \sum_{n=1}^{N} c_{i,n} = 1 \ \forall i \tag{14}$$

Following the literature on the distribution of expenditures shares and the evidence on Engel curves (Barigozzi and Moneta, 2016; Moneta and Chai, 2013), we assume that expenditure shares ($c_{n,i}$) vary with income. Less wealthy classes tend to consume more basic goods, and more wealthy classes tend to consume more luxury goods. Let us consider the asymptotic distribution of consumption shares for the wealthiest possible class: $\bar{c}_n$. As we move from the first class towards the asymptotic class, we model the change in expenditure shares logistically:

$$c_{i,n} = c_{i-1,n}\left(1 - \eta\left(c_{i-1,n} - \bar{c}_n\right)\right) \tag{15}$$

where η is the speed of convergence to $\bar{c}_n$, i.e. the pace at which wealthier classes change consumption shares towards more luxury goods.[11]

[10] The actual savings can differ from the desired share in case of sudden changes in income: accumulated when income increases and used when income reduces.

[11] See for example Verspagen (1993) and Lorentz (2015).

2.2.2 Consumer Preferences

We model bounded rational consumption behaviour inspired by the literature on experimental psychology (Gigerenzer, 1997; Gigerenzer and Selten, eds, 2001), and implemented in Valente (2012).

Consumers do not have full information on the quality and price of goods.[12] They make a selection on goods based on a *perceived* value of quality and price drawn from a normally distributed random function centred on the true values ad with variance ι.

For each sector n consumers first select a subset of firms with probability proportional to their visibility $\hat{\upsilon}_f(t)$.[13] Next, consumers rank the available alternatives according to the perceived level of price and quality. Consumers then select a subset of goods with a quality above, and a price below, a selectivity threshold: respectively $\lambda_{q,i}$ and $\lambda_{p,i}$. The selectivity thresholds defines the maximum distance between the price and the quality of a good produced by firm $\{f,n\}$ and the minimum price and maximum quality available in the same sector and period. The preferences are therefore defined in terms of the selectivity with respect to the best option. We assume that higher income classes are less selective with respect to deviations from the lowest prices (they are ready to buy more expensive goods), and that they are more selective with respect to deviations from the highest quality (they are not ready to buy goods of lower quality). Conversely, we assume that lower income classes are more selective with respect to price and less selective with respect to quality. More formally, the selectivity parameter with respect to price $\lambda_{p,i}$ decreases with income classes, and the selective parameter with respect to quality $\lambda_{q,i}$ increases with income classes:

$$\lambda_{p,i} = (1-\eta_\lambda)\lambda_{p,i-1} + \eta_\lambda \lambda_{min} \tag{16}$$

$$\lambda_{q,i} = (1-\eta_\lambda)\lambda_{q,i-1} + \eta_\lambda \lambda_{max} \tag{17}$$

where λ_{min} and λ_{max} are the asymptotic values of selectivity, as well as the selectivity of the least wealthy class ($\lambda_{min} = \lambda_{q,1}$, $\lambda_{max} = \lambda_{p,1}$); η_λ is the speed at which preferences change with income classes. The smaller is the difference between λ_{min} and λ_{max}, and the lower η_λ, the smaller is the differences between classes in terms of preferences. For a large η_λ households have a large ambition to keep up with the Jones.

How do we distinguish the two growth regimes with respect to the norms of consumption? *Regime one* is characterised by a relatively lower consumption of luxury goods *cæteris paribus*, i.e. irrespective of classes' income. In other words, firms tend to concentrate on fewer sector, and the demand for niche goods is relatively low. Accordingly, *regime one* is also characterised by a lower rate of change of consumption preferences as new classes emerge and consumers tend to be more selective on price, on average, than on quality. These differences are summarised in Table 3.

[TABLE 3 HERE]

2.3 Competition and Market Concentration

We consider two aspects of the norms of competition distinguishing economic regimes. The first is exogenously defined as barriers to the entry of new firms. The second is endogenous to consumer behaviour: firms selection.

2.3.1 Industrial Dynamics

The number of firms $F(t)$ active in each sector at time t results from the interplay between a stochastic entry and an endogenous exit mechanism based on firms' performance.

[12] See for example Celsi and Olson (1988); Hoch and Ha (1986); Rao and Monroe (1989); Zeithaml (1988) and Rotemberg (2008).

[13] See equation 41.

Firms in the final good sectors exit when their estimated return on capital falls below a given threshold ξ. A firm's f return on capital is computed as the ratio between a firm' profits' moving average ($\hat{\Pi}_f(t)$)[14] and the value of its assets ($\hat{K}_f(t)$):

$$RoK_f(t) = \frac{\hat{\Pi}_f(t)}{\hat{K}_f(t)} \tag{18}$$

The value of the assets used to compute a firm's $RoK_f(t)$ consists of the cumulated loans received from the financial sector since birth, either to purchase new capital goods $J_f^k(j)$ or to cover losses ($J_f^l(j)$):

$$\hat{K}_f(t) = \sum_{j=t_f}^{t} [J_f^k(j) + J_f^l(j)] \tag{19}$$

where j is the time period the loan was received. The model assumes that the money borrowed from the financial sector are never repaid because households, through the intermediation of the financial sector, effectively become shareholders of the firms. Firm's profits not invested in R&D or used to pay bonuses are returned to the financial sector to be distributed to consumers as dividends.

At each time step a new firm enters in each final good sector with a probability ϑ. New firms are assumed to produce a good with the same quality of the firm with the best quality in the sector. They are given a loan equal to 10% of the sum of the net worth of all firms in the sector to purchase a capital good of the latest vintage. Each firm is assumed to have a level of visibility which conditions the probability of being selected by consumers. We assume that new firms have low visibility (0.1),[15] and therefore initially serve a niche demand.

2.3.2 Firm's Selection: Price and Quality

Firms compete on price and quality. Which strategy is most effective depends on the composition of the demand, which in our model depends on the distribution of earnings, bonuses, and dividends (the wage-labour nexus), and on the changes in consumption shares and preferences (norms of consumption).

Firms in the final good sector charge a mark-up $m_f(t)$ on unitary production costs:

$$p_f(t) = (1 + m_f(t)) \frac{\omega * w_{min}(t-1) \sum_{i=1}^{\Lambda_f(t)} b^{i-1} \nu^{1-i}}{A_f(t-1)} \tag{20}$$

As firms grow they invest in new capital vintages of higher productivity (on average),[16] which reduces the labour cost, and hire new labour, which increases the labour costs due to the increase in the number and levels of executives.[17]

The mark-up increases when demand exceeds a firm's production capacity and reduces when inventories exceed its desired ratio. Formally, the mark-up mechanisms can be described as follows:

$$m_f(t) = \begin{cases} \bar{m} + \mu \log\left(1 + \frac{Y_f^e(t) + I_f(t)}{Q_f(t)}\right) \text{ ; for } I_f(t) < 0 \mid Y_f^e(t) > 0 \mid Q_f(t) > 0 \\ \\ \bar{m} \text{ ; for } I_f(t) \geq 0 \mid Y_f^e(t) > 0 \mid Q_f(t) > 0 \end{cases} \tag{21}$$

where $\bar{m}$ is a minimum mark-up; μ is a coefficient of variation that determines how much mark-up can adjust in the short period; $Y_f^e(t)$ represents the expected sales of the firm; $Q_f(t)$ its current production level; and $I_f(t)$ its current inventories.

[14] $\hat{\Pi}_f(t) = \Pi_f(\hat{t} - 1)a + (1-a)\Pi_f(t)$.

[15] See equation 41.

[16] See Appendix A.3.3.

[17] Labour costs are computed are computed only with respect to the shop-floor workers.

Changes in a firm's good quality ($q_{n,f}(t)$) result from product innovation. In each period final good firms spend a fixed share ρ of the moving average of expected sales in R&D: $RD_f(t) = \rho \bar{Y}^e_f(t)$. As a result a firm has a proportional number of innovation trials, which increases at a decreasing rate to acknowledge for both Schumpeter Mark I and Schumpeter Mark II innovative behaviour (Malerba and Orsenigo, 1995) – *cæteris paribus* a new firm has a higher probability of benefiting from an innovation, but larger firms innovate more: $RT_f(t) = log(1 + RD_f(t))$.

The probability of success for a given trial is assumed to be fixed, χ, and uniformly distributed across trials/firms. For a successful trial[18], the quality of the new product is normally distributed:

$$q^e_f(t) \sim N(q_f(t-1); q_f(t-1) * \sigma^q) \tag{22}$$

where σ^q is fixed. The new product replaces the current one if its quality is higher:

$$q_f(t) = max\{q_f(t-1); q^e_f(t)\} \tag{23}$$

How do we distinguish the two growth regimes with respect to the norms of competition? On the one hand *regime one* is characterised by a relatively higher probability of entry, therefore more opportunities and lower barriers, *cæteris paribus*. On the other hand, in *regime one* the least wealthy consumers selectivity with respect to price is lower. That is, for each sector, the most selective consumers with respect to price (the least wealthy class) purchases goods from a relatively larger set of firms with different prices; and the difference with respect the most wealthy class (with a very low selectivity with respect to price) is smaller. These differences are summarised in Table 4.

[TABLE 4 HERE]

3 Simulation Results

We investigate computationally the results of the model with respect to aggregate output, income distribution, and their relation for two growth regimes that differ with respect to labour relations, competition, and consumption. For each parametrisation we run the model several times and analyse the resulting average and across runs standard deviation.[19]

Before studying the two regimes, we discuss the properties of the model and its robustness with respect to several stylised facts. We employ a "benchmark" parametrisation of the model relying on empirically calibrated values for all parameters for which we could find empirical evidence.[20] Table 1 in Appendix C provides full detail of the parameters' initialisation. The "benchmark" parameter values are also the average between the values in the two regimes. The model was implemented and studied in the open source software Laboratory for Simulation Development.

3.1 Model Properties and Empirical Validation

Our model is equipped to study the evolution of an economy through different phases of economic development, including long term stagnation and economic take off.[21] Because in this paper we are interested in studying regimes characterising modern capitalistic systems, we run the model until a modern economy emerges, after take off – an emergent property of the model related to

[18]If successful, no more trials are used in that period, and the firm must wait Ξ periods before the next investment in R&D.

[19]100 runs when investigating the model properties and empirical validation and 25 runs when investigating the regimes.

[20]For some of the behavioural parameters unfortunately we could not find any evidence and we had to rely on qualitative evidence.

[21]See for example the literature on unified growth theory (Galor, 2010; Desmet and Parente, 2012).

several structural changes (Ciarli et al., 2010, 2012). As part of the economy take-off firms grow in size and adopt complex organisational structures; new consumer classes emerge, that purchase relatively larger ratios of luxury goods; lower income classes consumption basket changes as an outcome of imitation; productivity growth accompanies population growth; sectors become more concentrated; and inequality increases.

We then initialise the model from this stage, using parameters values observed in modern economies (Table 1). We let the model run for 250 time periods to eliminate from the analysis the noise of the initial adjustments, and we analyse the model for the following 1000 time periods.[22] The level of detail of the agents' micro behaviour in our model suggests that each time period is equivalent to approximately a fortnight.

The model exhibits endogenous exponential growth of output, accompanied by growth of consumption, investment (Figure 2a) and aggregate labour productivity (Figure 2b). The main aggregate drivers of the endogenous growth are demand and productivity enhancing technological change (more on this in the next Section).

[FIGURE 2 HERE]

Technological change in the capital good sector increases the productivity of capital vintages purchased by incumbents and new firms, which has two main effects: replacing labour, which reduces demand in the short term; reducing relative prices and increasing relative wages, which increases demand and output in the medium term.

The model reproduces a large number of empirical regularities at the macro, meso and microeconomic level. These are summarised in Table 5 and discussed in Appendix F.

[TABLE 5 HERE]

3.2 Growth Regimes, Income Distribution and Economic Growth

Inspired by the analysis of the regulation theory (Coriat and Dosi, 2000) we distinguish two different regimes with respect to the following three dimensions:[23] the wage labour nexus, competition and market concentration, and norms of consumption.

With respect to the first dimension (wage labour nexus), the two regimes differ in terms of the wage variation along the firm hierarchical organisation (b in equation 6), the size of bonuses and wage premia distributed to managers according to their hierarchical position (π in equation 8), and the purchasing power of the least wealthy class, as a result of changes in the minimum wage with respect to productivity (ε^A in equation 11) and prices (ε^P in equation 11).

With respect to the second dimension, the two regimes differ in terms of entry barriers to new firms in all sectors (ϑ in Section 2.3.1) and the selectivity of consumers of the first class (least wealthy) with respect to price ($\lambda_{p,1}$ in equation 17) and quality ($\lambda_{q,1}$ in equation 17).

With respect to the third dimension, the two regimes differ in terms of the speed at which consumption shares change between income classes (η in equation 15) and in terms of weather middle income class consumer preferences are closer to the wealthiest consumers – more (less) selective on quality (price), or to the least wealthy consumers (η_λ in equation 17) – less (more) selective on quality (price).

[22] The adjustment is due to small differences in consumer preferences, productivity, and the adjustments of the labour market, introduced to reflect parameter values that are closer to those observed in a modern system with respect to those observed in a pre take-off economy: the first class of wage earners are less selective with respect to price; innovation efforts are more successful, and wages follow more closely changes in prices and in productivity. These changes cause an initial minor downturn in the economy as prices, firms' market shares and concentration (exit and entry) adjust to the new system.

[23] The regulation theory discusses two more relevant dimensions: finance and the role of the state. Both are crucial, but for the sake of clarity we leave the analysis of these other dimensions to further research.

Table 6 reports these dimensions of the two different regimes, with reference to the model's parameters.

We define *Regime one* in resemblance to what the regulation theory qualifies as *Fordist* with relatively lower differences in wages and profit shares, and relatively higher wage elasticity with respect to productivity and inflation; higher entry and competition; and relatively less differentiated consumption patterns, but relatively more similar preferences between the middle and the top classes. We define *Regime two* in resemblance to what the regulation theory qualifies as *Post-Fordist*: larger differences in wages, higher profit shares, and lower minimum wage elasticity with respect to productivity and inflation; lower entry and competition; and relatively more differentiated consumption patterns, but relatively more similar preferences between the low and the middle classes. Table 6 reports the initial conditions of the two different regimes, with reference to the model's parameters.

[TABLE 6 HERE]

We employ the model to study how the two regimes differ in terms of output and income distribution, and to which extent the differences are related to different dimensions of structural change. Table 7 reports the mean values over 25 independent runs with different pseudo random seeds for each regime – and the t-statistics and p-values for the mean difference test between the two regimes, for a selected number of macroeconomic indices: output, income distribution, employment, productivity, and different indices for the structure of production, consumption, and earnings. Each value is the average over 2000 steps.

[TABLE 7 HERE]

The two regimes differ significantly with respect to output level, unemployment rate, and inequality (measured using the Atkinson index).[24] Regime one experiences higher output, lower inequality, and to some extent also lower unemployment.

To investigate the extent of the relation between economic growth and inequality we estimate the correlation between the Atkinson index and real output using a LAD estimator for the average values computed over each simulation run. Table 8 shows that, although in both regimes inequality is positively related to real output,[25] the relation is significantly stronger in regime two. In a regime with larger wage differences, lower distribution of productivity gains to wages, lower competition, and more skewed consumption patterns, productivity gains are more unevenly distributed among workers.

[TABLE 8 HERE]

3.2.1 Institutional Components of Income Distribution and Economic Growth

The differences in the distributive outcomes can be traced down to four related institutional components in our model. First, higher inequality in regime two is a direct consequence of the difference in the wage multiplier between tiers of workers (b), which is lower in regime one (Table 6). The wage-income ratio[26] measures the share of wage earnings in the households total income. For both regimes, wages correspond to the largest component of income (Table 7). As a consequence, the wage settings account for a large part of the income inequality differences among the two regimes.

The second component of the difference in inequality is the minimum wage. While regime two has a higher average level of household income, the minimum wage is significantly lower

[24]See equation 59 in appendix B.

[25]As noted, in our model we do not consider any redistributive mechanism. We study income distribution as an outcome of the structure of production and demand

[26]See equation B in appendix B.

(Table 7). The higher average household income in regime two is accompanied by a lower wage of the first tiers of workers, the least wealthy households.

The third component of the difference in inequality is due to dividends (the functional distribution of income). The share of dividends on total household income, as measured by the dividends-income ratio[27], in regime two is significantly higher than in regime one (Table 7). Moreover, firms in regime two make a significantly higher level of (total) profits than the firms in the regime one (Table 7). As the higher tiers of workers have a higher saving rate, the profits redistributed to the corresponding wealthier classes as dividends are also higher in regime two. However, the dominating weight of wages in total income limits the actual contribution of dividends to inequality.

Fourth, the differences in the industrial structure between regimes magnify the differences in the structure of earnings. As measured by the inverse Herfindhal index in sales,[28] the final good sector in regime one is significantly less concentrated than in regime two (Table 7). Market concentration tends to increase income inequality:[29] larger firms require more organisational tiers, and therefore higher wage differences between the bottom and the top tiers; they also make higher profits, redistributed through premia and dividends to the wealthiest income classes. The lower market concentration in regime one is driven by two distinct mechanisms. The first one is a direct consequence of the regimes setting: a higher probability of firm entry and less selective consumers in regime one, by assumption (Table 6), imply a higher degree of competition. The second and more interesting one is an emerging property of the model: the most concentrated sectors are those producing luxury goods, representing the main consumption shares of top income classes, whereas basic good sectors that represent the highest shares of consumption of the least wealthy classes (e.g. food, housing, and power) are significantly less concentrated (more on this below).

We study the relative influence of these four components by comparing the Atkinson index for different combinations of parameters ranging between the values of the two regimes, *cæteris paribus*.[30] Tables 10 to 11 report the results of t-test for mean values of the Atkinson index across 2000 simulation steps for 20 replications.

Table 9 reports the combined effect of the wage multiplier and the elasticity of the minimum wage to productivity and consumer price on inequality with respect to the benchmark case ($b = 1.6$, $\varepsilon^A = \varepsilon^P = 1$). Increasing the tier-multiplier for wages (increasing b) in our model significantly increases the wage inequality among workers, as expected. However, the elasticity of the minimum wage (ε^A and ε^P) alone does not have a significant effect on inequality, in our model, not even when combined with a higher wage multiplier.

[TABLE 9 HERE]

Table 10 reports the combined effect on inequality of the wage multiplier with the share of profits redistributed as premia, with respect to the benchmark case ($b = 1.6$ and $\pi = 0.15$). Both parameters affect mechanically the individual and functional income distribution: increasing the share of profits (higher π) redistributed as premia significantly increases the level of inequality, magnifying the effect that a higher wage multiplier has on inequality. Because the distribution of premia is proportional to wage in our model, higher wage differences imply higher premia differences, reinforcing income inequality.

[TABLE 10 HERE]

We next focus on the effect of the parameters defining the nature of competition, and therefore concentration: the joint effect of consumer's selectivity – which tends to reduce the number of

[27] See equation B in appendix B.

[28] See equation 62 in appendix

[29] See also Ciarli et al. (2010) and Ciarli and Valente (2016).

[30] Where by *cæteris paribus* we mean the benchmark configuration (Table 7).

firms fit to compete, and of the probability of firm entry, with respect to inequality. Table 11 shows the effect of competition on inequality with respect to the intermediate case ($\vartheta = 0.08, \lambda_{p,1} = 0.\bar{8}25, \lambda_{q,1} = 0.\bar{1}75$). *Cœteris paribus*, increased competition in all sectors (higher ϑ) reduces market concentration.[31] In turn, an equal reduction of market concentration in all sectors tends to decrease the relative size of firm: the same output is produced by a larger number of smaller firms. As a result, there are fewer managers with large salaries, lower profits distributed as dividends, as well as a lower savings and capital gains.

[TABLE 11 HERE]

Selection has the opposite effect. The increased concentration due to higher consumer selectivity (higher $\lambda_{p,1}$) reduces income inequality. This is due to two main emergent properties in our model.

First, the most concentrated sectors are those in which the least wealthy classes have the lowest consumption shares.[32] This in turn is due to two main features in our model. On the one hand, price strategy is more flexible than innovation strategy: firms can change their prices and follow consumer price preferences more quickly than innovate and improve the quality of their good. In other words, firms can more easily escape selective pressure from the large amount of consumers that prefer less expensive goods, but struggle to excel in quality and capture the demand of the consumers that prefer high quality goods. On the other hand, mass consumption exerts a strong pressure even on large firms, which in the short period will accumulate large backlogs – as they wait for the new capital goods – and deviate consumer demand towards competitors, even if their price is higher.[33] In other words, time-to-build capital creates more competition among consumer good firms.

Second, increased price selectivity induces small changes in employment shares out-migrating from sectors which constitute the highest shares of less wealthy consumers. Despite being the least concentrated, these are the sectors with the largest incumbents, cumulated revenues, and profits. The changes in employment shares then have the small but significant negative effect on inequality observed in table 11, despite the overall increase in concentration due to stronger market selection.

When we compare the relative effect of each parameter on income inequality with respect to the differences between the two regimes (Table 7), it turns out that the first component (inflated by the third component of dividends, which are proportional to wages) represents the lion's share. A larger distribution of bonuses increases the relevance of wage differences even further.

Market competition alone plays an ambiguous role, depending on whether it comes from lower barrier to entry (which reduces inequality) or weaker consumer selection (which in our model increases inequality).

Finally, changes in the minimum wage, alone, do not seem to play a significant role.

However, it is important to acknowledge that in a model with so many non linear relations, such as the one presented in this paper, the composite effect of several parameters (the two regimes) is not equal to the sum of the effects of the single parameters.

The higher inequality in regime two is accompanied by a significantly lower level of real output and labour productivity, and a significantly higher unemployment rate. Tables 10 to 11 report the results of t-test for mean values of the output across 2000 simulation steps for 20 replications for the parameters defining the two regimes.

Except for a few parametrisations, increasing the wage multiplier (higher b) significantly limits output growth (Table 12). Similarly, increasing the share of profits redistributed as premia (higher π) also has a negative effect on output. Both parameters seem to hinder growth as they increase inequality.

[31] See the effect of selectivity and entry probability on market concentration in the appendix table 20.

[32] Results not shown here are available from the authors.

[33] Note that firms with high backlogs in our more also have an incentive to increase the mark-up.

Third, reducing the elasticity of minimum wages to prices and productivity (lower ε^A and ε^P) has a negative effect on output only below a threshold, which in our model is 0.75 (Table 13). This negative effect is independent from changes in income distribution. This is a purely demand driven effect: increases in prices and productivity that are not reflected in an increase in the level of all wages tend to depress demand.

Fourth, the competition parameters also have a different effect on output with respect to income distribution (Table 14). On the one hand, alongside income inequality a higher probability of entry (higher ϑ) also significantly increases output. On the other hand, stronger market selection (higher $\lambda_{p,1}$), although it reduces inequality, does not have a significant impact on real output.

[TABLE 12 HERE]

[TABLE 13 HERE]

[TABLE 14 HERE]

Comparing the relative effect of each parameter on real output with respect to the overall difference between the two regimes (Table 7) we find that: wage differences can account for large differences in output, but not the overall difference that we observe between the two regimes. When combined with the share of profit redistributed as bonuses, the *cœteris paribus* differences in output are very similar to those observed between the two regimes.

The elasticity of the minimum age accounts for a small fraction of difference between regimes, even when combined with differences in the wage coefficient.

Entry barriers, *cœteris paribus*, also account for a large share of the differences between the regimes, especially in the case of lower barriers, but selection almost leave output unchanged

3.2.2 Structural Change, Income Distribution and Economic Growth

As we argue in this section, some of the differences in output and income distribution resulting from the two different institutional settings are rooted in the structure of production and consumption.

First, in our model an increase in demand and output can be satisfied by new entrants or by growing incumbents. As firms grow, higher hierarchical tiers are required. These higher tiers of workers correspond to higher income classes. The sheer emergence of large firms then explain part of the raising inequality. As discussed, the modes of competition that distinguish our two regimes fine tune the extent to which output growth is concentrated.

Whereas supply side concentration has a direct impact on income distribution, concentration of demand also plays a significant role in explaining the two regimes.

As noted, the aggregate level of concentration hides significant differences between sectors. However, concentration is significantly negatively related to the expenditure shares of the least wealthy income classes: the higher the demand from low income classes, the lower the concentration. Consumption shares of income classes above the first one, though, change between the two regimes, as the rate of change of expenditure shares increase from regime one to regime two. As the demand shifts more rapidly to luxury goods, more employment should concentrate in sectors that tend to be more concentrated, increasing the overall concentration of production. This effect may be counterbalanced by changes of preferences that reduce price selectivity and increase quality selectivity, which on average reduce the competitive pressure on firms.

Third, the structure of demand influences competition. Sectors serving high shares of the less wealthy consumers expenditures, experience a significantly higher demand, from consumers that are very selective with respect to price. Given the pyramidal structure of firms and society, these classes represent the large majority of consumers.[34] As a result, sectors representing high shares of the less wealthy consumers expenditures are significantly more competitive, and firms tend to charge a lower mark-up, than in less competitive sectors. Profits are also remarkably lower. Therefore, a faster increase in the expenditure shares of luxury goods, as in regime two, should imply higher inequality (and lower output growth).

We test how differences in the modes of consumption affect output, *cæteris paribus*. Whether a larger heterogeneity of expenditure shares (η) and preferences (η_λ) has a positive or negative effective on output and inequality. Table 15 reports the difference in output for different rates of change in expenditure shares (η) and consumer preferences (η_λ) ranging between the values of the two regimes, *cæteris paribus*. Table 15 also reports the results of t-test for mean values of output across 2000 simulation steps for 20 replications. Moving from lower to higher heterogeneity in expenditures shares or preferences, alone, has no significant effect on real output (although the direction of the change is as expected).

[TABLE 15 HERE]

We run the same analysis for inequality outcomes (Table 16), and also find no significant effect of the heterogeneity of consumption shares or consumer preferences.

[TABLE 16 HERE]

Results point to the fact that in our model the tier(firm)/class(consumer) structure is more relevant than the expenditure shares. This is relatively straightforward to explain. As noted, the first two classes of consumers with respect to income represent, respectively, 88% of total population and 72% of total consumption.[35] η and η_λ modify the expenditure shares and preferences of income classes above the first one, as we move towards wealthier classes. The contribution of these classes in shaping the level of firms employment and profits is notably limited.

Finally, the relation between output and productivity points to another fundamental mechanism in the model that links the structure of production and demand to aggregate output. Table 17 shows the correlation between labour productivity and real output estimated using a LAD estimator for the average values across the 2000 periods. While in both cases labour productivity is positively and significantly correlated to output, the relation is stronger for regime one than for regime two.

[TABLE 17 HERE]

However, as Table 7 suggests, higher output and productivity in regime one are also due to a larger demand. With lower output, regime two experiences a small but significantly higher capital-labour ratio. This implies that for the same level of output regime two may show a larger labour productivity, related to the higher concentration of production. However, the uneven distribution of productivity gains, due to institutional and structural differences, leads to an overall significantly lower output and productivity.

4 Discussion and Concluding Remarks

In the last four decades most OECD countries have experienced a sharp increase in income inequality, mainly due to the raise in top incomes. During the same period, economies have also reduced income growth, and some of them have entered stagnation following the 2008 crisis. The

[34] In the benchmark configuration the first class is populated by approximately 66% of the total population and the second class by approximately 22% of the total population. Their share of total consumption is, respectively, approximately 47% and 25%.

[35] In the benchmark scenario.

observed changes in income distribution and growth are related to a number of changes in the structure of the economy, such as decreasing labour shares, de-linked dynamics of productivity and wages, increased mechanisation, increased rents, changes in consumer preferences and shares of goods consumed, and increased concentration of production in fewer firms. These structural changes have been accompanied by institutional changes that have increased the within-firm differences in wages and the appropriation of innovation-induced rents.

In this paper we proposed a model to study the relation between income inequality and economic growth due to exogenous institutional features and endogenous structural features of the economy. We then studied the role of these features on the relation between income growth and distribution by comparing the results from two different growth regimes.

The two regimes differ with respect to (i) labour relations – differences in compensation within firms, profit shares, and the elasticity of wage with respect to productivity; (ii) norms of competition – entry barriers and market selection; and (iii) income related norms of consumption – consumption shares, and consumer preferences. Regime one (Fordist) was characterised by relatively more equal labour relations, more competition and lower selection, and smaller difference in consumption behaviour across consumer classes. Regime two (post-Fordist) was characterised as more unequal, with relatively more protection for incumbents and higher market selection, and larger differences in consumption behaviour across consumer classes.

We find that a Fordist regime (one) exhibits significantly lower inequality, higher output and lower unemployment than a Post-Fordist regime (two). We distinguish between institutional and structural determinants of these differences, although we also suggest that the two types of determinants are strongly related.

Institutional determinants are used to differentiate the two regimes with respect to labour relations, norms of competition, and norms of consumption. We find that, keeping all other features of the regimes fixed, wage differences play the most important role in increasing inequality and limiting output growth. The financial market magnifies the effect of wage differences by increasing the wealth of high wage earners with respect to low wage earners. Accruing to these differences and their negative effect on income distribution and output growth is also the share of profits distributed as bonuses. In our results, the role of the minimum wage, instead, is substantially weaker. A lower elasticity with respect to price and productivity has a significant effect on output only below a certain threshold.

The concentration of production also magnifies the negative effect of labour relations on income distribution and output growth, suggesting the relevance of the norms of competition. However, in our model we find two opposite effects. On the one hand concentration through entry barriers increases inequality and reduces output growth. On the other hand, concentration via market selection reduces inequality, but has no effect on output.

Finally, the norms of consumption – changes in the distribution expenditure shares and in consumer preferences – have no significant effect on either income distribution or output. This is because the most relevant consumers in our model are those who work in the first two tiers (or even in the first one). If wealthy income classes have different expenditure shares and preference plays no substantial role in our model

Structural determinants, instead, are emerging properties in our model. First, in the absence of any redistributive policies, an increase in average firm size have a direct effect on increasing income inequality (see also Autor et al. (2017)). Change in the structure of production amplify the effect of institutional difference in wage setting. In our model firm size is related to the norms of competition, but it could also be related to technological features (Malerba and Orsenigo, 1995) or trade strategies (Keller and Olney, 2017).

Second, the structure of the demand also plays a crucial role. Sectors that attract the largest share of consumption of low income classes tend to be also significantly less concentrated in our model than sectors that sell mainly luxury goods. Alone, a higher share of employment in less concentrated sectors reduce overall concentration of production (with positive effects on income distribution and output as discussed above). The structure of demand also influences competition: sectors that constitute the largest expenditure shares of the low income classes face fiercer competition, more selective consumers with respect to price, and therefore tend to exhibit a low mark-up in our model. This implies lower profits and dividends which accrue wealthier classes income.

Demand plays a crucial role in explaining the differences in output between the two regimes. Even if regime two catches up in terms of productivity, due to the structure of demand the uneven distribution curtails output growth.

In conclusion, in order to improve income distribution and, as a consequence, output growth, policies should aim at breaking the vicious cycle between the institutional and the structural determinants that in regime two (Post-Fordist) induces a more unequal distribution of income, lower output, and higher unemployment. Assuming that expenditure shares do not change as a consequence of distribution, and that firms retain a hierarchical organisation, the determinants of growth and inequality that can be more easily addressed are the institutional ones.

For a given concentration of production, large differences in wages, returns to capital, and bonuses may need to be capped, or redistributed through progressive taxation. On the other hand, for given differences in wages, returns to capital and bonuses, reducing market concentration by reducing barriers to entry (which may depend on trusts, but also on technology specific factors and protection of property rights) would also be beneficial. Among the two, results from our model suggest that the first type of redistributive would have a stronger impact.

Our model suggest that policies on the demand side that address consumer behaviour alone may be less relevant. However, one crucial message from our model is that the structure of consumption has a crucial bearing on the economy, shaping sectoral concentration and the related structure of compensation. Redistributive policies should also consider non trivial effects of changing consumption behaviour and market selection as the demand becomes more homogeneous.

Although the results are robust under the two regimes explored in this paper, in future research we will test the model with respect to more extreme regimes. The model can also be used to test explicitly the effect of alternative fiscal policies. The model in itself if already relative rich, but future work from the authors aim to explore an explicit modelling of the labour market, and an open economy.

References

Acemoglu, Daron and David Autor, "Skills, tasks and technologies: Implications for employment and earnings," in David Card and Orley Ashenfelter, eds., *Handbook of Labor Economics*, Vol. 4, Elsevier, 2011, pp. 1043–1171.

Alvaredo, Facundo, Anthony B Atkinson, Thomas Piketty, and Emmanuel Saez, "The Top 1 Percent in International and Historical Perspective," *Journal of Economic Perspectives*, 2013, *27* (3), 3–20.

Amendola, Mario and Jean-Luc Gaffard, *Out of Equilibrium*, Oxford and New York: Oxford Clarendon Press, 1998.

Andrews, Martyn J, Steve Bradley, David N Stott, and Richard Upward, "Successful Employer Search? An Empirical Analysis of Vacancy Duration Using Micro Data," *Economica*, 2008, *75* (299), 455–480.

Assenza, Tiziana, Domenico Delli Gatti, and Jakob Grazzini, "Emergent dynamics of a macroeconomic agent based model with capital and credit," *Journal of Economic Dynamics and Control*, 2015, *50*, 5–28.

Atkinson, Anthony B, *Inequality: What Can Be Done?*, Harvard University Press, 2015.

_ **and Salvatore Morelli**, "Chartbook of Economic Inequality," mar 2014.

_ **, Thomas Piketty, and Emmanuel Saez**, "Top Incomes in the Long Run of History," *Journal of Economic Literature*, mar 2011, *49* (1), 3–71.

Autor, David, David Dorn, Lawrence Katz, Christina Patterson, and John Van Reenen, "The Fall of the Labor Share and the Rise of Superstar Firms," may 2017.

Autor, David H and David Dorn, "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market," *American Economic Review*, aug 2013, *103* (5), 1553–1597.

Barigozzi, Matteo and Alessio Moneta, "Identifying the Independent Sources of Consumption Variation," *Journal of Applied Econometrics*, mar 2016, *31* (2), 420–449.

Bassin, William M, Michael T Marsh, and Stefanie Walitzer, "A Macroeconomic Analysis Of Inventory/Sales Ratios," *Journal of Business & Economics Research*, 2003, *1* (10), 37–45.

Baum, Christopher F and Mark E Schaffer, "ACTEST: Stata module to perform Cumby-Huizinga general test for autocorrelation in time series," 2013.

Blanchflower, David G and Andrew J Oswald, "The Wage Curve: An Entry Written for the New Palgrave, 2nd Edition," Discussion Paper 2138, IZA, Bonn may 2006.

Boeri, Tito, "Setting the Minimum Wage," IZA Discussion Papers 4335, Institute for the Study of Labor (IZA) jul 2009.

_ , "Setting the minimum wage," *Labour Economics*, 2012, *19* (3), 281–290.

Börsch-Supan, Axel H, "Panel Data Analysis of the Beveridge Curve: Is There a Macroeconomic Relation between the Rate of Unemployment and the Vacancy Rate?," *Economica*, aug 1991, *58* (231), 279–297.

Boucekkine, R, David De la Croix, and O Licandro, "Vintage human capital, demographic trends, and endogenous growth," *Journal of Economic Theory*, 2002, *104* (2), 340–375.

Bouvet, F., "The Beveridge curve in Europe: new evidence using national and regional data," *Applied Economics*, sep 2012, *44* (27), 3585–3604.

Boyer, Robert, "Formalizing growth regimes," in Giovanni Dosi, Christopher Freeman, Richard Nelson, Gerald Silverberg, and Luc Soete, eds., *Technical Change and Economic Theory*, Pinter Publisher, 1988.

_ , "Is a Finance-led growth regime a viable alternative to Fordism? A preliminary analysis," *Economy and Society*, dec 2010, *29* (1), 111–145.

Brynjolfsson, Erik and Andrew McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, New York: W. W. Norton & Company, 2014.

Buchanan, Mark, "Economics: Meltdown modelling. Could agent-based computer models prevent another financial crisis?," *Nature*, 2009, *460*, 680–682.

Caiani, Alessandro, Antoine Godin, Eugenio Caverzasi, Mauro Gallegati, Stephen Kinsella, and Joseph E. Stiglitz, "Agent based-stock flow consistent macroeconomics: Towards a benchmark model," *Journal of Economic Dynamics and Control*, 2016, *69*, 375–408.

Caliendo, Lorenzo, Ferdinando Monte, and Esteban Rossi-Hansberg, "The Anatomy of French Production Hierarchies," *Journal of Political Economy*, aug 2015, *123* (4), 809–852.

Cardaci, Alberto and Francesco Saraceno, "Inequality, Financialisation and Economic Crisis : an Agent-Based Model," 2015.

Celsi, Richard L and Jerry C Olson, "The Role of Involvement in Attention and Comprehension Processes," *Journal of Consumer Research*, 1988, *15* (2), 210–224.

Ciarli, Tommaso and Marco Valente, "The complex interactions between economic growth and market concentration in a model of structural change," *Structural Change and Economic Dynamics*, may 2016, *38* (September), 38–54.

_ , André Lorentz, Maria Savona, and Marco Valente, "The effect of consumption and production structure on growth and distribution. A micro to macro model," *Metroeconomica*, 2010, *61* (1), 180–218.

_ , _ , _ , and _ , "The role of technology, organisation, and demand in growth and income distribution," LEM Working Papers 2012/06, Laboratory of Economics and Management, San'Anna School of Advanced Studies, Pisa 2012.

Cimoli, Mario, "Technological Gaps And Institutional Asymmetries In A North-South Model With A Continuum Of Goods," *Metroeconomica*, 1988, *39* (3), 245–274.

Coelli, Tim, Emili Grifell-Tatjé, and Sergio Perelman, "Capacity utilisation and profitability: A decomposition of short-run profit efficiency," *International Journal of Production Economics*, 2002, *79* (3), 261–278.

Colander, David, Peter Howitt, Aalan Kirman, Axel Leijonhufvud, and Perry Mehrling, "Beyond DSGE models: toward an empirically based macroeconomics," *American Economic Review*, 2008, *98* (2), 236–240.

Coriat, Benjamin and Giovanni Dosi, "The Institutional Embeddedness of Economic Change. An Appraisal of the 'Evolutionary' and 'Regulationist' Research Programmes," in Giovanni Dosi, ed., *Innovation, Organization and Economic Dynamics: Selected Essays*, Celtenham UK: Edward Elgar, 2000, pp. 347–376.

Davis, Steven J, R Jason Faberman, and John C Haltiwanger, "The Establishment-Level Behavior of Vacancies and Hiring," Working Paper 16265, National Bureau of Economic Research aug 2010.

Dawid, H, S Gemkow, P Harting, K Kabus, K Wersching, and M Neugart, "Skills, Innovation, and Growth: An Agent-Based Policy Analysis," *Journal of Economics and Statistics (Jahrbuecher fuer Nationaloekonomie und Statistik)*, jun 2008, *228* (2+3), 251–275.

De Loecker, Jan and Frederic Warzynski, "Markups and firm-level export status," NBER Working Papers 15198, National Bureau of Economic Research, Inc jul 2009.

Deissenberg, C, S Van Der Hoog, and H Dawid, "EURACE: A massively parallel agent-based model of the European economy," *Applied Mathematics and Computation*, 2008, *204* (2), 541–552.

Delli Gatti, Domenico, Edoardo Gaffeo, and Mauro Gallegati, "Complex agent-based macroeconomics: a manifesto for a new paradigm," *Journal of Economic Interaction and Coordination*, 2010, *5* (2), 111–135.

Desmet, Klaus and StephenL. Parente, "The evolution of markets and the revolution of industry: a unified theory of growth," *Journal of Economic Growth*, 2012, *17* (3), 205–234.

DeVaro, Jed, "Employer Recruitment Strategies and the Labor Market Outcomes of New Hires," *Economic Inquiry*, 2005, *43* (2), 263–282.

Doms, Mark and Timothy Dunne, "Capital Adjustment Patterns in Manufacturing Plants," *Review of Economic Dynamics*, apr 1998, *1* (2), 409–429.

Dosi, Giovanni, Giorgio Fagiolo, and Andrea Roventini, "Schumpeter Meeting Keynes: A Policy–Friendly Model of Endogenous Growth and Business Cycles," *Journal of Economic Dynamics and Control*, 2010, *34* (9), 1748–1767.

_ , _ , Mauro Napoletano, and Andrea Roventini, "Income distribution, credit and fiscal policies in an agent-based Keynesian model," *Journal of Economic Dynamics and Control*, 2013, *37* (8), 1598–1625.

_ , _ , _ , _ , and Tania Treibich, "Fiscal and Monetary Policies in Complex Evolving Economies," *Journal of Economic Dynamics & Control*, 2015, *forthcomin.*

_ , Marcelo C Pereira, Andrea Roventini, and Maria Enrica Virgillito, "The Effects of Labour Market Reforms upon Unemployment and Income Inequalities: An Agent Based Model," 2016.

_ , Silvia Fabiani, Roberta Aversi, and Mara Meacci, "The Dynamics of International Differentiation: A Multi-Country Evolutionary Model," *Industrial and Corporate Change*, 1994, *3* (1), 225–242.

Dynan, Karen E., Jonathan Skinner, and Stephen Zeldes, "Do the Rich Save More?," *Journal of Political Economy*, 2004, *112* (2), 397–444.

Fagerberg, Jan and Bart Verspagen, "'Modern Capitalism' in the 1970s and 1980s," 1999.

Fagiolo, Giorgio and Andrea Roventini, "Macroeconomic Policy in DSGE and Agent-Based Models," *Revue de l'OFCE*, 2012, *124* (5), 67.

_ and _ , "Macroeconomic Policy in DSGE and Agent-Based Models Redux: New Developments and Challenges Ahead," *Journal of Artificial Societies and Social Simulation*, 2017, *20* (1), 1.

— **, Giovanni Dosi, and Roberto Gabriele**, "Matching, Bargaining, and Wage Setting in an Evolutionary Model of Labor Market and Output Dynamics," *Advances in Complex Systems*, 2004, *14*, 237–273.

— **, Mauro Napoletano, and Andrea Roventini**, "Are output growth-rate distributions fat-tailed? some evidence from OECD countries," *Journal of Applied Econometrics*, aug 2008, *23* (5), 639–669.

Farmer, J Doyne and Duncan Foley, "The economy needs agent-based modelling," *Nature*, 2009, *460* (7256), 685–686.

Fraumeni, Barbara M, "The Measurement of Depreciation in the U.S. National Income and Product Accounts," Survey of Current Business, Bureau of Economic Analysis jul 1997.

Freeman, Christopher and Luc Soete, *The Economics of Industrial Innovation*, Routledge, 1997.

Frydman, Carola and Dirk Jenter, "CEO Compensation," *Annual Review of Financial Economics*, dec 2010, *2* (1), 75–102.

Galor, Oded, "Multiple growth regimes - Insights from unified growth theory," *Journal of Macroeconomics*, 2007, *29* (3), 470–475.

— , "The 2008 Lawrence R. Klein Lecture Comparative Economic Development: Insights from Unified Growth Theory," *International Economic Review*, 2010, *51* (1), 1–44.

— **and D.N. Weil**, "Population, technology, and growth: From malthusian stagnation to the demographic transition and beyond," *American Economic Review*, 2000, *90* (4), 806–828.

Garcia-Macia, Daniel, Chang-Hai Hsieh, and Peter J Klenow, "How Destructive is Innovation ?," 2015.

Gervais, Martin and Paul Klein, "Measuring consumption smoothing in CEX data," *Journal of Monetary Economics*, 2010, *57* (8), 988–999.

Gigerenzer, Gerd, "Bounded Rationality: Models of Fast and Frugal Inference," *Swiss Journal of Economics and Statistics*, 1997, *133* (2).

— **and Reinhard Selten, eds**, *Bounded rationality: The adaptive toolbox*, Cambridge, MA: MIT Press, 2001.

Hay, Michael, David W Thomas, John L Craighead, Celia Economides, and Jesse Rosenthal, "Clinical development success rates for investigational drugs.," *Nature biotechnology*, jan 2014, *32* (1), 40–51.

Hernández, Héctor, Fernando Hervás, Alexander Tübke, Antonio Vezzani, Mafini Dosso, Sara Amoroso, Nicola Grassano, Alexander Coad, and Petros Gkotsis, "The 2015 EU Industrial R&D Investment Scoreboard," Technical Report, European Commission – Joint Research Centre – Institute for Prospective Technological Studies – DG Research, Luxembourg: Office for Official Publications of the European Communities 2015.

Hoch, Stephen J and Young-Won Ha, "Consumer Learning: Advertising and the Ambiguity of Product Experience," *Journal of Consumer Research*, 1986, *13* (2), 221–233.

Joaquim Oliveira, Martins, Stefano Scarpetta, and Dirk Pilat, "Mark-Up Ratios in Manufacturing Industries: Estimates for 14 OECD Countries," OECD Economics Department Working Papers 162, OECD Publishing 1996.

Jones, Benjamin F. and Benjamin A. Olken, "The Anatomy of Start-Stop Growth," *Review of Economics and Statistics*, aug 2008, *90* (3), 582–587.

Jung, Philip and Moritz Kuhn, "The era of the U.S.-Europe labor market divide: what can we learn?," MPRA Paper 32322, University Library of Munich, Germany jul 2011.

Kaldor, Nicholas, "A Model of Economic Growth," *Economic Journal*, 1957, *December*, 65–94.

_ , "The Irrelevance of Equilibrium Economics," *Economic Journal*, dec 1972, *82* (328), pp 1237–1255.

Kar, S, L Pritchett, S Raihan, and K Sen, "Looking for a break: Identifying transitions in growth regimes," *Journal of Macroeconomics*, 2013, *38* (PB), 151–166.

Karabarbounis, L. and B. Neiman, "The Global Decline of the Labor Share," *The Quarterly Journal of Economics*, oct 2013, *129* (1), 61–103.

Keller, Wolfgang and William W. Olney, "Globalization and Executive Compensation," 2017.

King, Robert G and Ross Levine, "Capital fundamentalism, economic development, and economic growth," Policy Research Working Paper Series 1285, The World Bank apr 1994.

Krueger, Dirk and Fabrizio Perri, "Understanding Consumption Smoothing: Evidence from The U.S. Consumer Expenditure Data," *Journal of the European Economic Association*, 2005, *3* (2/3), 340–349.

Lamperti, Francesco and Clara Elisabetta Mattei, "Going Up and Down: Rethinking the Empirics of Growth in the Developing and Newly Industrialized World," *LEM Papers Series*, 2016.

Lazonick, William, "Profits without prosperity," *Harvard Business Review*, 2014, (September), 1–11.

_ **and Mariana Mazzucato**, "The risk-reward nexus in the innovation-inequality relationship: who takes the risks? Who gets the rewards?," *Industrial and Corporate Change*, jul 2013, *22* (4), 1093–1128.

LeBaron, Blake and Leigh Tesfatsion, "Modeling Macroeconomies as Open-Ended Dynamic Systems of Interacting Agents," *American Economic Review*, 2008, *98* (2), 246–250.

Leijonhufvud, Axel, "Agent-Based Macro," in L Tesfatsion and K L Judd, eds., *Handbook of Computational Economics*, Vol. 2, Elsevier, 2006, pp. 1625–1637.

Lengnick, Matthias, "Agent-based macroeconomics: A baseline model," *Journal of Economic Behavior and Organization*, feb 2013, *86*, 102–120.

Llerena, Patrick and André Lorentz, "Cumulative Causation and Evolutionary Micro-founded Technical Change: On the Determinants of Growth Rates Differences," *Revue Economique*, 2004, *55* (6), 1191–1214.

Lorentz, André, "Sectoral Specialisation in an Evolutionary Growth Model with a Kaldorian Flavour," *International Journal of Computational Economics and Econometrics*, 2015, *5* (3), 319–344.

_ **, Tommaso Ciarli, Maria Savona, and Marco Valente**, "The Effect of Demand-Driven Structural Transformations on Growth and Technological Change," *Journal of Evolutionary Economics*, 2016, *26* (1), 219–246.

Lydall, H F, "The Distribution of Employment Incomes," *Econometrica*, 1959, *27* (1), 110–115.

Malerba, Franco and Luigi Orsenigo, "Schumpeterian patterns of innovation," *Cambridge Journal of Economics*, 1995, *19* (1), 47–65.

Manning, Alan, "We Can Work It Out: The Impact of Technological Change on the Demand for Low-Skill Workers," *Scottish Journal of Political Economy*, nov 2004, *51* (5), 581–608.

Marchetti, Domenico, "Markups and the Business Cycle: Evidence from Italian Manufacturing Branches," *Open Economies Review*, 2002, *13* (1), 87–103.

Mazzolari, Francesca and Giuseppe Ragusa, "Spillovers from High-Skill Consumption to Low-Skill Labor Markets," *Review of Economics and Statistics*, mar 2013, *95* (1), 74–86.

Metcalfe, J Stan, John Foster, and Ronnie Ramlogan, "Adaptive economic growth," *Camb. J. Econ.*, 2006, *30* (1), 7–32.

Moneta, Alessio and Andreas Chai, "The evolution of Engel curves and its implications for structural change theory," *Cambridge Journal of Economics*, nov 2013, *38* (4), 895–923.

Mueller, Holger M, Paige P Ouimet, and Elena Simintzi, "Wage Inequality and Firm Growth," jan 2015.

Nadiri, M Ishaq and Ingmar R Prucha, "Estimation of the Depreciation Rate of Physical and R&D Capital in the U.S. Total Manufacturing Sector," *Economic Inquiry*, 1996, *34* (1), 43–56.

Napoletano, Mauro, Giovanni Dosi, Giorgio Fagiolo, and Andrea Roventini, "Wage Formation, Investment Behavior and Growth Regimes: An Agent-Based Analysis," *Revue de l'OFCE, Debates and policies*, 2012, *124* (5), 235–261.

Nelson, Richard Robert and Sidney G Winter, *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press, 1982.

Nickell, Stephen, Luca Nunziata, Wolfgang Ochel, and Glenda Quintini, "The Beveridge Curve, Unemployment and Wages in the OECD from the 1960s to the 1990s," Working Paper, CEPR, LSE, London 2002.

Nijkamp, Peter and Jacques Poot, "The Last Word on the Wage Curve?," *Journal of Economic Surveys*, 2005, *19* (3), 421–450.

OECD, "Making Innovation Benefit All: Policies for Inclusive Growth," Technical Report, OECD, Paris 2017.

Pammolli, Fabio, Laura Magazzini, and Massimo Riccaboni, "The productivity crisis in pharmaceutical R&D.," *Nature reviews. Drug discovery*, jun 2011, *10* (6), 428–38.

Petit, Pascal, "Structural Forms and Growth Regimes of the Post-Fordist Era," *Review of Social Economy*, 1999, *57* (2), 220–243.

Petrongolo, Barbara and Christopher A Pissarides, "Looking into the Black Box: A Survey of the Matching Function," *Journal of Economic Literature*, jun 2001, *39* (2), 390–431.

Piketty, Thomas, *Capital in the Twenty-First Century*, Cambridge, MA: Belknap Press of Harvard University Press, 2014.

Poschke, Markus, "The Firm Size Distribution across Countries and Skill-Biased Change in Entrepreneurial Technology," 2015.

Pritchett, L, “Understanding patterns of economic growth: Searching for hills among plateaus, mountains, and plains,” *World Bank Economic Review*, 2000, *14* (2), 221–250.

Rao, Akshay R and Kent B Monroe, “The Effect of Price, Brand Name, and Store Name on Buyers’ Perceptions of Product Quality: An Integrative Review,” *Journal of Marketing Research*, 1989, *26* (3), 351–357.

Rosen, Sherwin, “Authority, Control, and the Distribution of Earnings,” *Bell Journal of Economics*, 1982, *13* (2), 311–323.

Rotemberg, Julio J, “Behavioral Aspects of Price Setting, and Their Policy Implications,” jan 2008.

Russo, Alberto, Luca Riccetti, and Mauro Gallegati, “Increasing inequality, consumer credit and financial fragility in an agent based macroeconomic model,” *Journal of Evolutionary Economics*, mar 2016, *26* (1), 25–47.

Ryoo, Jaewoo and Sherwin Rosen, “The Market for Engineers,” Working Paper 83, University of Chicago - George G. Stigler Center for Study of Economy and State, Chicago 1992.

Saviotti, Pier Paolo and Andreas Pyka, “Micro and macro dynamics: Industry life cycles, intersector coordination and aggregate growth,” *Journal of Evolutionary Economics*, 2008, *18*, 167–182.

_ and _ , “Technological Change, Product Variety and Economic Growth,” *Journal of Evolutionary Economics*, 2008, *18* (3-4), 323–347.

Silverberg, Gerald and Bart Verspagen, “Evolutionary Theorizing on Economic Growth,” in Kurt Dopfer, ed., *The Evolutionary Foundations of Economics*, Cambridge: Cambridge University Press, 2005, chapter 16, pp. 506–539.

Simon, Herbert A, “The Compensation of Executives,” *Sociometry*, 1957, *20* (1), 32–35.

Stockhammer, Engelbert, “Why have wage shares fallen? A panel analysis of the determinants of functional income distribution,” 2012.

Summers, Lawrence H., “Economic Possibilities for Our Children,” *NBER Reporter*, dec 2013, *2013* (4), 1.

Tåg, Joacim, “Production hierarchies in Sweden,” 2013.

Teo, Edward, Shandre M Thangavelu, and Elizabeth Quah, “Singapore’s Beveridge Curve: A Comparative Study of the Unemployment and Vacancy Relationshio for Selected East Asian Countries,” Economic Survey of Singapore Second Quarter, Ministry of Manpower 2004.

The Economist, “Too much of a good thing,” *The Economist*, 2016.

U.S. Census Bureau, “Manufacturing and Trade Inventories and Sales,” http://www.census.gov/mtis/www/mtis.html 2008.

Valente, Marco, “Evolutionary demand: a model for boundedly rational consumers,” *Journal of Evolutionary Economics*, 2012, *22* (5), 1029–1080.

Verspagen, B, *Uneven Growth Between Interdependent Economies: Evolutionary Views on Technology Gaps, Trade and Growth*, Avenbury, 1993.

Wall, Howard J and Gylfi Zoega, "The British Beveridge curve: A tale of ten regions," *Oxford Bulletin of Economics and Statistics*, 2002, *64* (3), 257–276.

Yashiv, Eran, "Labor Search and Matching in Macroeconomics," Discussion Paper 2743, IZA apr 2007.

Zeithaml, Valarie A, "Consumer Perceptions of Price, Quality, and Value: A Means-End Model and Synthesis of Evidence," *The Journal of Marketing*, 1988, *52* (3), 2–22.

Zheng, Zhihao and Shida Rastegari Henneberry, "Household food demand by income category: evidence from household survey data in an urban chinese province," *Agribusiness*, 2011, *27* (1), 99–113.

A Remaining Components of the Model

In this appendix we report on the components of the model not already described in the main text, where we discuss the most relevant elements of the model for definition of the growth regimes. The elements reported below are crucial in understanding the functioning and outcome of the model, though not directly connected to the discussion on growth regimes.

A.1 Macroeconomic Dynamics

The macroeconomic dynamic of the model is the result of the aggregation of the microeconomic behaviour, except for the minimum wage which depends on aggregate changes in unemployment, productivity, and inflation. Wages, therefore, link supply and demand side of the model via income distribution, and mediate the feedback between the macro and micro dynamics. The remaining of this section presents the computation of the main macroeconomic variables, and how they define the minimum wage.

A.1.1 Aggregate Unemployment

We estimate the level of unemployment using the well established Beveridge Curve, the negative relation between the rate of unemployment and the rate of vacancies, which are endogenously determined at the firm-level in our model. In this respect, without explicitly modeling the dynamics of the labour market we assume that it mimics a matching model (Petrongolo and Pissarides, 2001; Yashiv, 2007). We adopt an hyperbolic form for the Beveridge curve as estimated in Börsch-Supan (1991):

$$u(t) = 1 + \frac{\beta}{v(t) + \Upsilon} \tag{24}$$

where $u(t)$ is unemployment rate at time t, Υ is a constant, β defines the relation between the vacancy rate $v(t)$ and unemployment.[36]

For every tier of worker i in every firm $k \in \{f, g\}$ we estimate the number of vacancies $V_{i,k}(t)$. We assume that the vacancies in a given tier i are proportional to the vacancies in the shop-floor:

$$V_{i,k}(t) = \nu^{1-i} V_{1,k}(t) \tag{25}$$

The total number of vacancies for firm k can therefore be expressed as a multiple of the vacancies for first-tier workers:

$$V_k(t) = \sum_{i=1}^{\Lambda_k(t)} \nu^{1-i} V_{1,k}(t) \tag{26}$$

The vacancies at the shop-floor level are computed as the difference between the number of shop-floor workers demanded to produce the planned output and the number of workers hired (matched). Formally, for the final good sectors and the capital good sector respectively:

$$\begin{aligned} V_{1,n,f}(t) &= max\left\{0\,;\,(1+\upsilon)\frac{min\{Q_f^d(t);\bar{B}K_f(t-1)\}}{A_f(t-1)} - L_{1,n,f}(t-1)\right\} \\ V_{1,g}(t) &= max\left\{0\,;\,(1+\upsilon_g)\frac{K_g^d(t)}{A_f(t-1)} - L_{1,g}(t-1)\right\} \end{aligned} \tag{27}$$

The mismatch between firms' labour demand and hiring depends on the parameter ε in equation 3.[37] and is due to the assumed frictions in the labour market, which are equal in both regimes

[36] The Beveridge curve constant is set to 1, because values in Börsch-Supan (1991) range between -5 and 4.

[37] initialised with a value generating vacancy rates corresponding to the empirical evidence.

The vacancy rate for firm k is then the ratio between vacancies and the overall labour demand:

$$v_{n,k}(t) = \frac{V_k(t)}{L_k(t) + V_k(t)} \tag{28}$$

The vacancy rate for the whole economy is computed as the average of firms' vacancy rate weighted by their contribution to total employment ($L(t)$):

$$L(t) = \sum_{n=1}^{N} \sum_{f=1}^{F(t)} \sum_{i=1}^{\Lambda_f(t)} L_{i,f}(t-1) + \sum_{g=1}^{G} (L_g(t) + L_{0,g}(t))$$

$$v(t) = \sum_{n=1}^{N} \sum_{f=1}^{F} \frac{L_{n,f}(t)}{L(t)} v_{n,f}(t) + \sum_{g=1}^{G} \frac{L_g(t)}{L(t)} v_g(t) \tag{29}$$

A.1.2 Aggregate Consumption

The selection procedure described in Section 2.2.2 is replicated H times per consumer class, representing a distribution of H random draws of perceived price and quality. To establish the aggregate expenditures directed at firm f in sector n we sum the H replicates that selected firm f,n in the subset of selected goods:

$$y_{n,f} = X_n(t) \frac{h_{n,f}}{H} \tag{30}$$

where $X_n(t)$ are the consumer class n expenditures and $h_{n,f}$ are the number of times that the selection procedure selected product of firm f. Finally, the number of units sold is derived dividing the revenues by the unit price:

$$x_{n,f} = \frac{y_{n,f}}{p_f} \tag{31}$$

Because consumers and firms are partially myopic there is a mismatch between the quantity demanded and the quantity produced. See Section A.3.1.

A.1.3 GDP, and total Employment

The nominal GDP is the sum of the value of sales across sectors and firms, corresponding to final and intermediate:

$$Y(t) = \sum_{n=1}^{N} \sum_{f=1}^{F(t)} p_f(t-1) Y_f(t) + \sum_{g=1}^{G} p_g(t-1) K_g(t) \tag{32}$$

where $p_f(t-1)$ and $p_g(t-1)$ are defined in Eqs. 20 and 52; $Y_f(t) = \min\{Y_f(t); Q_f(t)\}$, respectively Eqs. 36 and 37; and $K_g(t)$ is defined in Eq. 47.

Total employment is the sum of workers employed in all the tiers of all the firms in all sectors:

$$L(t) = \sum_{n=1}^{N} \sum_{f=1}^{F(t)} \sum_{i=1}^{\Lambda_f(t)} L_{i,f}(t-1) + \sum_{g=1}^{G} (L_g(t) + L_{0,g}(t))$$

A.2 Consumer Classes

A.2.1 Savings and Rents

A class's level of savings ($S_i(t)$) is the income left to a consumer class after expenditure:

$$S_i(t) = D_i(t) - X_i(t) + D_i^-(t) = (1-(1-\gamma)(1-s_i))D_i(t) - \gamma X_i(t-1) + D_i^-(t) \tag{33}$$

where $D_i^-(t)$ are returns from past demands that could not be met by firms (see Section A.3.1 for more details).

The savings by households are invested in the financial sector purchasing a financial title issued by the financial sector, financial assets, providing access to future dividends. To simplify we do not consider any other transaction on the financial market (financial assets cannot be traded among consumers or firms). The number of financial assets pertaining to class i, $U_i(t)$, is thus computed as:

$$U_i(t) = U_i(t-1) + \frac{S_i(t)}{P_u(t)} \tag{34}$$

where $P_u(t)$ is the current price of the financial asset (See Eq 57).

In line with recent empirical evidence (Dynan et al., 2004) we assume that the saving rate s_i increases with income. Considering that classes are indexed according to increasing levels of income, the desired saving rate of two adjacent classes can be expressed as:[38]

$$s_i = s_{i-1}(1-\varsigma) + \varsigma \tag{35}$$

where ς is the rate growth of savings from class i to the next one.

A.3 Final Good Firms

A.3.1 Output

The total demand of a final good firm is the sum of expenditures over all bootstraps over all classes, following the selection algorithm described in Section 2.2 and aggregated in Section A.1.2. If the demand exceeds a firm supply, the total units sold $Y_f(t)$ corresponds to its current production $Q_f(t)$:

$$Y_f(t) = \min\left\{\frac{1}{p_f(t-1)}\sum_{z=1}^{\Lambda_t}\sum_{m=1}^{H_{n,z}} y_{f_n,z,m,t}\frac{X_{z,t}}{H}; Q_f(t)\right\} \tag{36}$$

where $p_f(t-1)$ is the price charged by the firm at time t.

In the short-run firms produce using a fixed coefficient technology. The level of output produced $Q_f(t)$ is constrained by the availability of production factors:

$$Q_f(t) = \min\left\{Q_f^d(t); A_f(t-1)L_{1,f}(t-1); \bar{B}K_f(t-1)\right\} \tag{37}$$

where $A_f(t-1)$ is the level of productivity of labour $L_{1,f}(t-1)$ embodied in the firms' capital stock $K_f(t-1)$, and $\frac{1}{\bar{B}}$ is a constant capital stock intensity.[39]

Firms decide a desired output level $Q_f^d(t)$ to match their expectations on sales $Y_f^e(t)$, which are formed accounting for past inventories ($I_f(t-1) > 0$) or unfulfilled orders ($I_f(t-1) < 0$):

$$Q_f^d(t) = (1+\phi)Y_f^e(t) - I_f(t-1) \tag{38}$$

In order to cover unexpected changes in demand, firms maintain a level of inventories $\phi Y_{f,t}^e$ – where ϕ is a fixed ratio. Firms form their sales expectations ($Y_{f,t}^e$) in an adaptive way to smooth short term volatility

$$Y_f^e(t) = \alpha Y_f^e(t-1) + (1-\alpha)Y_f(t-1) \tag{39}$$

where $(1-\alpha)$ is the rate at which expectations on demand converge to the current value of demand, and Y_f it total demand.

[38]We assume the the savings are equal for all consumers in a class.

[39]The constant assumption is corroborated by numerous empirical studies, starting with Kaldor (1957). The investment decision in in new capital vintages ensures that the capital stock intensity remains fixed over time.

The difference between the planned production $Q_f^d(t)$ and the actual output $Q_{f,t}$ determines the level of inventories $I_f(t-1)$:

$$I_f(t) = Q_f^d(t) - Q_f(t) \tag{40}$$

When demand exceeds output, firms increase the value of backlogs (negative inventories) to be fulfilled with future output and increases the mark-up. Consumer classes failing to access demanded goods because of insufficient production keep their unspent money as forced savings while waiting for a delivery in the future. These resources are employed as extra-consumption when the firm is able to fulfil the order, or remain as permanent savings in case a firm cannot fulfil the order. In other words, we assume that at each time step backlogs are either fulfilled – delivering past unfulfilled sales – or reduced by a fixed ratio – representing orders cancelled by consumers. The value of cancelled goods is returned to the consumer class that purchased them in the past contributing to its saving and therefore future consumption.[40]

Backlogs negatively affect firms' visibility ($\hat{\upsilon}_{f,t}$), assuming that consumers prefer to buy goods from firms that can deliver immediately. Visibility is computed as a moving average of the ratio of the difference between expected sales and backlogs and expected sales:

$$\hat{\upsilon}_f(t) = \hat{\upsilon}_f(t-1)\alpha_{\hat{\upsilon}} + \frac{max\{Y_f^e(t) - BL_f(t), 0.001\}}{Y_f^e(t)}(1-\alpha_{\hat{\upsilon}}) \tag{41}$$

where $\alpha_{\hat{\upsilon}}$ is the pace at which visibility adapts through time.

A.3.2 Production Capacity and Productivity

Following Amendola and Gaffard (1998) and Llerena and Lorentz (2004) the accumulation of capital stock is a pre-condition for producing and a determinant of labour productivity. A firm's f capital stock $K_f(t)$ is the sum of capital vintages $k_{f,g}(\tau)$ purchased from capital good firm g in time τ and cumulated through time:

$$K_f(t) = \sum_{\tau=1}^{t} k_{f,g}(\tau)(1-\delta)^{t-\tau} \tag{42}$$

where δ is the depreciation rate. The level of productivity embodied in the capital stock is computed as the average productivity across all the vintages available:

$$A_f(t) = \frac{1}{K_f(t)} \sum_{\tau=1}^{t} k_{f,g}(\tau)(1-\delta)^{t-\tau} a_g(\tau) \tag{43}$$

where $a_g(\tau)$ is the productivity embodied in the h vintage.[41]

A.3.3 Investment in Capital Stock

Firms investment in a new a vintage ($k_f^d(t)$) is a function of expected sales $Y_f^e(t)$, the level of production capacity given the capital stock and labor force currently available, respectively $Y_f^K(t)$ and $Y_f^L(t)$, and the current amount of backlog sales, $BL_f(t)$.

$$k_f^d(t) = max\{min\{Y_f^L(t)\alpha_k; \left(Y_f^e(t) + \bar{B}L_f(t)\beta_k\right)(1+\upsilon)\} - Y_f^K(t); 0\}\bar{B} \tag{44}$$

[40] Given that in our model consumption occurs at the level of the class, and goods are then distributed to consumers, there is no rationing at the consumer level. We assume that although all consumers make a demand for all goods in all periods, only consumers who have not purchased the good in previous periods will need it. In other words, backlogs is a simplifying assumption to provide firms with market signals about future demand and allow consumers from a class to consume the same good in different time periods.

[41] When completely depreciated capital vintages are disposed off at no cost.

where α_k is a multiplier expanding the increase of capital stock to a multiple of the available labor force, in order to avoid capital stock bottlenecks in the short period (in line with the assumption that capital stock investment is lumpy); β_k is a coefficient indicating a share of the backlog sales that the firms would like to absorb with the new investment; υ is the share of desired unused (capital stock) capacity; $\bar{B}$ is the intensity of capital stock, translating production into units of capital.

All capital investment is financed with loans, without discriminating between firms (selection is done by consumers in our model).[42] The financial institution grants the loan to any firm with a probability proportional to the ratio between the cash available in the institution ($\Gamma(t)$) and the total value of the resources in the financial sector ($\Theta(t)$) (see equations 54 and 55). Rejected loans are resubmitted in following time steps until accepted.[43]

When investing in a new vintage, firms f select one of the capital good producers $g \in \{1;...;G\}$ and place an order $k^d_{g,f}(t)$ for the desired amount of capital goods. A capital good producer is selected with a probability that depends positively on the vintage's productivity $a_g(t-1)$, and negatively on its price $p_g(t-1)$ and on g's delivery time. Hence, capital good producers with a big order book may be discarded, even if they produce the best capital vintage, because delays in acquiring a new vintage may cause large losses for f.

After a capital producing firm receives an order it place it in its order book, using its production capacity to complete all the orders in the order they arrived.

A.4 Capital Good Firms

The capital good sector is populated by $g \in \{1,2,\ldots,G\}$ capital suppliers that produce one type of capital good with an embodied productivity $a_g(t)$. Firms in the capital good sector may sell to firms from any of the final good sectors, when they receive an order $k^d_{f,g}(t)$. Capital goods are produced on a first in, first out rule, and the time needed to produce each of them depends on firms' capacity and the number of orders.

A.4.1 Production

We assume that the production of capital goods is just-in-time, with no expectation formation or accumulation of inventories. The total demand $K^d_g(t)$ for a capital supplier g at t is the sum of the current order and earlier unfinished orders ($I_g(t-1)$):

$$K^d_g(t) = \sum_{f=1}^{F(t)} k^d_{g,f}(t) + I_g(t-1) \tag{45}$$

We assume, for the sake of simplicity, that capital good firms employ only labour, with constant productivity:

$$Q_g(t) = L_{1,g}(t-1) \tag{46}$$

where $L_{1,g}(t-1)$ are the shop-floor workers. The amount produced is then the minimum between a firm's capacity and demand:

$$K_g(t) = min\{Q_g(t); K^d_g(t)\} \tag{47}$$

and unfinished orders are the difference between current production and the sum of unfinished orders in $t-1$:

$$I_g(t) = \sum_{\tau=1}^{t} K^d_g(\tau) - \sum_{\tau=1}^{t} K_g \tau \tag{48}$$

[42]We assume that all profits are distributed to households as dividends.

[43]In the configurations adopted in this paper this form of rationing is rare and, when it happens, is lasts a maximum of a few time steps.

The total number of workers in a firm can be computed as:

$$L_g(t) = L_g^1(t) + ... + L_g^{\Lambda_g(t)}(t) = L_{1,g}(t) \sum_{i=1}^{\Lambda_g(t)} \nu^{1-i} + \rho_g L_g^1(t) \tag{49}$$

where ρ_g is the share of engineers per shop-floor worker.

A.4.2 Process Innovation

Capital good producers improve the productivity embodied in capital vintages $a_g(t)$ by means of their R&D department staffed by $L_{0,g}(t)$ engineers. The number of engineers is a constant share ρ_g of the total number of the firm's employees. In the tradition of Schumpeterian growth models (Silverberg and Verspagen, 2005), the outcome of R&D is stochastic and the probability of an increase in productivity ($\Phi_g(t)$) depends on the amount of financial resources invested to increase the total number of engineers ($L_{0,g}(t-1)$):

$$\Phi_g(t) = 1 - e^{-\zeta L_{0,g}(t-1)} \tag{50}$$

where ζ is the effectiveness of R&D investment.

If the R&D is successful, the productivity of the new capital vintage is randomly drawn from a normal distribution with average $a_g(t-1)$ and a variance σ^a representing the speed of technological change:

$$a_g(t) = a_g(t-1)\,(1 + max\{\varepsilon_g(t); 0\}) \tag{51}$$

where $\varepsilon_g(t) \sim N(0; \sigma^a)$.

A.4.3 Production Costs, Pricing, and Financial Account

Wages follow the same hierarchical structure as for firms in the final good sectors (Eq. 6). The wage of engineers working in the R&D department is a multiple ω_0 of the minimum wage.

The price of capital goods $p_g(t)$ is a fixed mark-up $\bar{m}_g$ over variable costs: shop-floor workers, executives, and engineers, divided by the level of output $Q_{g,t}$:

$$p_g(t) = (1 + \bar{m}_g) \left(\frac{\sum_{i=1}^{\Lambda_g(t)} w_{i,g}(t) L_{i,g}(t-1) + w_{0,g}(t) L_{0,g}(t-1)}{Q_g(t)} \right) \tag{52}$$

where $w_{0,g}(t)$ is the wage of engineers.

Profits are computed as the difference between revenues and labor costs:

$$\Pi_g(t) = p_g(t) K_g(t) - \sum_{i=1}^{\Lambda_g(t)} w_{i,g}(t) L_{i,g}(t-1) - w_{0,g}(t) L_{0,g}(t-1) \tag{53}$$

If profits are positive, a share π is distributed as premia to the managers of the firm in proportion to their share of the payroll (Eq. 9) and a share ρ_g is invested in R&D. The remaining profits $(1 - \pi - \rho_g)$ are pooled with those from all firms and distributed as dividends to households, in proportion to the number of financial assets owned by each class.

A.5 Financial Sector

The financial sector is an institution dealing with all the financial aspects of firms and households. For firms, it provides loans to purchase new capital goods and cover losses: firms' debt are registered as assets of the financial sector. Concerning households the financial sector receives their savings and issues a financial asset in exchange. Households' financial assets correspond to shares in firms capital (though loans). When firms pay dividends out of profits, the share of assets owned by a household's class (equivalent to the savings cumulated through time) determines the share of dividends distributed to that class. Dividends do not pertain to the financial sector, they form part of household's income.

The financial institution rests on a fundamental identity: the value of all the financial assets owned by households is identical to the value of all assets stored in the financial institution. The financial institution owns two types of assets: the cash collected from households and not yet used for loans, and the outstanding loans cumulated by existing firms. The total value of the financial sector is expressed as:[44]

$$\Theta(t) = \Gamma(t) + \sum_{k=1}^{F+G} \hat{K}_k(t) \tag{54}$$

where $k \in \{f, g\}$. The value of the stock of cash in the financial sector ($\Gamma(t)$) increases with new households' savings, and decreases with the loans granted to firms:

$$\Gamma(t) = \Gamma(t-1) + \sum_{i=1}^{\Lambda} S_i(t) - \sum_{k=1}^{F+G} J_k^l(t) \tag{55}$$

where $S_i(t)$ are consumer class i savings; J_k^l is the loan received by firm $k \in \{f, g\}$. The value of the outstanding loans consists of the sum of all past loans to firms minus the debt owned by firms that went bankrupt and exited the market:

$$\sum_{k=1}^{F+G} \hat{K}_k(t) = \sum_{k=1}^{F+G} \hat{K}_k(t-1) + \sum_{k=1}^{F+G} J_k^l(t) - \sum_{k \in W(t)} \hat{K}_k(t) \tag{56}$$

where $W(t)$ is the set of firms that went out of business at time t. We assume that society bares the cost of bankruptcy.

As shown in eq. 34 consumer classes use their savings to purchase a unique form of financial title, the financial assets ($U_i(t)$), issued by the financial sector. The price of an asset, $P_u(t)$, is determined by the ratio between the total value of the financial sector $\Theta(t-1)$ and the number of financial assets collectively owned by households in $t-1$:[45]

$$P_u(t) = \frac{\Theta(t-1)}{\sum_{i=1}^{\Lambda} U_i(t-1)} \tag{57}$$

The dividends received by household class i ($E_i(t)$) is computed as the share of distributed profits generated by all firms at time t proportional to the share of the assets owned by the class:

$$E_i(t) = (1-\pi-\rho) \sum_{i=f}^{F} \Pi_f \frac{U_i(t)}{\sum_{j=1}^{\Lambda(t)} U_j} + (1-\pi-\rho_g) \sum_{i=g}^{G} \Pi_g \frac{U_i(t)}{\sum_{j=1}^{\Lambda(t)} U_j} \tag{58}$$

[44] We adopt the convention that the nominal value of the debt is constantly equal to the loans received as long as the firm remains in activity, and then turns to zero in case the firm exits the market.

[45] In general, the price of financial assets, such as companies' stocks, is determined by trade, and consequently the market value of a company is computed multiplying the price by the number of outstanding stocks. In our model the financial assets are not traded and we use the same identity to compute the price, determined by the ratio of the total value of the financial sector (cash plus debt) and the number of assets. In this way we ensure that the total value of the financial assets owned by households equals the current value of the financial sector.

B Indices

We discuss the computation of the indexes used in the results sections.

Atkinson Inequality Index

Income inequality is measured using the Atkinson index $\mathscr{A}_{ind}(t)$ computed as follows:

$$\mathscr{A}_{ind}(t) = 1 - \frac{1}{\sum_{i=1}^{\Lambda(t)} \frac{D_i(t)}{L(t)}} \left[\frac{1}{L(t)} \sum_{i=1}^{\Lambda(t)} L_i(t) \left(\frac{D_i(t)}{L_i(t)} \right)^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{59}$$

where $D_i(t)$ is the total income for consumer class i, $L_i(t)$ is the total number of workers in class i, and ρ is the measure of inequality aversion.

Concentration of Output and Employment across Sectors

We measure the degree of concentration of production in terms of output and employment using an inverse Herfindahl index:

$$\mathscr{H}_Y(t) = \left[\sum_{n=1}^{N} \sum_{f}^{F(t)} \left(\frac{p_{n,f}(t-1)Y_{n,f}(t)}{Y(t)} \right)^2 + \sum_{g}^{G} \left(\frac{p_g(t-1)K_g(t)}{Y(t)} \right)^2 \right]^{-1} \tag{60}$$

$$\mathscr{H}_L(t) = \left[\sum_{j} \left(\frac{\mathscr{L}_j(t)}{\sum_{j=1} \mathscr{L}_j(t)} \right)^2 \right]^{-1} \tag{61}$$

We measure the degree of concentration in sales in the final good sector using an inverse Herfindahl index:

$$\mathscr{I}(t) = \left[\sum_{n=1}^{N} \sum_{f}^{F(t)} \left(\frac{p_{n,f}(t-1)Y_{n,f}(t)}{\sum_{n=1}^{N} \sum_{f}^{F(t)} p_{n,f}(t-1)Y_{n,f}(t)} \right)^2 \right]^{-1} \tag{62}$$

Value Added, Output, and Employment Sectoral Shares

We measure the contribution of the value added of each sectors to GDP $\mathscr{Y}_j(t)$, the respective shares of output $\mathscr{Q}_j(t)$ and employment $\mathscr{L}_j(t)$ for each final good sector and the capital good sector j:

$$\mathscr{Y}_j(t) = \frac{p_j(t-1)Y_j(t)}{Y(t)} \text{ with } Y_j(t) = \sum_{f=1}^{F(t)} Y_{j,f}(t) \forall n \in 1,...N \text{ or } Y_j(t) = \sum_{g=1}^{G} K_g(t) \tag{63}$$

$$\mathscr{L}_j(t) = \frac{L_j(t)}{L(t)} \text{ with } L_j(t) = \sum_{f=1}^{F(t)} L_{j,f}(t) \forall n \in 1,...N \text{ or } L_j(t) = \sum_{g=1}^{G} L_{j,f}(t) \tag{64}$$

Capital-Labour ratio – Degree of Mechanisation

We measure the degree of mechanisation of the Economy $\mathscr{M}(t)$ as follows:

$$\mathscr{M}(t) = \frac{\sum_{j=1}^{N} \sum_{f=1}^{F(t)} K_{j,f}(t)}{L(t)} \tag{65}$$

In doing so we consider the changes in the factor composition of the production.

Households' Income Composition

To account for changes in the structure of households' income we measure the contribution of wage and profits, respectively as the share of wage income in the total income $\mathscr{W}(t)$, the share of premia in total income $\mathscr{P}(t)$, and the share of returns on savings in total income $\mathscr{E}(t)$:

$$\mathscr{W}(t) = \frac{\sum_{i=1}^{\Lambda(t)} W_i(t)}{D(t)} \tag{66}$$

$$\mathscr{P}(t) = \frac{\sum_{i=1}^{\Lambda(t)} \Psi_i(t)}{D(t)} \tag{67}$$

$$\mathscr{E}(t) = \frac{\sum_{i=1}^{\Lambda(t)} E_i(t)}{D(t)} \tag{68}$$

The remaining share corresponds to the rents on savings.

C Initialisation

Parameter	Description	Value	Data
α	Adaptation of sales expectations	0.9	–[a]
ϕ	Desired ratio of inventories	0.1	[0.11 - 0.25][b]
υ	Unused labor/capital capacity	0.05	[0.042 - 0.075][c]
υ_g	Unused labor capacity in the capital good sector	0.2	[0.042 - 0.075][c2]
$\bar{m}$	Minimum mark-up	0.15	[0-0.28]; [0.1, 0.28]; [0.1, 0.39][d]
μ	Mark-up variation	0.3	[0-0.28]; [0.1, 0.28]; [0.1, 0.39][d]
$\bar{m}_g$	Mark-up in the capital good sector	0.2	[0-0.28]; [0.1, 0.28]; [0.1, 0.39][d]
δ	Capital depreciation	0.001	[0.03, 0.14]; [0.016, 0.31][e]
$\frac{1}{\bar{B}}$	Capital intensity	0.5	$\bar{B}$ = [1.36, 2.51][f]
ε	Labor market friction	0.3	0.6; [0.6, 1.5]; [0.7, 1.4]; [0.3, 1.4][g]
ω	Minimum wage multiplier	1.6	[1.6, 3.7][h]
b	Executives wage multiplier	1.6	[1.5, 2][h]2analysed
ω_0	Engineers' wage multiplier	2	[1.2, 1.4][h]3
π	Profits shared as bonuses	0.15	–[i] analysed
ν	Tier multiplier	3	[2, 7][j]
η_λ	λ inter-class multiplier	0.25	[-0.8, 2.4][k], analysed
$\lambda_{q,1}$	First tier quality selectivity	$\bar{0}.1$, analysed	–[l1]
$\lambda_{p,1}$	First tier price selectivity	$\bar{0}.9$, analysed	–[l1]
λ_{min}	Lowest selectivity	0.1	–[l2]
λ_{max}	Highest selectivity	0.9	–[l2]
η	Convergence to asymptotic consumption shares	0.4	analysed
ρ	R&D investment share in final good sectors	0.2	[0.01-0.231][m]
ρ_g	R&D engineers share in capital good sector	0.1	[0.01-0.231][m]
ζ	Probability of process innovation success	0.01	[0.07, 0.18]; [0.013, 0.198][n]
χ	Probability of product innovation trial success	0.05	[0.07, 0.18]; [0.013, 0.198][n]
Ξ	Min. interval between two successful innovations	10	–
σ^a	Standard deviation productivity shock	(0.015, 0.004)	–[o]
σ^q	Standard deviation product quality innovation	0.01	–[o1]
$\bar{c}_n$	Asymptotic consumption shares	–[+,x1]	–[+,p1]
$c_{1,n}$	First class consumption shares	–[+,x2]	–[+,p2]
ς	Increase in saving rate across income classes	0.2	–[q]
$1-\gamma$	Expenditure smoothing parameter	0.2	[.04, .14]; [.06, .19][r]
ε_U	Wage curve unemployment pressure	0.1	0.1[s]
ι	Error in the consumer's evaluation of characteristics	p: 0.05; q: 0.1	–[t]
β	Beveridge curve parameter	20	[6, 10][u]
Υ	Beveridge curve constant	0.2	–[u]
ε^P	Wage curve inflation elasticity	1	analysed
ε^A	Wage curve productivity elasticity	1	analysed

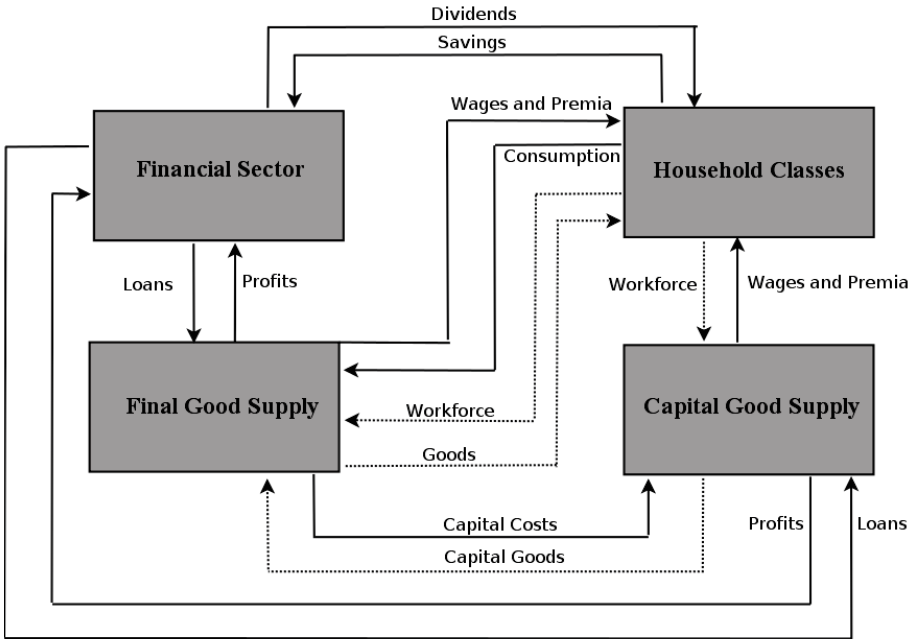
Ω^A	Increase in average productivity for wage renegotiations to occur	0.0001	–[w]
Ω^P	Increase in average price for wage renegotiations to occur	0.0001	–[w]
ϑ	Probability of firm entry in a sector	0.08	analysed
ξ	Exit threshold	0.001	–[x]
a	Smoothing parameter of profits moving average	0.95	–
$\alpha_{\hat{\upsilon}}$	Smoothing parameter of visibility	0.9	–
α_k	Labour multiplier in capital stock investment decision	10	–
β_k	backlogs absorption in capital stock investment decision	0.1	–
ρ	Atkinson index inequality aversion	0.5	–
F (0)	Initial number of final good firms	100	–
G	Capital good firms	10	–
N	Final good sectors	10	–
$\Lambda(t)$	Number of classes/tiers	E*	–
H	Consumer good iterations per sector	151	–

[a]Empirical evidence not available: the parameters has no influence on the results presented here. [b]U.S. Census Bureau (2008); Bassin et al. (2003). [c]Coelli et al. (2002) with reference to the 'optimal' unused capacity for labour (low value) and to the average ratio between technical efficient production and ray economic capacity in the airline industry. [c2] Larger than in the consumer good sector, due to the lumpiness of orders for capital goods (Doms and Dunne, 1998). [d]Marchetti (2002); De Loecker and Warzynski (2009); Joaquim Oliveira et al. (1996). [e]Nadiri and Prucha (1996); Fraumeni (1997) non residential equipment and structures. We use the lower limit value (the lower value reflects the assumption that in our model one simulation step represents approximately the dynamics of a fortnight (one year is 24 steps). [f]King and Levine (1994). [g]Vacancy duration (days or weeks) over one month: Davis et al. (2010); Jung and Kuhn (2011); Andrews et al. (2008); DeVaro (2005). [h]Ratio with respect to the average wage (not minimum) in OECD countries Boeri (2009). [h2]Simon (1957). [i] With reference to qualitative evidence from various sources. [h3]Relative to all College Graduates and to accountants Ryoo and Rosen (1992). We set the parameter to a higher value to differentiate engineer's compensation from shop-floor workers'. [j]Simon (1957). [k]Change of price selectivity for food product categories (Zheng and Henneberry, 2011) (inverted signs, as we use the change in selectivity rather than in price elasticity). [l1]Empirical evidence not available to our knowledge: based on qualitative evidence. The values are randomly drawn from a uniform distribution, respectively $\lambda_{q,1} \sim U[0.05, 0.15]$ and $\lambda_{p,1} \sim U[0.85, 0.95]$. [l1]Empirical evidence not available to our knowledge: based on qualitative evidence. [m]Hernández et al. (2015). We use a ratio close to the high end of high tech sectors. [n] Respectively Hay et al. (2014) and Pammolli et al. (2011) on the pharma industry from phase I to approval. For product innovation we take a lower bound value, given that the pharma industry is particularly innovative. For process innovation (capital good sector) we take a lower value. [o]Empirical evidence not available to our knowledge. Extensive analysis of this parameter has was done in past models (Ciarli et al., 2012), and is left for future work on this model. The two values refer, respectively, to the validation and the regimes analysis. We reduce variance in the analysis of regimes substantially in order to limit the effect due to stochastic shocks. [o1]Empirical evidence not available to our knowledge. [p1]We use the UK Family Expenditure Survey (FES) to compute the consumption shares across the ten aggregate consumption categories for the top centile of UK consumers (p99 in Figure 3). [p2]We use the UK FES to compute the consumption shares across the ten aggregate consumption categories for the bottom decile of UK consumers (p10 in Figure 3). Gervais and Klein (2010). [q]Based on the evidence on the increase in the saving rate by income quintile in Dynan et al. (2004). [r]Krueger and Perri (2005). [s]We implement the estimated wage equation in logs and use the widely estimated parameter (Nijkamp and Poot, 2005; Blanchflower and Oswald, 2006). [t]Specific empirical evidence not available to the best of our knowledge. Parameters set using the qualitative evidence in Zeithaml (1988) and the findings summarised in Rotemberg (2008). [u]Estimates from Börsch-Supan (1991). Most empirical exercises test a linear or quadratic form of the Beveridge curve (Wall and Zoega, 2002; Nickell et al., 2002; Teo et al., 2004; Bouvet, 2012) – a mean value of these estimates is found in Fagiolo et al. (2004). For modelling purposes the hyperbolic form is more convenient, but estimates are a bit outdated, so we adapt them using the more recent papers covering several countries. The constant Υ is meant to avoid extreme asymptotic values. [w] We assume a nearly continuous adjustment. [x]Assumed to allow firms in the market until their return on capital has nearly no value. *Endogenous. +Various

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 3*

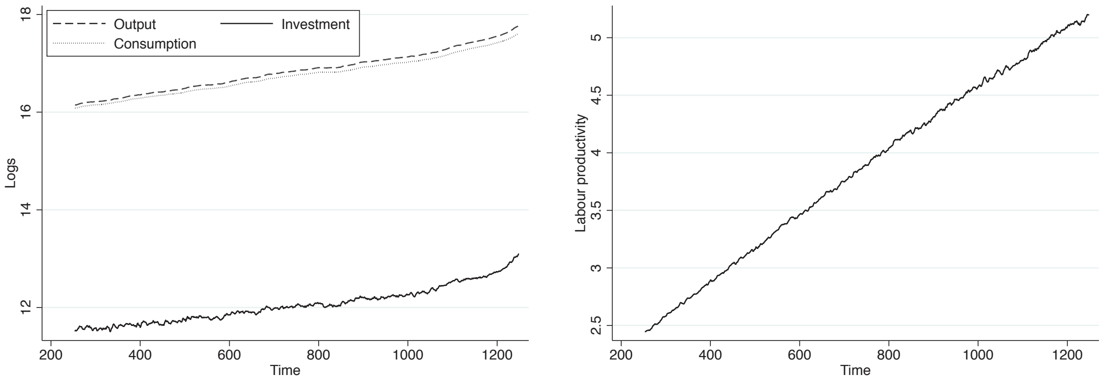
D Figures

D.1 Paper



Notes. Dashed lines represent goods or services exchanged between the agents and solid lines represent money flows.

Figure 1: Flow diagram of the model.



(a) Output, investment and consumption

(b) Aggregate labour productivity

Notes. Panel 2a exhibits the time series for aggregate output, investment, and consumption. All series are in logs. Output and consumption are in real values (deflated with a price index). Investment is proxied by the physical production of capital goods. Panel 2b exhibits the series for aggregate labour productivity computed as the total number of output over the total number of workers.

Figure 2: **Main macro series (2a) and productivity (2b):** .

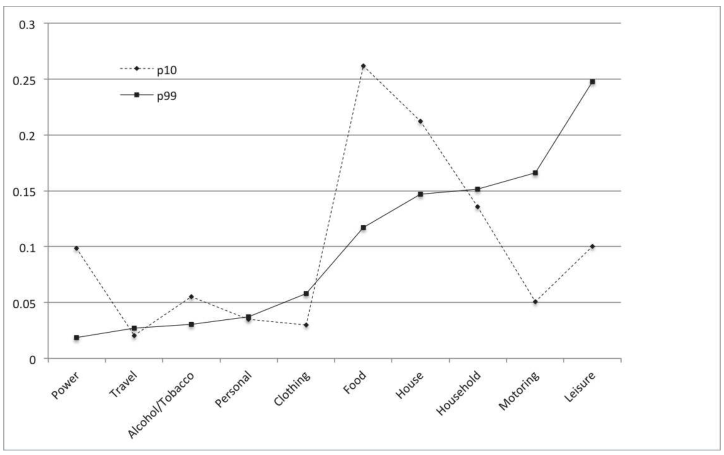


Figure 3: ***Expenditure shares: initial (*** $c_{i,n}$***, p10) and asymptotic (*** $\bar{c}_n$***, p99)***. *The distribution of the asymptotic level of shares corresponds to the shares of expenditures for the higher percentile of UK consumers in 2005-6. The distribution of the level of shares of the first class corresponds to the shares of expenditures for the bottom decile of UK consumers in 2005-6. We thank Alessio Moneta for sharing the data with us.*
Source: Own elaboration using UK FES

E Tables

E.1 Paper

Parameter		Equation	Regime 1	Regime 2
Wage difference between tiers:	b	6	low	high
Profit shares distributed to executives:	π	8	low	high
Elasticity of the minimum wage to productivity:	ε^A	11	high	low
Elasticity of the minimum wage to prices:	ε^P	11	high	low

Table 2: ***Parameters of the wage-labour nexus dimension of the growth regimes.***

Parameter		Equation	Regime 1	Regime 2
Changes in consumer preferences:	η_λ	17	lower	higher
Changes in expenditure shares:	η	15	lower	higher

Table 3: ***Parameters of the consumption dimension of the growth regimes.***

Parameter		Equation	Regime 1	Regime 2
Probability of entry:	ϑ	–	higher	lower
Consumer's selectivity with respect to price:	λ_{min}	17	lower	higher
Consumer's selectivity with respect to quality:	λ_{max}	17	lower	higher

Table 4: ***Parameters of the competition dimension of the growth regimes.***

Empirical regularity	Figure/Table
Macro	
Endeogenous growth	2
Business cycles	4
Auto-correlations of key variables	5
Cross-correlation of key variables	6
	7
Beveridge curve	8a
Wage curve	18
Output growth distribution (fat tailed)	8b
Meso	
Firm size distribution (log normal)	9
Firm growth distribution (skewed and fat tailed)	9
Growth of average firm size	10b
Micro	
Productivity differences	10
	19
Capital stock investment (lumpiness)	10d

Notes. For a complete discussion about the relation between the results of our model, the empirical evidence, and similar models, please refer to Appendix F.

Table 5: ***Macro, meso and micro empirical regularities tested and reproduced by the model***

Dimension	Parameter		Benchmark	Regime 1	Regime 2
Wage labour nexus	Wage difference between tiers:	b	1.6	1.4	1.8
	Profit shares distributed to executives:	π	0.15	0.1	0.35
	Elasticity of the minimum wage to productivity:	ε^A	1	1	0.8
	Elasticity of the minimum wage to inflation:	ε^P	1	1	0.8
Competition	Probability of entry:	ϑ	0.08	0.1	0.06
	Consumer's selectivity with respect to price:	$\lambda^a_{p,1}$	$\bar{0}.9$	$\bar{0}.775$	$\bar{0}.975$
	Consumer's selectivity with respect to quality:	$\lambda^b_{q,1}$	$\bar{0}.1$	$\bar{0}.225$	$\bar{0}.025$
Consumption	Changes in consumer preferences:	η_λ	0.25	0.2	0.3
	Changes in expenditure shares:	η	0.4	0.3	0.5

Notes. [a]The values are randomly drawn from uniform distributions, respectively $\lambda_{p,1} \sim U[0.85, 0.95]$, $\lambda_{p,1} \sim U[0.75, 0.8]$ and $\lambda_{p,1} \sim U[0.95, 1]$. [b]The values are randomly drawn from uniform distributions, respectively, $\lambda_{q,1} \sim U[0.05, 0.15]$, $\lambda_{q,1} \sim U[0.2, 0.25]$, and $\lambda_{q,1} \sim U[0, 0.05]$.

Table 6: ***Parametrisation of the two Growth Regimes.***

	Regime 1 (Fordist)	Regime 2 (Post-Fordist)	mean difference test t stat.	p-value
Output (real)	4382302	2848252	37.73	2.4e-37
Atkinson Index ($\mathscr{A}_{ind}$)	0.140	0.258	-143.4	7.4e-65
Unemployment Rate	4.624	4.804	-22.04	9.3e-27
Average Income Level	404.233	502.803	-108.7	4.1e-59
Average Profit Level	913257.72	1004774.08	-13.48	6.1e-18
Minimum Wage Level	222.850	206.559	45.02	6.4e-41
Wage-Income Ratio ($\mathscr{W}$)	0.738	0.698	36.91	6.8e-37
Premia-Income Ratio	0.025	0.021	181.531	9.2e-70
Dividends-Income Ratio ($\mathscr{E}$)	0.236	0.281	-40.07	1.5e-38
Aggregate Productivity	2.032	1.993	17.11	4.5e-22
Embodied Productivity	3.549	3.479	21.96	1.1e-26
Capital-Labour Ratio	5.792	5.818	-3.26	0.0020
Value-Added Concentration	7.804	7.901	-25.89	7.4e-30
Employment Concentration	15.987	16.104	-8.73	1.7e-11
Inverse Herfindahl Index ($\mathscr{H}_Y$)	103.85	72.07	71.18	2.5e-50
Consumption Concentration	6.952	7.088	-186.4	2.5e-70

Notes: Mean values over 25 replications for the average outcome over 2000 simulation steps.

Table 7: ***Main Macroeconomic Indicators for the Two Growth Regimes.***

		Real output	Const.
Regime one (Fordist):	Atkinson Index	6.707e-09**	0.166***
		(2.431e-09)	(0.003)
Regime two (Post-Fordist):	Atkinson Index	2.140e-08**	0.196***
		(8.255e-09)	(0.023)

Notes: Least Absolute Deviation estimates computed using the Barrodale-Roberts simplex algorithm for average output over the 2000 periods, 25 replications. LAD standard errors computed using 500 bootstraps. *** p<0.01, ** p<0.05, * p<0.1

Table 8: ***Inequality and Otuput***

		b 1,4	1,5	1,6	1,7	1,8
	1	0,139***	0,163***	*0,190*	0,220***	0,254***
	0,95	0,139***	0,163***	0,190	0,220***	0,254***
ε^A;	0,9	0,139***	0,164***	0,189	0,219***	0,256***
ε^P	0.85	0,139***	0,163***	0,189	0,219***	0,253***
	0,8	0,140***	0,162***	0,190	0,219***	0,254***
	0,75	0,140***	0,162***	0,189	0,219***	0,253***

Notes: Mean values over 20 replications for the average Atkinson index over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 9: ***Atkinson index for different wage multipliers and elasticities of the minimum wage to productivity and consumer price***

		b				
		1,4	1,5	1,6	1,7	1,8
	0,1	0,134***	0,157***	0,185***	0,216***	0,249***
	0,15	0,139***	0,163***	*0,189*	0,219***	0,253***
π	0,2	0,144***	0,167***	0,193***	0,223***	0,256***
	0,25	0,149***	0,173***	0,198***	0,228***	0,261***
	0,3	0,155***	0,176***	0,202***	0,229***	0,262***
	0,35	0,159***	0,181***	0,206***	0,234***	0,266***

Notes: Mean values over 20 replications for the average Atkinson index over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 10: ***Atkinson index for different wage multipliers and profit shares used for premia***

		ϑ				
		0.06	0.07	0.08	0.09	0.1
	$\bar{0}.725$; $\bar{0}.275$	0,196***	0,194***	0,193***	0,192***	0,192***
	$\bar{0}.775$; $\bar{0}.225$	0,193***	0,193***	0,191***	0,189	0,188
$\lambda_{p,1}$;	$\bar{0}.825$; $\bar{0}.175$	0,191***	0,191**	*0,189*	0,186***	0,185***
$\lambda_{q,1}$	$\bar{0}.875$; $\bar{0}.125$	0,189	0,187*	0,186***	0,185***	0,183***
	$\bar{0}.925$; $\bar{0}.075$	0,187**	0,186***	0,184***	0,182***	0,182***
	$\bar{0}.975$; $\bar{0}.025$	0,186***	0,184***	0,183***	0,182***	0,181***

Notes: Mean values over 20 replications for the average Atkinson index over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 11: ***Atkinson index for different levels of competition***

		b				
		1,4	1,5	1,6	1,7	1,8
	0,1	4864020***	4235668***	4011631**	3683588	3376438***
	0,15	4661710***	4203255***	*3759496*	3394171***	3280909***
π	0,2	4654574***	3987314*	3519672***	3335034***	3179175***
	0,25	4305037***	4070668*	3631770	3280466***	3074743***
	0,3	4439873***	3781925	3428948**	3108936***	2915391***
	0,35	4187097***	3697132	3257111***	3058699***	2824506***

Notes: Mean values over 20 replications for the average output over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 12: ***Real output for different wage multipliers and profit shares used for premia***

		b				
		1,4	1,5	1,6	1,7	1,8
	1	4740017***	4369584***	*3820829*	3416749,5***	3271559***
	0.95	4745794***	4230409***	3816053	3394517***	3264894***
ε^A;	0.9	4596226***	4265252***	3715884	3549755***	3278798***
ε^P	0.85	4595772***	4156223***	3717243	3526538***	3280086***
	0.8	4846935***	4109146***	3835208	3451350***	3247899***
	0.75	4999338***	4167746***	3660339,5**	3469940***	3303616***

Notes: Mean values over 20 replications for the average output over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 13: ***Real output for different wage multipliers and elasticities of the minimum wage to productivity and consumer price***

		ϑ				
		0.06	0.07	0.08	0.09	0.1
	$\bar{0}.725; \bar{0}.275$	3437995***	3750586***	4037649	4475096***	5066091***
	$\bar{0}.775; \bar{0}.225$	3330494***	3823845**	4147320	4244693	4757535***
$\lambda_{p,1}$;	$\bar{0}.825; \bar{0}.175$	3259839***	3731741***	*4094730*	4179639	4659407***
$\lambda_{q,1}$	$\bar{0}.875; \bar{0}.125$	3230594***	3570274***	4044367	4312567**	4694119***
	$\bar{0}.925; \bar{0}.075$	3136186***	3501718***	3917487*	4200508	4742372***
	$\bar{0}.975; \bar{0}.025$	3156582***	3461134***	3908788*	4431726	4821741***

Notes: Mean values over 20 replications for the average output over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 14: ***Real output for different levels of competition***

		η_λ				
		0.2	0.23	0.25	0.27	0.3
	0.3	3740007	3699658	3706482	3726182	3633038
	0.35	3970438***	3800109	3823381*	3783792	3921054***
η	0.4	3723198	3645007	*3653136*	3737845	3775070*
	0.45	3722838	3700330	3788916	3797486*	3732221
	0.5	3847599**	3780407	3798296*	3841521**	3752458

Notes: Mean values over 20 replications for the average output over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 15: ***Real output for varying differences in consumption shares and consumer preferences across consumer classes***

		η_λ				
		0.2	0.23	0.25	0.27	0.3
	0.3	*0.1880*	0.1885	0.1880	0.1890	0.1897
	0.35	0.1889	0.1884	0.1886	0.1903*	0.1903**
η	0.4	0.1889	0.1886	*0.1886*	0.1896	0.1902**
	0.45	0.1878	0.1879	0.1888	0.1898	0.1899*
	0.5	0.1881	0.1880	0.1886	0.1902*	0.1899

Notes: Mean values over 20 replications for the average Atkinson index over 2000 simulation steps. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p<0.01, ** p<0.05, * p<0.1

Table 16: ***Atkinson index for varying differences in consumption shares and consumer preferences across consumer classes***

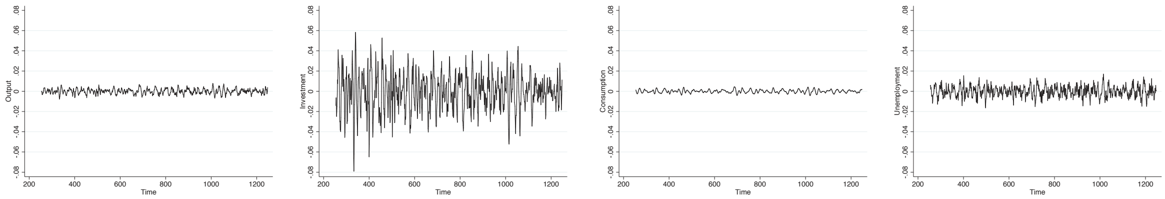
		Real output	Const.
Regime 1 (Fordist)	Labour Productivity	4.44e-08***	1.828***
		(2.431e-09)	(0.003)
Regime 2 (Post-Fordist)	Labour Productivity	4.11e-08***	1.872***
		(8.255e-099)	(0.023)

Notes: Least Absolute Deviation estimates computed using the Barrodale-Roberts simplex algorithm for average output over the 2000 periods, 25 replications. LAD standard errors computed using 500 bootstraps. *** p<0.01, ** p<0.05, * p<0.1

Table 17: ***Labour Productivity and Output***

F Empirical Validation

The feedbacks between technological and demand dynamics generate business fluctuations.[46] Figure 4 plots business cycles for output (4a), investment (4b), consumption (4c), and unemployment (4d) computed using the Hodrick-Prescott high-pass filter. To make the fluctuations comparable, the cyclical component was normalised by the series trend.



(a) Output (b) Investment (c) Consumption (d) Unemployment

Notes. The four panels exhibits the cyclical components of output (4a), investment (4b), consumption (**??**), and unemployment (4d). To separate the trend from the cyclical component we employ a Hodrick-Prescott high-pass filter. The cyclical component is normalised by the series trend.

Figure 4: **Cyclcical component of the main macro variables**

All series exhibit fluctuations that are qualitative similar to those observed in the data (Assenza et al., 2015; Caiani et al., 2016; Dosi et al., 2010, 2015). The volatility of employment and investment is significantly higher than that of consumption and output. Consumption is less volatile than output. Differently from observed time series, in our model investment is more volatile than employment. This is related to the lumpiness of capital stock investment which in our model is constrained by the choice of capital good producers, and their production cue (we do not model entry of new firms in the capital good sector).

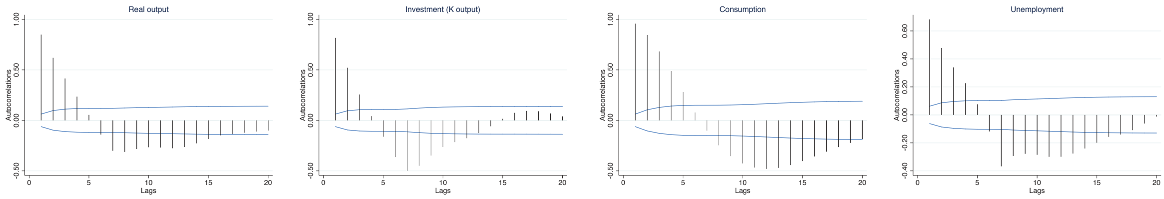
Figure 5 plots the autocorrelation structure for de-trended real output (5a), investment (5b), consumption (**??**), and unemployment (5d) for 20 lags. The simulated series are quite similar to real series (Assenza et al., 2015). The first lag autocorrelation of real series estimated by Assenza et al. (2015) for output, investment, consumption, and unemployment are, respectively, 0.8485, 0.7952, 0.8176, 0.6454. For our simulated series, the first lag autocorrelations are 0.8492, 0.8169, 0.9577, and 0.6826.

Figure 6 plots the cross-correlation between the cyclical component of real output and the cyclical components of, respectively, real output (6a), investment (6b), consumption (6c), and unemployment (6d) for 10 lags. Investment is pro-cyclical and coincident, consumption follow with a couple of lags, as in Caiani et al. (2016), and short term unemployment is countercyclical and coincident.

The model replicates a number of other macro stylised facts (Caiani et al., 2016; Dosi et al., 2010, 2015). Figure 7 plots the cross-correlation between the cyclical component of real output and a number of other aggregate dynamics. In line with the literature, growth of inventories is pro-cyclical and increases sharply (7a); the ratio between inventories and sales is counter cyclical (7b); average wages are pro-cyclical but lagged (7c); whereas average mark-ups are counter-cyclical (7d).

Labour market regularities also emerge in our model. Figure 8a plots the Beveridge curve. We estimated the relation between the vacancy rate and the unemployment rate for the 100 simulation replicates, and for the whole sample. The light gray series are the single run curves obtained from plotting the residuals of the following polynomial regression of order two: $u_{tr} = \alpha^b + \alpha_1^b v_{tr} +$

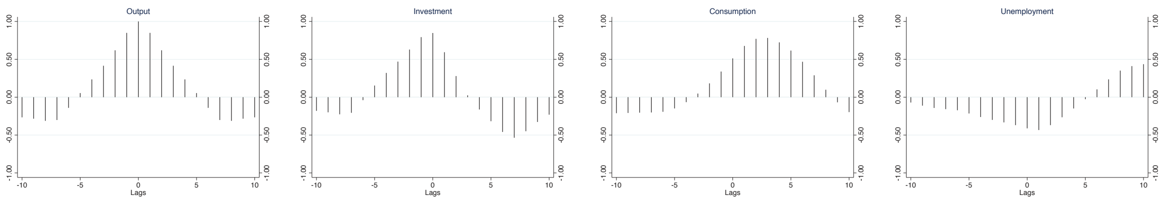
[46]As we have observed earlier, the feedbacks are slightly more complex at the micro level, depending on firms' growth and competition, which depends on their investment in product and process innovation and on consumer preferences, which depend on firm growth and industrial dynamics.



(a) Output (b) Investment (c) Consumption (d) Unemployment

Notes. The four panels exhibits autocorrelation graphs for de-trended real output (5a), investment (5b), consumption (5c), and unemployment (5d) for 20 lags. The autocorrelations is computed with pointwise confidence intervals (light blue lines) based on Bartlett's formula for moving average time series of order 20 (MA(20)). On the horizontal axis are the number of lags and on the vertical axis the autocorrelation.

Figure 5: **Autocorrelation of the main macro variables: output, investment, consumption, and unemploymnet**



(a) Output (b) Investment (c) Consumption (d) Unemployment

Notes. The four panels exhibits crosscorrelation plots between the cyclical component of real output and the cyclical component of real output (6a), investment (6b), consumption (6c), and unemployment (6d) for 10 lags. On the horizontal axis are the number of lags and on the vertical axis the crosscorrelation between the cyclical components of the two series at a given lag.

Figure 6: **Crosscorrelation between the cyclical component of output and the main macro variables: output, investment, consumption, and unemploymnet**

$\alpha_2^b v_{tr}^2 + \iota^b + \alpha_3^b v_{tr}\iota^b + \varepsilon_t^b$, where r is a simulation iteration, ι^b is a run fixed effect, and ε^b the residual. The black series is the regression fit of the data pooled from the different series, and the red bands represent the confidence interval. Overall, the curve is quite close to that found from a number of countries (Nickell et al., 2002).

We also tested for the wage curve. Because in our model the wage curve shifts with changes in price and productivity, plots are not particularly informative. We estimated the relation between unemployment rate and wages with a panel estimator with fixed effects and robust standard errors clustered at the simulation run level, controlling for the indexes of productivity and price.[47] Table 18 shows that the results are remarkably close to the empirical evidence across countries (Nijkamp and Poot, 2005).

We estimated the distribution of quarterly output growth rates and find that they are not normally distributed,[48] and that the moment's values are quite similar to to those estimated by Fagiolo et al. (2008) for US data[49] Figure 8b plots the skewed distribution.[50]

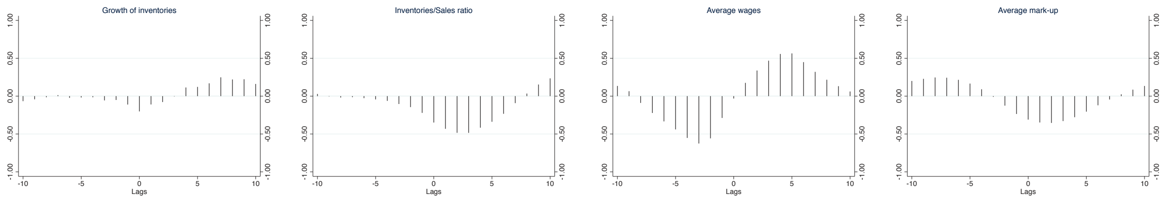
The model replicates as well some well known meso and micro stylised facts. Figure 9 plots the distribution of firm's size measured by quantity and employees, averaged across periods and

[47] We estimated the following equation: $\ln \bar{w}_t^r = \alpha^w + \beta^w \ln u_t^r + \gamma_0^w cpi_t^r + \gamma_1^w pi_t^r + \varepsilon_t^r$; where $\bar{w}$ is the average wage across classes, cpi is the consumer price index and pi is the productivity index, respectively the ratio between the price and productivity in $t > 0$ and the price and productivity in $t = 0$.

[48] The Shapiro-Wilk and the skewness and kurtosis tests for normality reject the normality hypothesis.

[49] Mean=0.00996, standard deviation=0.012, kurtosis=3.76. Skewness is larger in our simulations and equals 0.39.

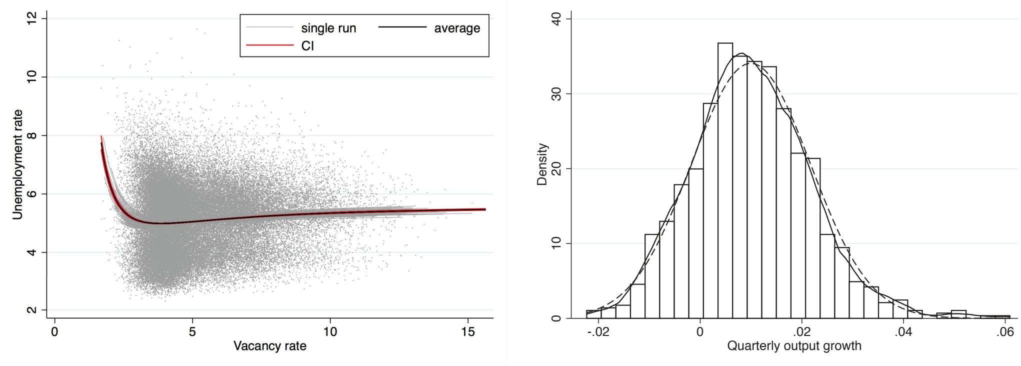
[50] We obtain results similar to the empirical evidence also for the fortnightly growth rates.



(a) (b) (c) (d)

Notes. The four panels exhibits cross-correlation plots between the cyclical component of real output and the cyclical component of inventories growth (7a), inventories/Sales ratio (7b), average wages (7c), and average mark-up (7d) for 10 lags. On the horizontal axis are the number of lags and on the vertical axis the crosscorrelation between the cyclical components of the two series at a given lag.

Figure 7: **Crosscorrelation between the cyclical component of output and other aggregate variables: inventories, wages, prices and mark-up**



(a) Beveridge curve (b) Output growth rate distribution

Notes. The left panel (8a) plots the estimation of the Beveridge curve for 60 runs (light grey series) and the estimation of the Beveridge curve for the pooled sample of the 100 series for 1000 time periods. The red band is the confidence interval of the aggregate curve. On the horizontal axis is the vacancy ratio (number of vacancies over employment) and on the vertical axis is the unemployment rate. All series are estimated with a polynomial regression of order 2. The right panel 8b exhibits the real output growth rate distribution (continuous line) against the normal distribution (dashed line) for the average growth rate across the 100 runs.

Figure 8: **Beveridge curve and output growth rate distribution**

pooled across the 100 series. The plot shows the relation between the log size and the log rank, compared with a log normal distribution with the same average and standard deviation. Both measures show a striking similarity with real data. The final distribution of firms' size is related to their growth process, which, as expected, is also not normally distributed and has a high kurtosis.[51] The distribution of firm growth emerging from our model is closer to a Laplace distribution than to a Gaussian distribution (Figure 9c and 9d) although it does not fit perfectly with a Laplace distribution.

Firms also differ with respect to their productivity and these differences build through time and tend to be persistent. We plot the time pattern of the productivity series for the "oldest" 14 firms surviving until the end of the simulation in a random replication (Figure 10c). All firms tend to maintain their relative position with respect to competitors. Figure 10a plots the average and standard deviation across all firms across all 100 simulation replicates. The average sharply increases, as well as the differences across firms (standard deviation).

[51] 11.3 for quarterly growth rate of output and 7.8 for quarterly growth of employees. For both series the Skewness/Kurtosis tests for normality and the Shapiro-Wilk test reject the null hypothesis of normal distribution.

	(1)
VARIABLES	Wage (log)
Unemployment (Log)	-0.14***
	(0.05)
Prod Index	0.00***
	(0.00)
CPI	0.02***
	(0.00)
Constant	4.21***
	(0.22)
Observations	100,100
Number of id	100
R-squared	0.98
within R^2	0.981
F	64662
Prob > F	0

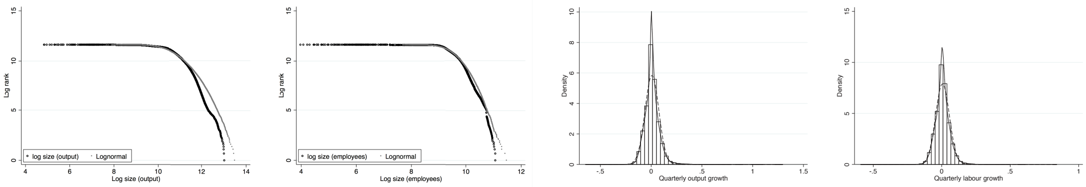
Notes. Panel regressions with fixed effects of unemployment on wages. Both variables are in natural logs, and the coefficient measures the elasticity between them. Prod Index is the index of labour productivity change between t and $t = 0$. CPI is the consumer price index between t and $t = 0$. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 18: ***Wage curve***

We also studied the autocorrelation of firms' productivity for all firms for the first replication employing the Cumby-Huizinga test, controlling for heteroskedasticity for the possibility that the series may exhibit arbitrary autocorrelation (Baum and Schaffer, 2013). Table 19 shows that there is strong and significant correlation at the micro level, both looking at the range between the first and the fifth lag, and for each lag, controlling for autocorrelations in the previous lag.

As a result of the vertical interaction between final good firms and capital good suppliers, our model also shows significant lumpiness in capital stock investment. Figure 10d plots the time pattern of the capital stock of the "oldest" 14 firms that survive until the end of the simulation in a random simulation replicate. Capital stocks depreciates through time and investment in new stocks is clearly lumpy.

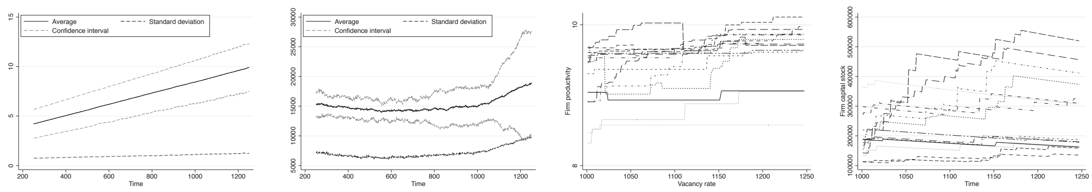
Finally, as discussed by Poschke (2015) the average size of firms has increased substantially in the last century, as well as the dispersion – increasing the skewness of the size distribution. Figure 10b plots the average of both the within run average and standard deviation of firms across 25 replications. Following an initial decrease, both the average firm size and dispersion increase substantially.



(a) Size (output) (b) Size (employees) (c) Growth (output) (d) Growth (labour)

Notes. The first two plots show the relation between the log of firm size (horizontal axis) and the log of the size rank (vertical axis). Size is measured as firm output (9a) and employment 9b. We pool all firms across the 100 time series and average size over the firm life span. Black circles represent the distribution of simulated firms, whereas grey circles represent a log normal distribution. The last two plots show the distribution of firm size quarterly growth with respect to output (9c) and employees (9d).

Figure 9: **Log-log plot of firm size distribution**



(a) Firm productivity (b) Firm size (c) Productivity: 14 firms (d) Capital stock: 14 firms

Notes. The three panels plot micro regularities across the firms. Panel 10a plots the average and the standard deviation of the productivity of all firms across all 100 simulation replicates. Panel 10b plots the average of the within simulation average across 25 simulation runs (with confidence interval) and the average standard deviation within 25 simulation runs. Panel 10c plots the series of the 14 "oldest" firms in the the first simulation replication. Panel 10d plots the capital stock of 14 "oldest" firms in the the first simulation replication.

Figure 10: **Firm productivity, capital, and size**

H0: q=0 (serially uncorrelated) HA: s.c. present at range specified				H0: q=0 (serially uncorrelated) HA: s.c. present at range specified			
lags	chi2	df	p-val	lag	chi2	df	p-val
1-1	525.306	1	0.00	1	525.306	1	0.00
1-2	525.309	2	0.00	2	506.186	1	0.00
1-3	540.39	3	0.00	3	451.117	1	0.00
1-4	541.171	4	0.00	4	295.336	1	0.00
1-5	541.877	5	0.00	5	71.669	1	0.00

Notes. Cumby-Huizinga test for autocorrelation for panel data with large sample size (Baum and Schaffer, 2013) under the null hypothesis of no autocorrelation at any lag order. Test robust to heteroskedasticity. Test also corrected for the possibility that the series may exhibit arbitrary autocorrelation. The left panel report the lag range (between the first and the the last period). The panel on the right reports the correlation at each lag.

Table 19: ***Autocorrelation of firm productivity***

G Extra Tables

		ϑ				
		0.06	0.07	0.08	0.09	0.1
	$\bar{0}.725; \bar{0}.275$	89.30***	96.36**	103.27***	110.90***	119.01***
	$\bar{0}.775; \bar{0}.225$	84.86***	93.58	100.05***	103.97***	111.82***
$\lambda_{p,1}$;	$\bar{0}.825; \bar{0}.175$	80.25***	88.24***	*94.01*	98.46***	105.54***
$\lambda_{q,1}$	$\bar{0}.875; \bar{0}.125$	75.27***	82.21**	89.96***	94.97	100.63***
	$\bar{0}.925; \bar{0}.075$	70.82***	78.07***	84.08***	89.46***	95.45
	$\bar{0}.975; \bar{0}.025$	67.84***	73.29***	79.70***	84.80***	90.59***

Notes: Mean values over 20 replications for the average inverse herfindahl index over 2000 simulation steps. The index is computes using sales, across all sectors. The significance of the difference between the benchmark configuration (in italics) and each pair of parameters is computed with a t-test: *** p$<$0.01, ** p$<$0.05, * p$<$0.1

Table 20: ***Inverse Herfindahl Index for different levels of competition***