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Abstract

The paper builds upon the Agent Based-Stock Flow Consistent model presented in Caiani et al. (2015) to analyze the relationship between income and wealth inequality and economic development. For this sake, the original model has been amended under three main dimensions: first, the households sector has been subdivided into workmen, office workers, researchers, and executives which compete on segmented labor markets. Conversely, firms are now characterized by a hierarchical organization structure which determines, according to firms' output levels, their demand for each type of workers. Second, in order to account for the impact of income and wealth distribution on consumption patterns, different households classes - also representing different income groups - have diversified average propensities to consume and save. Finally, the model now embeds technological change in an evolutionary flavor, affecting labor productivity evolution in the consumption sector through product innovation in the capital sector, where firms invest in R&D and produce differentiated vintages of machineries.

The model is then calibrated using realistic values for both income and wealth distribution across different income groups, and their average propensities to consume. Results of the simulation experiments suggest that more progressive tax schemes and labor market policies aiming to increase low and middle workers' coordination, and to support their wage levels, concur to foster economic development and to reduce inequality, though the latter seem to be more effective under both respects.

The model thus provides some evidence in favor of a wage-led growth regime, where improvements of middle-low levels workers' conditions create positive systemic effects, which eventually trickle up also to high income-profit earners households.

Keywords: Innovation, Inequality, Agent Based Macroeconomics, Stock Flow Consistent Models.
JEL Codes

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1 Introduction

Over the last thirty years inequality has kept rising, both in terms of personal income and wealth distribution (OECD, 2011), and functional distribution between profits and wages (Karanassou and Sala, 2010). After the political changes of the 1980s, a decline of the wage share has occurred in advanced countries, especially in unskilled sectors (IMF, 2007, Chapter 5), thus increasing inequality in the distribution of labor income. Hence, there have been both an increase of the national incomes' share claimed by capital owners and a rise of top labor incomes, while income levels in the middle-low range of the wage distribution have stagnated. This has been well described by the Piketty (2014)'s best-seller *Capital in the Twenty-First Century*: in particular, Piketty's book documents the increase in the capital share, the rising value of capital assets relative to national income, and the huge increase of inequality in the personal income distribution. Furthermore, data also suggest that, at least in the US, the dramatic increase of inequality is mainly due to the rise of top labor incomes (Atkinson et al., 2011),[1] as those gained by the top managers. Though there are differences between countries, top income inequality increased in all countries for which data are available, as shown by Jones and Kim (2014) who compare data from the World Top Income Database regarding the share of national income going to top 1% income earners in two periods: 1980-1982 vs. 2006-2008.

A vast literature has stressed the role of skill-biased technical change in explaining the increase in labor income inequality since the 1970s (see, for instance, Katz and Murphy (1992), Acemoglu (1998), Acemoglu (2002), Acemoglu (2007), and Goldin and Katz (2008)). Moreover, inequality may rise due to the impact of general purpose technologies, by favoring workers that are able to adapt faster than others (Aghion and Howitt, 1997). Beyond the role of the skill-premium as a broad measure of wage inequality, various explanations have been proposed for the increase of *top* income inequality. According to Piketty et al. (2014), such an increase is linked to the decline in top tax rates and the concomitant increase in rent seeking. Rising financial rents account for 30% to 50% of the wage differential between the financial sector and the rest of the private sector, as stressed by Philippon and Reshef (2009); in particular, they found that financial jobs were relatively skill intensive, complex, and highly paid until the 1930s and after the 1980s and that wages in finance were excessively high around 1930 and from the mid of 1990s on. However, other contributions (see, for instance, Kaplan and Rauh (2010)) argue that not only top managers and financial jobs, but also other occupations like doctors, lawyers, accountants, and athletes concur to determine the huge increase in top income inequality.[2] These studies suggest that the increase in top income inequality has to be related more to financial deregulation, tax laws and regulations in favor of the rich, rather than to technological factors and other explanations based on the alleged greater productivity of top income earners (Stiglitz, 2012).

Some authors, however, investigated the interplay between innovation dynamics and top income inequality. Jones and Kim (2014) proposes a Schumpeterian model in which income is Pareto distributed: in particular, the log of income is proportional to "entrepreneurial experience" whereas the distribution of experience is exponential. Combining these two ingredients, they obtain that exponential growth occurs over an exponentially-distributed amount of time thus delivering a Pareto distribution of income. In such a framework, an increase of the growth rate of top earners widens the distribution, while an increase of the "death rate", that is creative destruction, reduces top income inequality. All in all, Jones and Kim (2014) find a negative relationship between growth and top income inequality. The rationale for this result is that higher inequality tends to reduce growth by making research riskier; by contrast, faster growth boosts creative destruction which lowers inequality.[3] A different result is reached by Aghion et al. (2015) who employ as well a Schumpeterian framework with top income inequality.[4] Their finding is that more innovation-led growth should both increase the income of top earners (reflecting innovation rents) and social mobility (which reflects creative destruction). More precisely, technological innovations allow the entrepreneur to increase his technological advantage over competitors, reducing labor requirements at the expense of workers' share of income, at least temporarily. Therefore, there is a positive effect of innovation on top income inequality. At the same time, more innovation implies more creative destruction, with new entrants replacing incumbent firms. Therefore, innovation exerts a positive influence on

[1] This is even more evident if we include "business income" (as profits from sole proprietorships, partnerships and S-corporations) in the labor income category (Jones and Kim, 2014).

[2] See also Bivens and Mishel (2013) who stress the role of rents accruing to the top 1%.

[3] For example, globalization can have two different effects: on the one hand, it allows entrepreneurs to grow their profits more rapidly, for a given effort, thus increasing top income inequality; on the other hand, more competition among countries makes the death rate to rise thus resulting in more creative destruction and then less inequality.

[4] Admittedly, according to Aghion et al. (2015), the negative correlation between top income inequality and innovation depends on the Jones and Kim (2014)'s definition of "innovation" as the result of the innovative efforts by entrants only.

social mobility.[5] Finally, Antonelli and Gehringer (2013) maintain that technological change is a powerful factor in reducing income inequality for two main reasons: i) innovation boosts economic growth, increasing wage levels and thus reducing inequality; ii) innovation enhances market competition, in particular on prices of factors and producucts, thus dampening the accumulation of rents and resulting in lower income inequality. At the same time, inequality affects the dynamics of technological change: the lower inequality, the higher the incentives to increase human capital, and then the faster is economic growth.

In general, there does not seem to exist a general consensus on the relationship between innovation and inequality. Weinhold and Nair-Reichert (2009) analyzed a large sample of countries in the period 1994-2000 finding that a larger income share of the middle class (staying for a more equitable distribution) positively affects innovation, due to a positive effect on the quality of public and private institutions. As for the US, Jacobs (2016) finds that rising inequality results in a decline of innovative dynamism, with different implications for the bottom (children born from wealthy parents are far more likely than poor children to obtain a patent in life),middle (the stagnation of real incomes preventing many individuals to start an enterprise),[6] and top earners (the increasing fraction of top earners employed in finance and financialization has promoted a short-term view with negative consequences for production activities and innovation). Acemoglu et al. (2012) argue that a country, to be innovative, needs to adopt a "cut-throat" form of capitalism, like the US, in order to have the right incentives to be at the frontier of technological development; by contrast, countries characterized by a "cuddly" form of capitalism, more equality and redistribution, tend to hamper innovation. Yet, some countries, such as the Scandinavian ones, are quite successful in combining efficiency and equality. Hopkin et al. (2014) note that the advantage position of the US in technological development is manly circumscribed to patent filing: according to this indicator, Acemoglu et al. (2012) find that the US has outperformed the Scandinavian countries in the last two decades. However, Hopkin et al. (2014) also point out that Sweden outperforms the US in terms patent filings per resident, when we consider more decades, thus casting some doubts on the preeminence of "cut-throat" capitalism over its "cuddly" variety. Moreover, the phenomenon of "patent trolling" (that is, the use of patents as a deterrent to competitors rather than as a source of productive innovation) suggests that patent filing may measure rent-seeking behavior instead of innovation activity. By using an alternative indicator, that is the Global Innovation Index (GII) for 2013,[7] Hopkin et al. (2014) find that the less unequal a country is, the more likely it is to be innovative. Furthermore, while Acemoglu et al. (2012) assume that inequality and lower taxes on top incomes should be positively associated with innovation, Hopkin et al. (2014) find that, if anything, the opposite case is far more likely, though the positive link between higher tax rates and innovation is not robust to the introduction of some control variables. Even though more evidence is needed to assess the relation between inequality (and tax rates) and innovation, empirical evidence suggests that more egalitarian societies can reach high innovative performance as well, building upon good institutions and an active role by the state in promoting innovation: in order to boost innovation while preserving social inclusion (Mazzucato, 2013), this latter should not be confined to public funding of universities and research centers, but should also encompasses an active role in the very creation of new markets and their regulation.

Nonetheless, the involvement of the state in the economy has been downsized in the last three decades, according to Reagan's motto that the government is not the solution to our problem, government is the problem. In addition, labor market deregulation and the fall of the unionization rate have been observed in most developed countries, being identified by many as two of the main causes of the wage share's decline and the concomitant rise of incomes at the top, together with financial deregulation and top income tax rates cuts, as stressed by Jaumotte and Buitron (2015). Indeed, the lowest growth of real wages is found to be in those countries having more flexible labor markets, weak labor unions, and limited social welfare (Vergeer and Kleinknecht, 2010). While real wages and labor productivity had evolved along similar patterns for the three decades after WWII, their paths started to diverge since the 1970s onward, as real wages stagnated or even decreased, whereas labor productivity continued to grow, thereby opening a huge gap between productivity and the typical worker's wage. For instance, in the US, productivity and hourly compensation increased by 96% and 91.3% respectively during the period 1948-1973, while the correspondent rates for the period 1974-2014 are 72.2% and 9.2% (Bivens and Mishel, 2015). This implied

[5] As noted by Aghion et al. (2015), the finding that more innovation should increase both top income inequality and social mobility is reflected by the fact that California, the most innovative state in the US, has both a top 1% income share and a degree of social mobility that are much higher than in the least innovative state, that is Alabama, as reported in Chetty et al. (2015).

[6] Moreover, an increase of financial fragility due to more indebtedness and a precarious lifestyle have reduced the risk tolerance of this class of individuals (Jacobs, 2016).

[7] The GII aims at capturing the multi-dimensional facets of innovation; it includes five input pillars that summarize the innovative activities of a country: i) institutions, ii) human capital and research, iii) infrastructure, iv) market sophistication, and v) business sophistication; the two output pillars are i) knowledge and technology outputs and ii) creative outputs.

a change of the income functional distribution in favor of capital which prompted wealth accumulation at the top.

Changes in the distributive regime within a given institutional framework can have relevant implications for macroeconomic dynamics. According to the Keynesian tradition, changing the distribution in favor of the rich may reduce aggregate demand due to the different propensities to consume which characterize different income groups. Though credit may allow to temporarily overcome the deficiency of aggregate demand due to stagnation of wages of lower income groups, the ensuing increasing indebtedness enhances the financial fragility of the system. Therefore, the expansion of finance in a context of high income and wealth polarization, can only postpone,and possibly amplify, the crisis due to the rise of inequality. Though there is no conclusive empirical evidence of a direct link between inequality and crisis episodes, inequality can eventually result in a large crisis through the rise of indebtedness, as found by Perugini et al. (2016). This mechanism has been described by Kumhof et al. (2015) and Russo et al. (2016), in a Dynamic Stochastic General Equilibrium (DSGE) framework and using an Agent Based Modeling (ABM) approach, respectively.

Apart from the role of households' indebtedness, a distributive regime that favors capital over labor can have opposite effects: i) the increase of the profit share may boost investment and thus economic growth; ii) the decline of the wage share may lower consumption and thus economic growth. Which one of the two effects prevails depends on macroeconomic and institutional conditions. This question led to a resurgence of the debate between wage-led (trickle-up) and profit-led (trickle-down) growth regimes (see Lavoie and Stockhammer (2012) and Stiglitz (2015)).[8] The settlement of the dispute requires to assess the impact of different distributive regimes on the evolution of the demand and supply sides of the economy. In a closed-economy which abstracts from the role of imports and exports,[9] this asks to analyze how income and wealth distribution affects households' patterns of consumption and firms' investment determinants, that is entrepreneurs' "animal spirits". These latter not only represent a fundamental component of aggregate demand, but also a fundamental engine of technological change and labor productivity growth.[10] As for the demand side, a wage-led growth strategy rests on the positive effect of wage share increases on consumption, which in turn stimulates investment to keep up with rising demand. On the supply side, the expansion of investment and consumption may increase productivity levels, according to the Kaldor-Verdoon effect (see, for instance, McCombie and Thirlwall (1994) and McCombie (2002)). On the contrary, investment is profit-led if a wage increase discourages productivity-enhancing capital investment and a decrease of labor productivity follows. Based on data of G-20 countries, Onaran and Galanis (2012) find that the domestic demand regime tends to be wage-led in all economies.[11] This is an important result in the perspective of the closed-economy model we propose in this paper. Moreover, "higher employment protection and more extensive labor market regulation are associated with higher labor productivity growth" (Storm and Naastepad, 2012). Indeed, "unregulated markets, weak employment protection, low taxes, high earnings inequalities, and weak unions are not at all necessary to sustain high rates of labor productivity growth; in actual fact, they are detrimental to technological dynamism" (Storm and Naastepad, 2012, p. 108). This is confirmed by Vergeer and Kleinknecht (2014) who find that weak wage growth and a smaller wage share significantly reduce labor productivity growth.

The focus on the distribution of income between capitalists and workers, which characterizes several heterodox schools of thought (e.g. the classical-Marxian and post Keynesian lines of research) is also common to several contributions in the growing Agent Based Macroeconomic Modelling literature.[12]

[8] As highlighted by Lavoie and Stockhammer (2012), the benefits of a wage-led growth strategy have been resurrected and formalized by several authors in the field of post-Keynesian and Kaleckian economics starting with Rowthorn (1981), Taylor (1983), and Dutt (1987).

[9] In a closed-economy framework, as the one we propose, it is not possible to analyze the export-driven strategy in which the decrease of the wage share allows firms to compress production costs, thus improving the competitiveness of commodities in the world market, and resulting in a profit-led regime.

[10] Another strategy we do not consider in our framework is debt-led growth in which the increase of indebtedness allows households to keep unchanged or even increase their consumption, in spite of a stagnation or a reduction of wages.

[11] In an open economy context, total demand may be profit-led due to the prevailing effect of net export over domestic demand. For instance, global demand remains wage-led for European countries and the US, while it becomes profit-led for China (Onaran and Galanis, 2012).

[12] Besides the already mentioned Dosi et al. (2010), Ciarli et al. (2010) and their later contributions, the recent literature provides several other examples of prominent "families" of AB macroeconomic models, such as the EURACE models and the "Ancona-Cattolica" models. Contributions in the former group (Deissenberg et al., 2008; Cincotti et al., 2010; Raberto et al., 2012; Dawid et al., 2012, 2014; van der Hoog and Dawid, 2015) is based on a massively large-scale economic model of the EU economy first developed in 2006 and now implementing many hyper-realistic features such as day-by-day interactions, geographical space, and a huge variety of agents, including international statistical offices; the Ancona-Cattolica family develops from successive sophistications of Delli Gatti et al. (2010) and the ensuing stream of works on the financial accelerator. Recent contributions of this group are Riccetti et al. (2014) and later variations, Assenza et al. (2015), and Caiani et al. (2015).

Based on the "Keynes+Schumpeter" (KS) model (Dosi et al., 2010), Napoletano et al. (2012) study how the interplay between firms' investment behavior and income distribution shapes macroeconomic dynamics in the short and long run. They focus on two scenarios: a first one in which investment is fully determined by past profits which create more favorable conditions for a profit-led regime to emerge, and a second one in which investment is related to expectations on future consumption, thus making a wage-led growth regime more likely. Regardless the investment scenario employed, they find that steady growth with low unemployment needs a balance in the income distribution between profits and wages, otherwise either stagnation equilibria or growth trajectories with high volatility and unemployment rates can emerge. As for the wage-unemployment nexus, they show that a positive (Neoclassical) relation only emerges under the scenario which makes a profit-led regime more likely to occur. Under the opposite scenario, this relation is non-linear and a threshold exists under which unemployment increases as real wages decrease. Moreover, wage flexibility is able to restore growth only under the profit-led scenario thereby casting some doubts on the general validity of labor flexibility as a recipe for boosting economic growth (on this point see also Dosi et al. (2016)).[13] Similarly, Dosi et al. (2013) show that unequal economies are exposed to more severe business cycle fluctuations, higher unemployment rates, and higher probability of crises. They also find that fiscal policy is an effective stabilization tool and that the more the distribution is skewed towards profits the greater the effect of fiscal policy. Also monetary policy efficacy comes to depend on income distribution: monetary policy is effective when the profit-to-GDP ratio is low; by contrast, the higher the profit share the lower the investment of firms in the expansion of production capacity (that is, firms prefer to keep funds idle), so that monetary policy is completely ineffective in stimulating the real sector through the credit channel.

Though the impact of the functional distribution of income on macroeconomic dynamics is topical, we should not neglect the dramatic increase of inequality in the personal income distribution.[14] Dutt (2016) incorporates "vertical inequality" in both classical-Marxian and post Keynesian models by considering two groups of people representing top earners and the rest of the income distribution, each one receiving both labor and capital income. Whithin this framework, Dutt (2016) shows that an increase of the income share at the top promotes financialization, and that the growing weight of top managers' income can explain both lower rates of economic growth and rising inequality, which concomitantly depresses aggregate demand.[15] The ABM appraoch is a natural way to investigate the evolution of the personal distribution of income. For instance, Ciarli et al. (2010) introduce a multi-layer organizational structure according to which firms are characterized by hierarchical tiers (i.e. the proportion of workers and executives) that affect the pay structure: based on the labor productivity of capital vintages, firms hire first-tier workers; then, according to a given parameter, they hire a second-tier of managers to supervise first-tier workers; more managers are needed in a third-tier and so on, depending on the size of the firm. Engineers are also employed to carry out R&D activities. At the end, the number of workers depends on labor productivity and on the parameter governing the proportion between each tier. The different tiers are tied to different pays and then give rise to income-consumption classes which together form the aggregate demand. Moreover, firms produce goods of diversified quality. Lower classes, like first-tier workers, have a high tolerance to lower quality and a low tolerance to higher prices; by contrast, higher classes, e.g. top managers, have a high tolerance for higher price and a low tolerance for lower quality. As for the inequality-growth relationship, Ciarli et al. (2010) find two different patterns in their simulations. A first "demand-led" phase during which productivity is quite stable (capital sector's profit is not large enough to be spent in hiring R&D workers) and population increases, characterized by a virtuous circle between employment, wages and firms' investment; during this phase, the only source of inequality is the emergence of a new (top manager) tier, otherwise income distribution is quite stable. In a second "cumulative causation" phase, productivity starts to increase and product varieties expand; following a

[13] Fana et al. (2015), based on empirical assessment of the effects of the recent Italian reform of the labor market, the so called "Jobs Act", comes to similar conclusions.

[14] In *classical political economy* a perfect correspondence between income types and social classes was assumed, thus incomes received as wages, profits and rents went to the working, capitalist and rentier classes, respectively. But the link between factor shares and income inequality was eroded during the last decades: for instance, there has been an increasing contribution of human capital to the labor share; moreover, wealth held as housing has diffused outside the lites. However, the incomes of the social and economic lite still arise disproportionately as investment income (Ryan, 1996). According to Piketty (2014) the link between factor shares and income inequality remains quite clear due to the more unequal distribution of capital income compared to labor income, so that a transfer from capital to labor income reduces inequality. Such a link, however, may change along time and may vary across region. Nevertheless, there is empirical evidence that supports a positive relationship between capital shares and income inequality, also in the long run (Bengtsson and Waldenstrom, 2015).

[15] This result depends on the existence of a positive link between aggregate demand and investment. By contrast, if growth depends on capital accumulation through saving, then the increase of top managers' income is more likely to increase, rather than decrease, economic growth (Dutt, 2016).

Kaldorian path, aggregate demand increases via a reduction of prices and higher incomes; this phase is characterized by a higher skewness in wage distribution; heterogeneous productivity growth also concurs to increase to more income inequality. After the growth of income has reached a certain threshold, however, inequality stops growing and rather begins to fall (according to a sort of Kutznets curve).[16]

The present paper aims at giving a contribution to the debate on the nexus between inequality and growth by proposing an Agent Based Stock Flow Consistent Macroeconomic Model to assess the impact of different distributive regimes on innovation dynamics and economic development. The model has the same structure of that presented in Caiani et al. (2015). The economy is then composed of a household sector providing labor force to productive units and consuming; a capital sector producing investment goods out of labor; a consumption sector producing final goods out of labor and capital; a banking sector holding deposits by households and firms and providing loans to the latter, and finally a public sector composed of a central bank and a general government. To address our research question we made three major modifications to the original model:

1. In order to assess the impact of income and wealth distribution on consumption patterns, we abandon the common households' consumption function employed in the previous paper and we refer empirical data to determine the propensities to consume out of income and wealth for each income group. For instance, Dynan et al. (2004) find a strong positive relationship between current income and saving rates across all income groups, including the very highest income categories.[17] Given that the marginal propensities to save and to consume differ substantially across income groups, government policies that redistribute across income groups can have real effects on saving and macroeconomic dynamics. We will investigate this aspect by proposing a computational experiment on the progressiveness of taxation. Similarly, since labor market policies are topical as well, we investigate their impact on income and wealth accumulation patterns across social groups via an experiment in which different scenarios mimic different degrees of labor coordination and bargaining power.

2. We consider different classes of agents such as top managers, office workers, researchers and low-tier workers organized in the different layers of firms (Ciarli et al., 2010). While top managers receive dividends out of firms' profits in addition to their wage, other workers consume and save only based on labor incomes. This feature, that mimics the actual behavior of the stock markets in which only a minority benefits from capital incomes, affects the evolution of inequality and then macroeconomic dynamics.

3. Whereas in the original version of the model we abstracted from technological change, here we introduce innovation dynamics affecting the evolution of labor productivity through product innovation in the capital sector (i.e. different vintages characterized by different productivity levels) and process innovation in both the capital and consumption good sectors. Since the seminal work of Nelson and Winter (1977b, 1982), the evolutionary literature has provided well-established mechanisms to model innovation and imitation in a Schumpeterian Mark II flavor, which have been progressively refined through the ages (see for example Dosi et al. (2010) and its later versions). However, in order to better stress the influence of personal and functional distribution of income on labor productivity dynamics, in our framework the evolutionary mechanism of innovation is coupled with a multi-layer firms' organization which, as explained above, is tied to different income classes and various propensity to consume out of income and wealth.

The remainder of this paper is organized as follows. The model setup, the structure of markets and the sequence of events are described in Section 2. Section 3 provides a detailed characterization of agents' behavior. The configuration of the simulation setup, the initial conditions and the parameter space are presented in Section 4. The simulation results of the baseline scenario and a summary of the validation exercise performed are reported in Section 5. Section 6 presents the results of a computational experiment aimed at assessing the role of tax progressiveness. Section 7 is aimed at assessing the impact of wage downward rigidity in two scenarios: a first one in which the same degree of wage rigidity characterizes all workers and a second scenario involving only middle and low tiers workers. Section 8 concludes and set the future lines of this research.

[16] At the end of the simulation, top incomes follow the typical Pareto distribution.

[17] They also find a positive correlation when using proxies for permanent income such as education, lagged and future earnings, and measures of consumption. Estimated saving rates range from zero for the bottom quintile of the income distribution to more than 25 percent of income for the top quintile. The positive relationship is equally strong or even more pronounced when Social Security saving and pension contributions are included.

2 The model

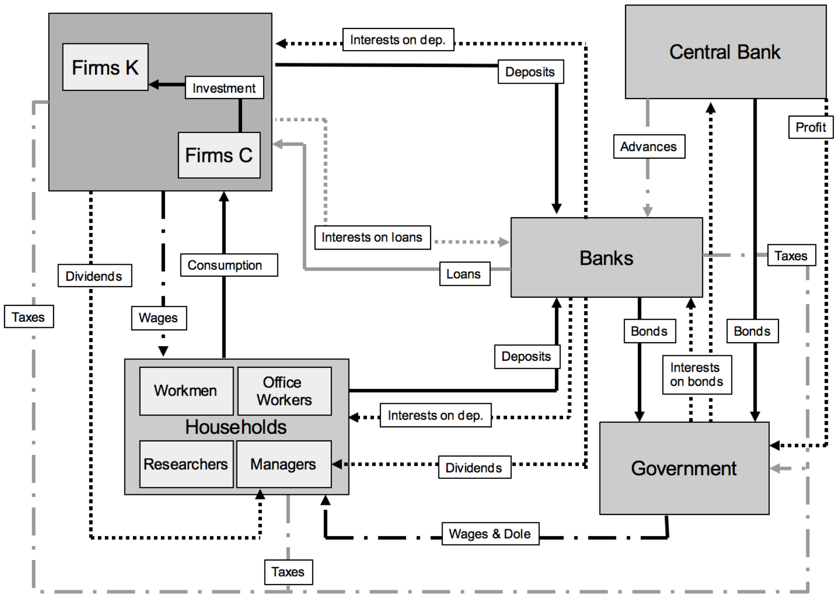

Figure 1: Flow Diagram of the model. Arrows point from paying sectors to receiving sectors.

In a nutshell, our model can be conceived as a combination of three major contributions in the AB literature. The core of the model is represented by the AB-SFC "benchmark" model presented in Caiani et al. (2015), providing a comprehensive and fully integrated representation of the real and financial sides of the economy through the adoption of rigorous accounting rules based on the quadruple entry principle developed by Copeland (1949). This bulk is then augmented by two additional blocks: first, we included R&D and innovation in the capital goods sector. These processes are shaped following the long-lasting evolutionary tradition building upon the Nelson and Winter seminal models, and it thus resambles - though being a simplified version[18] - the innovation process described in the Keynes+Schumpeter family of models (Dosi et al. (2010) and later works). Second, we model firms as a hierarchical organization encompassing different tiers of workers, thereby affecting the distribution of income and wealth in the model. This latter block was inspired by the family of models descending from Ciarli et al. (2010). Compared to these latter contributions, our model is simpler in that we maintain the number of tiers constant throughout the simulations, rather than allowing them to grow with the firm's size. Conversely, the labor market interaction is far more complicated in that wages of workers employed in the different tiers endogenously emerges as the result of the workers' competition process on segmented labor markets, rather than being mechanically determined as a multiple of the minimum wage.

The economy described by the flow diagram of figure 1 is composed of:

- A collection Φ_H of households selling their labor to firms in exchange for wages, consuming, paying taxes to government, and saving in the form of banks' deposits. Households are distinguished according to their function and income level into workmen ("blue-collars"), researchers and office workers ("white collars"), and ("top") managers. These latter own firms and banks proportionally to their net worth, receiving dividends from them and possibly participating to losses with their personal wealth in the case of a default.

- Two collections of firms: consumption (Φ_C) and capital (Φ_K) firms. Consumption firms produce a homogeneous consumption good using labor and capital goods manufactured by capital firms. Capital firms produce a homogeneous capital good characterized by the binary $\{\mu_k, l_k\}$, indicating respectively the capital productivity and the capital-labor ratio. Firms may apply for loans to banks in order to finance production and investment. Retained profits are held in the form of banks' deposits.

[18] Indeed, for simplicity reasons we abstract from innovation processes affecting labor productivity employed in the capital good sector.

- A collection Φ_B of banks, collecting deposits from households and firms, granting loans to firms, and buying bonds issued by the Government. Mandatory capital and liquidity ratios constraints apply. Banks may ask for cash advances to the Central Bank in order to restore the mandatory liquidity ratio.
- A Government sector, which hires public workers (a constant share of the workforce) and pays unemployment benefits to households. The government holds an account at the Central Bank, collects taxes, and issues bonds to cover its deficits.
- A Central Bank, which issues legal currency, holds banks' reserve accounts and the government account, accommodates banks' demand for cash advances at a fixed discount rate, and possibly buys government bonds which have not been purchased by banks.

During each period of the simulation agents interact on five markets:

- A consumption goods market: households interact with consumption firms.
- A capital goods market: consumption firms interacts with capital firms.
- Segmented labor markets: one for each type of households.
- A credit market: firms interact with banks.
- A deposit market: households and firms interact with banks.

Agents on the demand and supply sides of each market interact through a common matching protocol: 'demand' agents are allowed to observe the prices or the interest rates of a random subset of suppliers, whose size depends on a parameter χ reflecting the degree of imperfect information. Agents' switch from the old partner to the best potential partner selected in this random subset with a probability Pr_s which is defined, following Delli Gatti et al. (2010), as a non-linear (decreasing when the price/interest represents a disbursement for the demander, increasing otherwise) function of the percentage difference in their prices p_{old} and p_{new}. In the case of the capital goods market, where different vintages are sold by capital good producers, a global measure of the capital vintage attractiveness, based on its price and productivity level, is employed (see section 3.1.3). The shape of this function is governed by the 'intensity of choice' parameter $\epsilon > 0$: higher values of $\epsilon > 0$ imply a higher probability of switching.[19]

It might be the case that some suppliers exhaust their inventories available for sale, possibly leaving customers with a positive residual demand. When this happens, we allow demand agents to look for other suppliers within the original random subset of potential partners in order to fulfill it. Markets interactions are 'closed' when demand agents have fulfilled their demand, when there are no supply agents willing or able to satisfy their demand, or if demanders run out of deposits to pay for demanded goods.

2.1 Sequence of events

In each period of the simulation, the following sequence of events takes place:

1. Production planning: consumption and capital firms compute their desired output level.

2. Firms' labor demand: firms assess the number of workmen, researchers, office workers, and managers needed. Researchers are hired by capital firms to perform R&D activity.

3. Prices, interest, and Wages: consumption and capital firms set the price of their output; banks determine the interest rate on loans and deposits. Workers of all types adaptively revise their reservation wages.

4. Investment in capital accumulation: consumption firms' determine their desired rate of capacity growth.

[19] For the consumption, and credit markets, where prices (or interest rates) express a disbursement from the demander, the probability of switching to the new partner is decreasing (in a non-linear way) with the difference between p_{old} and p_{new}:

$$Pr_s = \begin{cases} 1 - e^{\epsilon(p_{new}-p_{old})/(p_{new})} & \text{if } p_{new} < p_{old} \\ 0 & \text{otherwise} \end{cases} \tag{2.1}$$

On the deposit market, interest rates generates an income for the depositor, the probability of switching is thus:

$$Pr_s = \begin{cases} 1 - e^{\epsilon(p_{old}-p_{new})/(p_{old})} & \text{if } p_{new} > p_{old} \\ 0 & \text{otherwise,} \end{cases} \tag{2.2}$$

5. Capital good market (1): consumption firms compare the productivities and prices of capital goods advertised by eligible suppliers, they choose their preferred capital supplier, and place their orders after having assessed the number of capital units to be purchased (depending on desired capacity and current capital).

6. Credit demand: Firms assess their demand for credit. When positive, they select the bank to apply for a loan.

7. Credit supply: Banks evaluate loan requests and supply credit accordingly.

8. Labor markets: unemployed households interact with firms on the corresponding labor market: first, the labor market for workmen opens, then the market of managers, afterwards the market of researchers, and finally, that of top managers.

9. Production: capital and consumption firms produce their output.

10. R&D Activity: Capital firms perform R&D. In case of success, the productivity gain is embedded in capital goods produced from the following period onward.

11. Capital goods market (2): consumption firms purchase capital from their supplier. New machineries are employed in the production process starting from the next period.

12. Consumption goods market: households interact with consumption firms and consume.

13. Interest, bonds and loans repayment: firms pay interests on loans and repay a (constant) share of each loan principal. The government repays bonds and interest to bonds' holders. Banks pay interest on deposits. Cash advances and related interests, when present, are repaid.

14. Wages and dole: wages are paid. Unemployed workers receive a dole from the government.

15. Taxes: taxes on profits and income, when positive, are paid to the government.

16. Dividends: dividends are distributed to firms' and banks' owners.

17. Deposit market interaction: households and firms select their deposit bank.

18. Bond purchases: banks and the Central Bank purchase newly issued bonds.

19. Cash Advances: the Central Bank accommodates cash advances requests by private banks.

In each period of the simulation, firms may default when they run out of liquidity to honor their commitments (e.g. wages, debt service, taxes) while banks default if their net wealth turns negative. The effects of firms' and banks' defaults are treated in section 3.4.

3 Agent behaviors

This section details the behavior of each type of agent. We used the following notation in the equations. The subscript t indicates that we refer to the variable value at time t. When generically referring to a firm, regardless its type, we employ the x subscript. Consumption firms' variables have a c subscript, capital firms' a k[20], banks' a b, generic households' a h, while workmen, office workers, researchers, and managers are identified by their initial letter, respectively w, o, r, m. Expected variables are marked by a e superscript, while the desired or target levels of a variable are indicated by D to distinguish them from the variables realization.

All agents share the same simple adaptive scheme to compute expectations for a generic variable z:

$$z_t^e = z_{t-1}^e + \lambda(z_{t-1} - z_{t-1}^e) \tag{3.1}$$

3.1 Firms' behavior

3.1.1 Production planning and labor demand

Firm x desired output in period t (y_{xt}^D) depends on the firm's sales expectations s_{xt}^e. We assume firms want to hold a certain amount of real inventories, expressed by a share ν of expected real sales, as a buffer against unexpected demand swings (Steindl, 1952) and to avoid frustrating customers with supply constraints (Lavoie, 1992).

$$y_{xt}^D = s_{xt}^e(1+\nu) - inv_{xt-1} \text{ with } x = \{c, k\} \tag{3.2}$$

Firms are characterized by a simplified hierarchical structure of workers and executives: at the lowest tier of the pyramid there are relatively unskilled workmen, who are responsible for carrying out the production process. At the middle level, office workers (i.e. middle management) supervise workmen and are responsible for carrying out the "top floor" entrepreneurial strategies. These strategies are defined

[20] In some cases, k is also employed to indicate a specific capital vintage produced or owned by a specific firm.

at the top of the hierarchy by the executive management, composed of "top" managers who are also assumed to be the owners of firms and banks.[21]

Indeed, following Ciarli et al. (2010) and previous empirical and theoretical contributions on which they build upon (Simon (1957), Lydall (1959), Waldman (1984), Abowd et al. (1999), Prescott (2003)), we assume that firms are organized in distinct hierarchies of labor, where only low-tier workers enter the production process, while workers in higher layers of the hierarchy manage the production process.

In addition, capital firms hire researchers to perform R&D activities, which are assimilated to middle level management in terms of their initial income and wealth endowments, though competing on their own segmented labor market.

This hierarchical organization indirectly affects the distribution of earnings and income in two fundamental ways: first, initial differentiated wages for each tier of workers are exogenously set in order to reflect a certain degree of inequality in the economy. Second, wages evolve endogenously during the simulation on the base of a decentralized matching process between firms and households on the different different markets which characterize our simulated economy: the labor market for workmen, the labor market for office workers, the labor market for researchers, and the labor market for executives. Hence, both the functional and personal distribution of income and wealth evolve endogenously as a result of this process.

For simplicity reasons we assume there is no social mobility across classes of households and that the hierarchical structure of firms does not evolve over the simulation time-span.

The demand for low tier workers fundamentally depends on the productivity of workmen employed by firms and on their desired output level y^D_{xt}. Firms in the capital-good industry produce their output out of labor only. Capital firms' demand for workmen at time t N^D_{kwt} thus depends on y^D_{kt} and the labor productivity μ_N, which we assume to be constant and exogenous.

$$N^D_{kwt} = y^D_{kt}/\mu_N \tag{3.3}$$

By contrast, consumption firms employ labor in conjunction with different capital vintages purchased from capital firms. We indicate the collection of capital vintages composing consumption firm's c capital stock at time t by K_{ct}. Therefore, consumption firms' demand for labor depends on the productivities of the different vintages of capital employed in the production process. Assuming for simplicity reasons a constant capital-labor ratio $\overline{l_k}$ across capital vintages, the productivity of workers employing the vintage k can then be expressed as $\mu_{Nk} = \mu_k \overline{l_k}$, being μ_k the productivity associated to the capital vintage k. In order to minimize their unitary costs of production, consumption good producers rank the vintages in their current capital stock according to their productivity level and employ them in the production process starting from the most productive vintages. Given y^D_{ct} - the desired output of firm c - the target rates of utilization for each capital vintage can be then derived from equation 3.4:

$$y^D_{cwt} = \sum_{k \in K_{ct}} u^D_{ckt} k_{ck} \mu_k \tag{3.4}$$

where u^D_{ckt} is the desired rate of utilization of capital vintage k in order to produce y^D_{ct}, and k_{ck} is the (real) stock of capital of type k owned by firm c.

The required number of workmen can then be calculated as:

$$N^D_{cwt} = \sum_{k \in K_{ct}} u^D_{ckt} \frac{k_{ck}}{\overline{l_k}} \tag{3.5}$$

Since the demand for workmen must be an integer N^D_{kwt}, N^D_{cwt} are then rounded to the next larger integer (i.e. the minimum amount of workers required to attain the planned level of production) and constitute the demand for workmen by capital and consumption firms.

In addition to workmen, firms need office workers to supervise and coordinate them and "executives" to manage firms' activity. Similarly to Ciarli et al. (2010), we assume that the fractions between different tiers of employees (i.e. low tier workers, middle managers, and top managers) are fixed, though in

[21] Indeed, although the separation of firms' managers (i.e. salaried workers) from firms' owners (i.e. profit earners) is a relatively distinct trait of large, publicly listed firms, this distinction is less marked for small-medium enterprise, thus justifying our simplifying assumption. In addition, top managers and owners can be treated as a relatively homogeneous class of agents also in terms of their income levels. Finally, while most large firms' managers are salaried workers, their salary often includes stock options, bonuses, and other contractual conditions allowing managers to participate to firms' profits and capital gains, just as traditional owners.

our model the number of hierarchical tiers is given rather than depending on the firms' size. Knowing $N^D_{xwt}, x = \{c, k\}$ we can compute the demand for office workers N^D_{xot} (and researchers, N^D_{xrt}, in the case of capital firms), and top managers N^D_{xmt} as follows:

$$N^D_{xht} = N^D_{xwt} \frac{share_w}{share_h} \text{ with } h = \{o, r, m\} \tag{3.6}$$

$$share_w + share_o + share_r + share_m = 1 \tag{3.7}$$

where N^D_{xht} is the demand for workers of the generic type h and $share_w/share_h$ is the ratio between the (fixed) shares of workmen and type-h employees. Therefore, the requirement of h workers is expressed as a fraction of the firm' demand for workmen. Ultimately, capital firms' productive capacity is constrained by first-tier workers and their productivity only, whereas consumption firms' capacity may also be constrained by the stock of capital. Higher tiers workers on the contrary do not produce anything directly, but are nonetheless required to supervise workmen and to manage the firm, thereby concurring with their wages to increase firms' variable costs.

Employees in excess, when present, are randomly sampled from the pool of the firm's employees and fired. We also assume a positive turnover of employees, expressed as a share ϑ of firm's employees. The turnover applies indifferently on the different tiers of employees. In other words, a share ϑ of employees is randomly sampled from the complete list of employees and fired at the beginning of each simulation period, before the labor markets interactions, and the demand for each type of workers is accordingly revised.

3.1.2 Pricing

Prices of goods are set as a non-negative markup mu_{xt} over expected unit labor costs. Given the firm's total labor demand $N^D_{xt} = N^D_{xwt} + N^D_{xot} + N^D_{xrt} + N^D_{xmt}$:

$$p_{xt} = (1 + mu_{xt}) \frac{W^e_{xt} N^D_{xt}}{y^D_{xt}} \tag{3.8}$$

where W^e_{xt} is the expected average wage of the firm's employees.

The mark up is endogenously revised from period to period following a simple adaptive rule. When a firm ends up having more inventories than desired (see section 3.1.1), or if the rate of capacity utilization of a consumption firm is below the desired level, the markup is reduced in order to increase the attractiveness of the firm's products.

$$mu_{xt} = \begin{cases} mu_{xt-1}(1 + FN_1) & \text{if } \frac{inv_{xt-1}}{s_{it-1}} \leq \nu \ \text{ (or } u_{ct-1} < \overline{u}) \\ mu_{xt-1}(1 - FN_1) & \text{if } \frac{inv_{xt-1}}{s_{it-1}} > \nu \ \text{ (and } u_{ct-1} \geq \overline{u}) \end{cases} \tag{3.9}$$

where FN_1 is a random number picked from a Folded Normal distribution with parameters $(\mu_{FN_1}, \sigma^2_{FN_1})$.

3.1.3 Investment

In each period consumption firms invest in order to attain the desired rate of growth of their productive capacity g^D_{ct}. This latter is defined as a function of their planned rate of capacity utilization u^D_{ct} (depending on y^D_{ct}) and their past-period rate of return, defined as in equation 3.11.

$$g^D_{ct} = \gamma_1 \frac{r_{ct-1} - \overline{r}}{\overline{r}} + \gamma_2 \frac{u^D_{ct} - \overline{u}}{\overline{u}} \tag{3.10}$$

$$r_{ct} = \frac{OCF_{ct}}{\sum_{k \in K_{ct-1}} (k_{ck} p_k)(1 - \frac{age_{kt-1}}{\kappa})} \tag{3.11}$$

Here, $\overline{u}$ and $\overline{r}$ denote firms' 'normal' rates of capacity utilization[22] and profit respectively, both assumed to be constant and equal across firms. The denominator in equation 3.11 expresses the previous

[22]The empirical evidence suggests that normal rates of utilization range between 80 and 90% (Eichner, 1976). Some authors (Steindl, 1952; Lavoie, 1992) explain the presence of excess capacity as an expedient to face unexpected jumps in demand; Spence (1977) argues that excess capacity can be employed by incumbent firms as a deterrent to entry by new firms. A detailed discussion about empirical and theoretical contributions on this aspect can be found in Lavoie (2015).

period value of the firm's stock of capital, being age_{kt-1} the age in period $t-1$ of the batch of capital goods k_{ck} belonging to the collection K_{ct-1} of firm c, and p_k the original purchasing price.

We assume that consumption firms are able to interact with a limited number of capital suppliers, comparing the prices and productivities of their capital vintages in order to rank capital vintages and identify their preferred supplier. Consumption firms follow a simple algorithm to compare pairs of capital vintages according to which capital j is preferred to capital i if:

$$\kappa(uc^e_{it} - uc^e_{jt}) > p_{jt} - p_{it} \rightarrow (uc^e_{it}\kappa + p_{it}) > (uc^e_{jt}\kappa + p_{jt}) \tag{3.12}$$

$$uc^e_{kt} = \frac{W^e_{xt}}{(\mu_{kt}\overline{l_k}share_w)} \text{ with } k = \{i, j\} \tag{3.13}$$

where uc^e_i and uc^e_j indicate the expected unit labor costs associated with the two vintages[23], κ represents the technical life-span of capital goods, assumed to be constant and equal across vintages, and p_{jt}, p_{it} and μ_{it}, μ_{it} are respectively the prices and productivity levels of the two vintages. This rule is employed recursively by consumption firms in order to obtain a complete ordering of observed capital vintages, from the best to the worst.

Since the two polynomials $(uc^e_{kt}\kappa + p_{kt})$ with $k = i, j$ in the right-hand disequation 3.12 provide a synthetic measure of the attractiveness of each capital vintage - the lower it is, the more attractive is the capital good - this latter is also employed to calculate the probability of switching from the previous supplier to the best potential one according to equation 2.1.

Having planned their desired capacity (i.e. having determined g^D_{ct}) and having chosen the capital vintage to invest in, consumption firms assess their desired investment i^D_{ct} as the number of capital units required to replace obsolete capital and fill the possible gap between current and desired capacity.[24] Nominal desired investment I^D_{ct} can then be computed by multiplying i^D_{ct} for the price p_{kt} applied by the selected supplier k.

3.2 R&D activity

Firms operating in the capital-good industry aim at increasing their market share and their profits by improving the technology embedded in their output through R&D investment. Since R&D by capital firms is carried out using only labor, capital firms' investment in R&D coincides with wages paid to hire researchers.[25]

Following the well established Evolutionary tradition (Nelson and Winter, 1977b,a, 1982; Winter, 1984; Andersen, 1996; Dosi et al., 2010; Caiani, 2012; Vitali et al., 2013) we model firms' innovative research activity as a two-step stochastic process: first, a Bernoulli experiment is done to determine whether R&D activity has been successful. If this is the case, the capital firm makes a second draw to determine the productivity gain. Innovator's k probability of success Pr^{inn}_{tk} is increasing with the number of workers hired to carry out research activity:

$$Pr^{inn}_{tk} = 1 - e^{-\xi^{inn} N_{krt}} \tag{3.14}$$

The productivity gain associated to an innovation is then extracted from a Folded Normal distribution FN_3 with parameters $(\mu_{FN_3}, \sigma^2_{FN_3})$. This productivity gain sums up to the productivity of the most recent vintage of capital produced by the firm. The new productivity level is then embedded in the output of the firm starting from the next period.[26]

In addition, capital firms also perform R&D imitative activity that allows them to copy the technology of some competitor. The probability of achieving an imitative draw Pr^{imi}_{tk} is defined, similarly to innovation, as:

$$Pr^{imi}_{tk} = 1 - e^{-\xi^{imi} N_{krt}} \tag{3.15}$$

[23] Notice that $\overline{l_k}$ indicates the ratio between capital units and workmen required to employ them in the production process. The overall capital-labor ratio, accounting for office workers and managers as well, can then be approximated by $\overline{l_k}share_w$ which is multiplied in the denominator of equation 3.13 to obtain the value of labor productivity associated with a certain vintage.

[24] Conversely, in case $g^D_{ct} < 0$ implying that current capacity is greater than desired, they replace capital units reaching obsolescence only partially, or even abstain from investing.

[25] As the number of researchers that capital firms want to hire is a constant share of workmen required for production, R&D investment eventually depends upon planned production levels, which are a function expected real sales.

[26] For tractability reasons, we assume that also the stock of unsold inventories is updated at the new productivity level.

In case of success, capital firms can look at the technology embedded in the capital produced by a subset of N^{imi} competitors, possibly imitating them when the level of productivity of competitors' capital vintages is higher than the firm's current one.

3.2.1 Firms' profits and finance

Consumption firms' pre-tax profits are the sum of revenues from sales, interest received, and the nominal variation of inventories,[27] minus wages, interest paid on loans, and capital amortization:

$$\begin{aligned} \pi_{ct} &= s_{ct}p_{ct} + i^d_{bt-1}D_{ct-1} + (inv_{ct}uc_{ct} - inv_{ct-1}uc_{ct-1})\dots \\ &\dots - \sum_{n\in N_{ct}} w_{nt} - \sum_{j=t-\eta}^{t-1} i^l_j L_{cj}\frac{\eta - [(t-1)-j]}{\eta} - \sum_{k\in K_{ct-1}} (kckp_k)\frac{1}{\kappa} \end{aligned} \tag{3.16}$$

where i^d_{bt-1} is the interest rate on past period deposits D_{ct-1} held at bank b, uc_c are unit costs of production, N_{ct} is the complete list of employees, w_{nt} is the wage paid to worker n, i^l_j is the interest rate on loan L_{cj} obtained in period $j = t-\eta, ..., t-1$, p_k is the price paid for the batch of real capital goods k_{ck} belonging to the firm's collection of capital goods K_{ct-1}, and $\eta = \kappa$ are the duration of loans and capital respectively. Capital firms' profits only differ in that they do not display capital amortization.

Taxes are then computed on gross profits as: $T_{xt} = Max\{\tau_{\pi t}\pi_{xt}, 0\}$, $\tau_{\pi t}$ being the corporate profits tax rate at time t (see section 3.6). A firm's total dividends to be distributed to the class of managers are then computed as a constant share ρ_x of firm's after-tax profits: $Div_{xt} = Max\{0, \rho_x\pi_{xt}(1-\tau_{\pi t})\}$.

In addition to profits, we also define firms' net 'operating cash flows' OCF_{xt} as after-tax profits plus capital amortization costs (for consumption firms), minus changes inventories and principal repayments.[28]

Firms' demand for external finance L^D_{ct} is based on the slightly modified pecking-order mechanism explained in Caiani et al. (2015): although firms usually prefer internal funding to (expensive) external financing, they also want to maintain a certain level of deposits - expressed as a share σ of the expected wages disbursement - for precautionary reasons, this possibly increasing their demand for credit.[29]

3.3 Banks' behavior

3.3.1 Credit Supply

On the credit market firms interact with several banks, selecting the best partner, and possibly obtaining multi-period loans.[30] As a consequence, firms generally have a collection of heterogeneous loans with different banks.

The supply side of the credit market follows the novel procedure extensively discussed in Caiani et al. (2015), based on the following three pillars:

- Active management of banks' balance sheet through endogenously evolving capital ratio targets and interest rate management strategy.
- Case-by-case quantity rationing based on applicants' probability of default and the ensuing loan project expected rate of return.
- Credit worthiness based on operating cash flows and collateral value.

Banks' interest rates on loans depend on a comparison between bank's current capital ratio $CR_{bt} = NW_{bt}/L^{Tot}_{bt}$ and the common target CR^T_t,[31] determined for simplicity reasons as the past-period average

[27] In accordance with standard accounting rules, firms' inventories are evaluated at the firms' current unit cost of production. As a consequence, the value of inventories may vary due to variation of either their quantity or of their productive costs.

[28] As explained in Caiani et al. (2015) operating cash flows can be interpreted as a sort of 'Minskian' litmus paper: an $OCF \geq 0$ implies that the firm is capable of enough generating cash flow to honor the debt service (hedge position). If OCF is negative, but its absolute value is less than or equal to the principal repayment, the firm is in a speculative position since its cash flows are sufficient to cover the interest due, but the firm must roll over part or all of its debt. Finally, when OCF is negative and its absolute value is greater than principal payments, the firm is trapped in a Ponzi position.

[29] Their credit demand can formally be expressed by:

$$L^D_{ct} = I^D_{ct} + Div^e_{ct} + \sigma W^e_{ct}N^D_{ct} - OCF^e_{ct} \tag{3.17}$$

where Div^e_{ct} is the expected disbursement for dividends (based on expected profits). Credit demand function for capital firms can be derived from equation (3.17) by omitting I^D.

[30] Loans last for $\eta = 20$ periods (i.e. 5 years): in each period firms repay a constant share $(1/\eta)$ of the principal.

[31] Yet, banks' capital ratio has a mandatory lower bound (6%).

of the sector. When banks are more capitalized than desired, they offer an interest rate lower than their competitors' average thus trying to expand further their balance sheet by attracting more customers on the credit market. In the opposite case firms want to reduce their exposure: a higher interest rate has the twofold effect of making bank's loans less attractive while increasing banks' margin. Formally:

$$i^l_{bt} = \begin{cases} \bar{i}^l_{bt-1}(1 + FN_2) & \text{if } CR_{bt} < CR^T_t \\ \bar{i}^l_{bt-1}(1 - FN_2) & \text{otherwise ,} \end{cases} \tag{3.18}$$

where $\bar{i}^l_{bt-1} = \frac{\sum_{b\in\Phi_B} i^l_{bt-1}}{size_{\Phi_B}}$ is the market average interest rate in the previous period and FN is a draw from a Folded Normal Distribution $(\mu_{FN_2}, \sigma^2_{FN_2})$.

A case-by-case credit rationing mechanism starts with banks evaluating applicants' single-period probability of default, under the hypothesis that the loan requested is granted. We define the debt service variable as the first tranche of payment associated to the hypothetic loan: $ds^{L^d} = (i^l_{bt} + \frac{1}{\eta})L^d$. The probability of a default in each of the 20 periods ahead is then computed using a logistic function, based on the percentage difference between borrowers' OCF_{xt} and ds^{L^d}:

$$pr^D_x = \frac{1}{1 + \exp(\frac{OCF_{xt} - \varsigma_x ds^{L^d}}{ds^{L^d}})}, \tag{3.19}$$

ς_c and ς_k are two parameters expressing banks' risk aversion in lending to capital and consumption firms. The higher ς the more banks are risk averse (i.e. the higher the probability of default for given OCF and ds).

The expected return of a credit project also depends on firms' collateral: consumption firms' collateral is identified with their stock of real capital. In the case of a default by a consumption firm, each bank then expects to be able to recover a share $\delta_c \leq 1$ of outstanding loans to the defaulted firm c through fire sales of its capital. δ_c is equal to the ratio between firm's capital discounted value (see section 3.4) and firm's outstanding debt, for all lenders, being revenues from fire sales distributed across creditors proportionally to their exposure. $\delta_k = 0$ since capital firms have no collateral. Knowing $L^d, i^l_{bt}, pr^D_x, \delta_x$, banks compute the overall expected return of a credit project by summing the payoffs arising from each possible outcome of the decision to grant the loan, each one weighted for its probability of occurrence.

Banks are willing to satisfy agents' demand for credit whenever the expected return is greater or equal than zero. Otherwise, the bank may still be willing to provide some credit, if there exist an amount L^{D*} for which the expected return is non-negative.

3.3.2 Deposits and bonds market

Banks hold deposits of households and firms.

Given the fact that banks must satisfy a mandatory liquidity ratio of 8% and since deposits represent a source of reserves much cheaper than Central Bank cash advances (that is, $i^d_{bt} << \bar{i}^a_{cb}$) banks compete with each other on the deposit market.[32] As in the case of the capital ratio, we assume that banks have, besides the mandatory lower bound, a common liquidity target LR^T_t defined as the sector average in the last period.

When the liquidity ratio is below the target banks set their interest on deposits as a stochastic premium over the average interest rate in order to attract customers, and vice-versa when banks have plenty of liquidity.

$$i^d_{bt} = \begin{cases} \bar{i}^d_{bt-1}(1 - FN_2) & \text{if } LR_{bt} \geq LR^T_t \\ \bar{i}^d_{bt-1}(1 + FN_2) & \text{otherwise ,} \end{cases} \tag{3.20}$$

where FN being drawn from a Folded Normal Distribution $(\mu_{FN_2}, \sigma^2_{FN_2})$.

Finally, we assume that banks use their reserves in excess of their target (after repayment of previous bonds by the government) to buy government bonds. Remaining bonds are assumed to be purchased by the Central Bank.

[32] Whenever the liquidity ratio falls below the mandatory threshold banks apply for cash advances to the Central Bank (see 3.6).

3.4 Firms' and banks' bankruptcy

Firms and banks may go bankrupt when they run out of liquidity or if their net-wealth turns negative. We assume defaulted firms and banks to be bailed in by their owners, the "managers" thus maintaining the number of firms and banks constant.

A bankruptcy by a firm implies that wages paid to workers are reduced or not paid at all, since deposits are insufficient to cover the expenses. Similarly, it also generates a non-performing loans for her creditors, who see their net wealth shrinking. In the case of capital firms, the loss is totally borne by banks, as capital firms do not have any collateral. In the case of a consumption firm, we assume instead that its ownership passes temporarily to creditors which try to recover part of their outstanding loans through fire sales of the firm's physical capital to the class of "managers", who collectively own firms and banks (each one proportionally to their individual net-worth).

The financial value of assets sold through fire sales is lowered by a share ι, which thus represents a devaluation factor. When the discounted value of capital is greater or equal to the firm's bad debt, the loss caused by the bankruptcy falls completely on households' shoulders. However, in general the loss is split between households and banks which are able to recover only a fraction of their loans. Individual households' contribution to fire sales follows the same rule of dividends distribution (section 3.5), the disbursement being distributed proportionally to households' net wealth. Finally, if the net-worth of the firm is still below 25% of the firms' average net-worth in the industry, her deposits are increased up to the point this lower bound is reached via a deposit transfer by owners. As for the fire-sales procedure of consumption firms' capital, in this eventuality each manager contributes to the recapitaliztion proprtionally to his net-worth.

Banks default whenever their net-worth turns negative. We assume owners bear the loss associated to the default. Owners intervene to restore a positive net-worth up to the point the capital ratio of the bailed-in bank is equal to the average one. As in the former cases, the contribution of each owner to the overall disbursement is proportional to his share of the total owners' net-worth. [33]

3.5 Households' behavior

All types of workers follow a similar adaptive heuristic to set their reservation wage: if over the year (i.e., four periods), they have been unemployed for more than two quarters, they lower the asked wage by a stochastic amount, and vice versa. Therefore, the higher the level of unemployment, the greater the probability that agents are unemployed and revise downwardly their reservation wages.

$$w_i^{d,t} = \begin{cases} w_{ht-1}^D(1 - FN_1) & \text{if } \sum_{n=1}^4 u_{ht-n} > t_u \\ w_{ht-1}^D(1 + FN_1) & \text{if } \sum_{n=1}^4 u_{ht-n} \leq t_u \end{cases} \tag{3.21}$$

where $h = w, o, r, m$, $t_u = 2$, and $u_{ht} = 1$ if h is unemployed in t, and 0 otherwise.

Workers consume with fixed propensities $\alpha_h, h = w, o, r, m$ out of expected real disposable income. These propensities are differentiated, as higher income groups consume a lower share of their expected income. As workers set their real demand before interacting with consumption firms, they formulate expectations on consumption good prices p_{ht}^e. In addition, consumption has a certain degree of downward rigidity in that consumers' demand cannot fall under a share β of past-period real consumption[34]:

$$c_{ht}^D = Max\left\{\alpha_h \frac{NI_{ht}}{p_{ht}^e}, \beta c_{ht-1}\right\} \text{ with } h = w, o, r, m \tag{3.22}$$

The idea of differentiated saving and consumption propensities according to income levels obviously stems from the Keynesian tradition.[35] The opposite Neoclassical view, embodied by the *permanent income hypothesis* instead takes that aggregate saving and consumption behaviors are not affected by the distribution of income, as consumption can be smoothed through lending and borrowing, despite the volatility of transitory income. This vision however has not been supported by evidence. On the contrary, the *relative income hypothesis* originally proposed by Duesenberry (1949) states that the households' saving rate is not linked to the absolute level of income but is positively associated with both the household's

[33] For owners holding their deposits at the defaulted bank, this disbursement is realized through a reduction of the owners' deposit (thus reducing the liability side of the defaulted bank's balance sheet). Otherwise, also a transfer of reserves from the banks holding other owners' deposits and the defaulted bank takes place (thereby increasing the asset side of the defaulted bank while leaving unaltered the balance sheets of other banks).

[34] Obviously consumption by households can still be financially constrained, so that c_{ht}^D might end up being unfeasible.

[35] See section 4 for the details regarding the empirical evidence employed to calibrate these parameters

positioning in the distribution of income (in particular, with respect to her reference group) and the relation of the households current to past income (see also van Treeck (2014) on this latter aspect). The first aspect set the basis for the well known "keeping up with Joneses" phenomenon according to which agents' of different income groups tend to imitate consumption habits of superior classes, as well as to maintain the pattern of consumption of agents belonging to their same income group, even in presence of temporary income drops. This habits persistence motivated our inclusion of a persistence parameter in households consumption function.

The gross nominal income of employed workmen, researchers, and office workers is composed of wages and interests received on previous period deposits $w_{ht} + i^d_{bt-1}D_{ht-1}$, whereas executives workers also receive dividends from banks and firms Div_{mt}[36]. Unemployed workers, regardless their type, receive a tax-exempt dole from the government which is defined as a share ω of the average wage of workmen only.

In the baseline of the model, we assume that households pay taxes on their income and wealth being subjected to two flat tax rates τ_{it}, τ_{wt}. Notice that, under this scenario, the income (wealth) tax load of each group, as well as the share of total taxes on income (wealth) each group pays, is proportional to the share of income the group earns (wealth it owns).[37]

In the aftermath, we then introduce a progressive taxation scheme in order to analyze the impact of a redistribution of income on the system performance. For this sake, the progressive tax regimes are shaped in order to keep the overall tax load of households equivalent to the level we would have under corresponding flat-tax-rates case (see section 6.1).

3.6 Government and Central Bank's behavior

Government behavior largely resembles that presented in Caiani et al. (2015): the public sector hires a constant share of households[38] and pays unemployment benefits (d_t) to unemployed people (U_t). However, some novelty aspects have been introduced: first, the government hires different types of workers with the same proportions characterizing consumption firms. Second, while in the original version of the model the state collected taxes only on income and profits, here we assume that the government charges taxes on households' wealth as well. Third, profits, income, and wealth tax rates $\tau_{\pi t}, \tau_{it}, \tau_{wt}$, rather than being fixed once and for all, follow an adaptive revision rule of the benchmark tax rates $\tau_{\pi 0}, \tau_{i0}, \tau_{w0}$. Taxes are increased whenever the previous period debt/GDP ratio increased or if the deficit/GDP ratio raised over a threshold def^1, whereas they are lowered if the the deficit/GDP ratio falls under a threshold def^0, provided that the debt/GDP ratio is not increasing. Formally:

$$\tau_{it} = \tau_{i0} * rev_t \tag{3.24}$$

$$\tau_{wt} = \tau_{w0} * rev_t \tag{3.25}$$

$$\tau_{\pi t} = \tau_{\pi 0} * rev_t \tag{3.26}$$

where,

$$rev_t = \begin{cases} rev_{t-1} * (1+\upsilon) & \text{if } \frac{def_{gt-1}}{GDP_{t-1}} > def^1 \text{ or } \Delta\frac{debt_{gt-1}}{GDP_{t-1}} > 0 \\ rev_{t-1} * (1-\upsilon) & \text{if } \frac{def_{gt-1}}{GDP_{t-1}} < def^0 \text{ and } \Delta\frac{debt_{gt-1}}{GDP_{t-1}} \leq 0 \\ rev_{t-1} & \text{otherwise} \end{cases} \tag{3.27}$$

[36]These are determined as: $Div_{mt} = (Div_{Ct} + Div_{Kt} + Div_{Bt})\frac{NW_{mt}}{NW_{Mt}}$, where Div_{Xt}, $X = C, K, B$ are total dividends distributed by consumption and capital firms, and banks, and NW_{mt}/NW_{Mt} is the share of managers' total wealth held by the individual.

[37]Indeed, by defining total gross income as $GI_t = (GI_{wt} + GI_{ot} + GI_{rt} + GI_{mt})$, GI_h, $h = w, o, r, m$ being the total gross income of h-type households, we have:

$$TI_t = GI_t\tau_{it} = TI_{wt} + TI_{ot} + TI_{rt} + TI_{mt} = (\underbrace{\sum_w^W gi_{wt}}_{GI_{wt}=GI_tSI_{wt}} + \underbrace{\sum_o^O gi_{ot}}_{GI_{ot}=GI_tSI_{ot}} + \underbrace{\sum_m^M gi_{mt}}_{GI_{mt}=GI_tSI_{mt}} + \underbrace{\sum_r^R gi_{rt}}_{GI_{rt}=GI_tSI_{rt}})\tau_{it} \tag{3.23}$$

where TI_t indicates total taxes on income paid by households as a whole, TI_{ht},$h = w, o, r, m$ are taxes on income paid by the group h, and $SI_{ht} = \frac{GI_{ht}}{GI_t}$, is the h-group share of total gross income earned. From equation 3.23 it is easy to show that $\frac{TI_{ht}}{TI_t} = SI_{ht}$ for $h = w, o, r, m$.

The same reasoning can be applied to show that $\frac{TW_{ht}}{T_t} = SW_h$, being TW_t, TW_{ht}, SW_h total taxes on wealth, total taxes on wealth paid by households of type h, and the share of gross (i.e. pre-tax) wealth held by group h, respectively.

[38]Public servants are also subject to a turnover ϑ.

After having collected taxes on income and wealth from households, and taxes on profits from firms and banks the state issues bonds b_t (at fixed price $\bar{p}^b$ and interest $\bar{i}^b$) which are assumed to last 1 period for simplicity reasons:

$$\bar{p}^b \Delta b_t = def_{gt} = T_t + \pi_{CBt} - \sum_{n \in N_{gt}} w_n - U_t d_t - \bar{i}^b \bar{p}^b b_{t-1}, \tag{3.28}$$

where $T_t = T_{Ht} + T_{Ct} + T_{Kt} + T_{Bt}$ are total taxes, π_{CBt} are Central Bank profits, N_{gt} is the collection of public workers.

The Central Bank buys bonds not purchased by commercial banks and accommodates banks' request for cash advances. Cash advances are assumed to be repaid after one period and their constant interest rate represents the upper bound for interest paid by banks on customers' deposits. For simplicity reasons, we assume the Central Bank pays no interest on private banks' reserves account. Finally, Central Bank earns a profit equal to the flow of interest coming from bonds and cash advances: $\pi_{CBt} = \bar{i}^b B_{t-1} + \bar{i}^a_{CB} CA_{cbt}$. Central Bank's profits are distributed to the government.

4 Simulations Setup

In order to calibrate the initial conditions and parameters of the model we relied on the baseline configuration of the "parent" model presented in Caiani et al. (2015). In particular, the aggregate values of initial stocks and flows are computed in the same way. For the details regarding the calibration procedure we hence refer to that paper, which provides the full set of equations employed to set initial conditions and an extended discussion of some of the main challenges posed by the calibration of AB macro model in a Stock Flow Consistent (Godley and Lavoie, 2007) manner.

Here we remind that, as in the original calibration, we start from a symmetric initial characterization of agents belonging to the same classes. Agents of the same type are initially homogeneous and heterogeneity emerges progressively as a consequence of the cumulative effects triggered by stochastic factors embedded in agents adaptive rules. In particular, agents of a same class start equal regarding the type, number and amount of stocks (e.g. machineries, consumption goods, deposits, loans) they hold, and the number of relations they have with other agents. For example, debt-credit relations linking firms to banks on the credit market are drawn randomly, albeit we ensure that each bank starts with the same number of loans, for the same amount, with similar ages and time to maturity, with the same number of customers. Conversely, firms start with the same number and amount of loans, having the same ages and time to maturity, and being supplied by the same number of banks.

Although the bulk of the baseline set up has undergone only minor amendments with respect to the previous version, some integrations is required as a consequence of the variations embedded in the structure of the economy depicted by the present model. These integrations are mainly related to the decomposition of the previously aggregated households sector in four sub groups, representing different types of workers, performing different functions and characterized by different income and wealth levels.

We assume that different types of workers also represent different percentiles of income so that the numerosity of each class and the share of income she earns are strictly connected. More precisely, we assumed that workmen, i.e. less specialized-low tier employees, correspond to the lowest 60 percentiles which collectively earn 30% of pre-tax total income. Office workers and researchers may be conceived as the middle class, have equal initial personal income and toghether they account for 30% of the total population and earn 40% of total gross income. Finally, executives represent the richest 10% of the population and collectively earn 30% of the gross income. In this way we aim at embedding in the model a realistic initial distribution of income: our setup is placed somewhere in the middle between advanced countries traditionally characterized by high inequality and advanced countries with low inequality.[39]

This configuration is then embedded in the model by properly tuning initial wages of each class of workers in order to attain the desired share of income. We indicate by w_0 the overall workers' average wage, its value being equal to initial wages in the Caiani et al. (2015) model. In order to keep firms' labor costs unaltered (compared to the "parent model" with a single type of workers), and taking into account the fact that managers also receive dividends (Div_{m0}) from firms and banks, we setup initial wages as

[39] As a matter of example, in the US which are traditionally characterized by a significant level of inequality, the bottom 60% of households in the US earns a share of 29% of gross before-tax income, the next 30 percentiles earn approximately 35% of income, and the top 10% earns aproximately 36% of gross income. (Source: supplemental data of the US Congressional Budget Office's report "The Distribution of Household Income and Federal Taxes, 2011", 2014, available at https://www.cbo.gov/publication/49440).

follows[40]:

$$GI_0 = w_0 N_H + Div_{m0} = \underbrace{w_{w0}N_W}_{SI_{w0}GI_0} + \underbrace{w_{o0}N_O}_{SI_{o0}GI_0} + \underbrace{w_{r0}N_R}_{SI_{r0}GI_0} + \underbrace{w_{m0}N_M + Div_{m0}}_{SI_{m0}GI_0} \tag{4.1}$$

where N_W, N_O, N_R, N_M are the total number of workmen, office workers, researchers, and mangers, and N_H indicates their sum.

Since office workers and researchers can be both considered as middle tier workers, we consider them as a unique group having a common initial wage. From 4.1 we then obtain:

$$SI_{m0}(w_0 N_H + Div_{m0}) = w_{m0}N_M + Div_{m0} \rightarrow w_{m0} = \frac{SI_{m0}}{SP_m}w_0 + \frac{Div_{m0}}{N_M}(SI_{m0} - 1) \tag{4.2}$$

$$SI_{w0}(w_0 N_H + Div_{m0}) = w_{w0}N_W \rightarrow w_{w0} = \frac{SI_{w0}}{SP_w}w_0 + SI_{w0}\frac{Div_{m0}}{N_W} \tag{4.3}$$

$$(SI_{o0} + SI_{r0})(w_0 N_H + Div_{m0}) = w_{or0}(N_O + N_R) \rightarrow w_{or0} = \frac{SI_{o0} + SI_{r0}}{SP_o + SP_r}w_0 + \frac{Div_{m0}}{N_O + N_R} \tag{4.4}$$

where w_{w0}, w_{or0}, w_{m0} are initial wages of workmen, office workers and researchers, and managers respectively.

Although wealth inequality is well known to be more pronounced than income inequality, we chose instead to employ the same distribution of income to setup initial shares of wealth held by each group (in the form of deposits), and see whether a realistic distribution of wealth emerges endogenously along the simulation as a consequence of agents' income dynamics and consumption/saving behaviors.[41]

Total deposits held by households are then simply distributed across different types of workers according to these wealth shares.

In order to assess the impact of income inequality on consumption and demand patterns we also takes into account the well known empirical fact that richer people tend to save a higher portion of their income with respect to poorer people. The same intuition was at the base of Keynes' fundamental psychological law of consumption which states that the marginal propensity to consume is between 0 and 1, implying that further increases in income levels increase consumption less than proportionally. Accordingly, we assume that the average propensity to consume of workmen α_w is equal to 95% whereas that of office workers and researchers ($\alpha_o = \alpha_r$) is lower and equal to 85%, and that of managers is equal to 75%.[42]

We assume that consumption firms' hierarchical structure reflects the subdivision of workers in different classes observed in the society. This means that the ratio between workers employed in different layers, e.g. workmen and office workers, is equal to the ratio between the two populations. More formally, $share_w, share_o, share_m$ in equation 3.6 are respectively equal to SP_w, SP_o, SP_m. A similar assumption applies to capital good producers although these latter also hire researchers to perform R&D activity. In this case we assume that $share_o$ and $share_r$ are both equal to 0.15, thereby summing up to 30%.

We then set the total number of households, the size of each population of households, and the number of employees in the capital good sector and consumption good sectors[43] so that all populations starts with

[40] In order not to complicate too much the procedure and without lack of generality, we do not consider interests paid to households by banks, which constitute a negligible portion of households' gross income.

[41] In addition, though managers receive dividends from firms and banks, we consider them as separated legal entities so that the net assets of firms and banks are kept separated from those of the managers'. Although this simplifying assumption may underestimate managers' wealth, it is not devoid of realism as a consequence of the rapid diffusion of limited liability companies, and equivalent legal forms of private corporations which find their reason to be in the separation of owners' and firms' assets.

[42] These values are reasonably similar to empirical ones: Dynan et al. (2004) reports that the lowest quintile has a propensity to save equal to 0.14%, the second 0.09%, the middle quintile equal to 11%, the fourth 17%, and the top quintile equal to 23.6%. Yet, the average saving rate increases significantly for top percentiles as the top 5% and 1% of households saves 37,2% and 51,2% of their net income. This suggests that our average propensities to consume may slightly overestimate the empirical equivalent for high-income earners, thereby understimating the possible negative impact of income inequality on demand patterns. However, some facts tends to counter-act this tendency, enhancing the depressive effects on demand caused by income inequality and high saving propensity by rich people. Saving by high income agents are just held in the form of deposits which remain almost idle in banks' deposit accounts, except when they are employed to bail-in defaulted firms or used as a buffer stock for consumption to face temporary unemployment. In reality, savings may circulate again in the economic circuit, being employed for inter-generational transfers - which enhance the consumption potential of almost zero-income agents, such as students -, or being invested in real estates and financial assets. These investments in turn can increase demand both directly, for example by boosting the construction sector, and indirectly, through capital gains and wealth effects. These arguments seem to provides some justification for the adoption of slighlty higher average consumption propensities.

[43] In this respect we keep the same proportions between sectors employed in Caiani et al. (2015). Workers employed in each sector are then equally distributed across firms.

a rate of unemployment approximately equal equal to 8%, net of integer rounding of required workers' units. We then compute the value of labor productivity in the capital sector which allows to produce the initial desired level of output given the initial number of workmen employed. Similarly we set the initial productivity of capital goods (assumed to be equal across capital producers) and the technical ratio between capital units and workmen at the level consistent with initial desired output, the initial stock of capital available to manufacturers of consumer goods, and the number of workmen emplyed in the sector. Desired output and real capital stocks in turn have been calculated following the procedure explained in Caiani et al. (2015).[44]

Table 1 in the appendix provides an overview of the parameters values employed in the simulations.

Simulation were then run for 1000 periods, each period representing a quarter, performing 25 Monte Carlo repetitions for each scenario.

5 Baseline results, an overview

5.1 Validation

After having run all the simulation experiments discussed in the next sections we first proceed to the empirical validation of the model results. For this sake, we follow the same procedure outlined in Caiani et al. (2015) which builds upon the well established practice (see for example Dosi et al. (2010, 2012, 2013, 2015); Assenza et al. (2015); van der Hoog and Dawid (2015)) of comparing the properties of our artificial data with an extended set of empirical stylized facts collected from other contributions in the AB macroeconomic field, as well as from empirical studies.

This procedure yields very similar qualitative and quantitative results compared to the original model, suggesting that also the current version provides a good approximation of the properties displayed by real world data and matches a huge variety of micro and macroeconomic stylized facts. On the macro level, artificial time series volatility resembles main real aggregates volatility[45] and their auto and cross correlation structure, the only difference in this respect being represented by consumption which is still positively correlated to real GDP but appears to be lagged by two quarters, rather than coincident. This can probably be explained by the inclusion of a persistence factor in agents' consumption function (eq.3.22). On the other hand, this characteristic of the model allows to match a more important stylized facts for the purpose of the paper: the greater than one average propensity to consume observed at the low end of the income distribution (see Fisher et al. (2015)): in our model this can be explained by the fact that workers who loose their jobs do not immediately adapt their demand for consumption goods to the new income level, but rather lower it gradually, employing previously accumulated deposits as a buffer stock to fund their expenses, till they eventually end up being financially constrained in case they do not find a new job. In these cases, their average propensity to consume can be greater than one, as observed in reality.

In accordance with the empirical evidence on prices dynamics over the business cycles, inflation tends to be pro-cyclical and lagging whereas mark-ups are counter-cyclical and lagging (Bils, 1987; Rotemberg and Woodford, 1999). In addition, the model is fairly in lines with the stylized facts highlighted in Klenow and Kryvtsov (2005) concerning the frequency of price changes and the relative frequency of price-decreases and increases. Also changes in inventories and inventories/sales ratio are in accordance with available empirical evidence (Bils and Kahn, 2000), the former being pro-cyclical and the latter counter-cyclical. As in the original model banks leverage tends to be moderately pro-cyclical (Nuño and Thomas, 2013) while firms' total debt (Lown and Morgan, 2006; Leary, 2009) and firms' leverage are pro-cyclical.

Finally, real GDP growth rates have the typical tent-shaped leptokurtic distribution (Fagiolo et al., 2008).

At the micro level, we observe that our artificial firms are highly and persistently heterogeneous regarding their dimension, market shares and productivity levels, this differences being generated by selection processes occurring in both capital and labor markets, which are enhanced by the presence of innovation and Schumpeterian competition triggered by innovation. In accordance with reality, firms'

[44] Notice that since only workmen are directly employed in the production process, whereas other types of workers are in charge of different functions (supervision and basic management, R&D, strategic management), labor productivity in the capital good sector and the capital-workmen ratio are both significantly higher than the correspondent values in the previous version of the model.

[45] With investment and unemployment volatility being significantly more volatile than real GDP, and consumption being slightly less volatile than output.

investment appear to be lumpy rather than being smoothed over time. Finally, all the properties extensively discussed in Caiani et al. (2015) related to firms' size distribution, banks credit, credit degree, and bad debt distributions continues to hold also for the model presented here. All distributions are right-skewed and characterized by excessive kurtosis and fat tails.

Finally the model produces plausible outcomes for both income and wealth distribution, as measured by the Lorenz Curve and the Gini Index. Though income and wealth are initially distributed in the same way, the models highlights that wealth inequality ends up being significantly more marked than income inequality. In addition, in the baseline configuration with a flat tax rate income and wealth distribution are characterized by an increasing pattern which is partially attenuated when a progressive tax system is introduced, and reversed when labor market policies more favorable to lower income workers are introduced. These aspects will be treated in details in sections 6.1 and 7.

Properties highlighted in this section are robust across all the configurations analyzed in the paper.[46]

5.2 Baseline dynamics

Before focusing our attention on the analysis of the relationship between inequality and economic growth, in the present section we provides an overview of the model dynamics in the baseline scenario. Panel 2 displays a batch of variables selected for this sake. For explanatory reasons, variables values refer to the time span 500:1000 of a single simulation.[47]

Figures on the top line show that the model generates exponential real growth of both real GDP and consumption. Real consumption grows as a consequence of the incremental innovation process taking place in the capital good sector, which enhances capital (and thus labor) productivity. The number of units of capital purchased by consumption firms instead fluctuates around a broadly steady level. This latter fact is not surprising given our assumption that labor productivity in the capital good sector is constant.[48]

Unemployment fluctuates around approximately 15% for most of the time span displayed, albeit in the last part of the simulation it displays a slightly increasing trend. These values are fairly high, in particular if compared to the baseline of the original version of the model.[49] This can be easily explained by the fact that the average propensity to consume of the household sector as a whole is significiantly lower compared to the original version, as a consequence of the lower propensity of middle and high income workers[50]. Lower demand in turn tends to depress the economy. While one may be prone to ascibe higher unemployment to the inclusion of innovation in the model, which has definitevly a labor-saving character, a set of pilot simulations especially performed to test this hypotesis seems to reject it for values of the innovation parameters in a nieghborhood of the selected ones.

The increasing pattern of unemployment in the last part of the simulation seems to be due to increased inequality, which causes a greater share of income to go in the hands of low-propensity-to-consume agents thereby slowing down demand growth for consumption goods, compared to their supply.

The three figures also highlights that economic development unfolds through a succession of business cycles characterized by both mild and sever boom-and-bust episodes. The darker and lighter grey areas highlight, by way of example, one of such events. These episodes can be ascribed to the combined effect of both real and financial factors: an initial increase of investment caused by a spur of consumption firms' profit rates (see the periods before the darker grey area in the bottom-center figure of panel 2) triggers a process of expansion which allows employment, demand, and production to grow together. Higher demand causes firms' capacity utilization rates to increase (bottom-left figure in panel 2) while greater impulse to innovation caused by rising output allows firms to maintain and even increase their profit margins (bottom-center figure in panel 2) notwithstanding wages inflation increment due to falling unemployment. On the contrary, wages recover after the previous economic slowdown allows firms' higher

[46] This suggests that, although changes in the parameters employed in the various experiments affect the dynamics of the economy, the causal structure of the model and the structural inter-dependencies between its main variables is not subverted. More important, this provides some (non exhaustive) evidence for the fact that the model ability to replicate the empirical properties presented here is not originated by the specific parametrization employed.

[47] In all the experiments performed in the paper, the transition takes approximately 200 periods before the system converges to a quasi-steady trend.

[48] Yet real investment, computed as nominal investment divided by average consumption goods price, is increasing as a consequence of the higher inflation of capital goods prices. This in turn can be attributed to the fact that more productive capital goods reduce unit labor costs of consumption firms, on which the markup is applied, thereby dampening inflation. On the contrary, this does not happens for capital firms given their workmen's constant productivity.

[49] In the quasi-Steady State of the model presented in Caiani et al. (2015) unemployment fluctuated around 8%.

[50] Indeed, the values employed for the marginal propensities to consume out of income and wealth in the former model brought an average propensity above 95% of income, whereas in the current model the average propensity to consume of the economy at the beginning of the simulations is equal to 85%, given initial income shares of various groups.

production to translate in higher sales. Altogether this stimulates further increases in investment and a parallel increase in loans as firms are more prone to apply for loans as a consequence of higher wages, and banks are more willing to grant credit due to higher operating cash flows of applicants. Consumption firms leverage then increases (bottom-right figure in 2). However, further increases of workers's wages, in particular of middle and top tiers (see section 7) and augmented outlays to service the debt start squeezing profit margins. Over-investment and the progressive replacement of old capital batches with new more productive vintages on the other hand tend to reduce labor requirements. As a consequence, investment increasing trend is reversed though it takes some time before the cycle is reverted for unemployment and consumption as well. In the meanwhile, some of the firms which have undergone excessive debt, being exposed to this worsened economic scenario starts to default, causing further drops in demand and employment. The economy then undergoes a period of contraction (top line figures 2) and deleveraging, as displayed by the lighter grey area in the bottom-right figure of panel 2. This phase continues till excessive debt and capital in the economy are absorbed, and the dynamics of wages, unit costs, and prices allow firms to recover some profitability. On the other hand, depressed investment which slackened or even reversed firms' productive capacity growth, put a brake to the fall of capacity utilization rates caused by the recession. Investment can then recover, possibly setting the stage for a new expansionary phase.

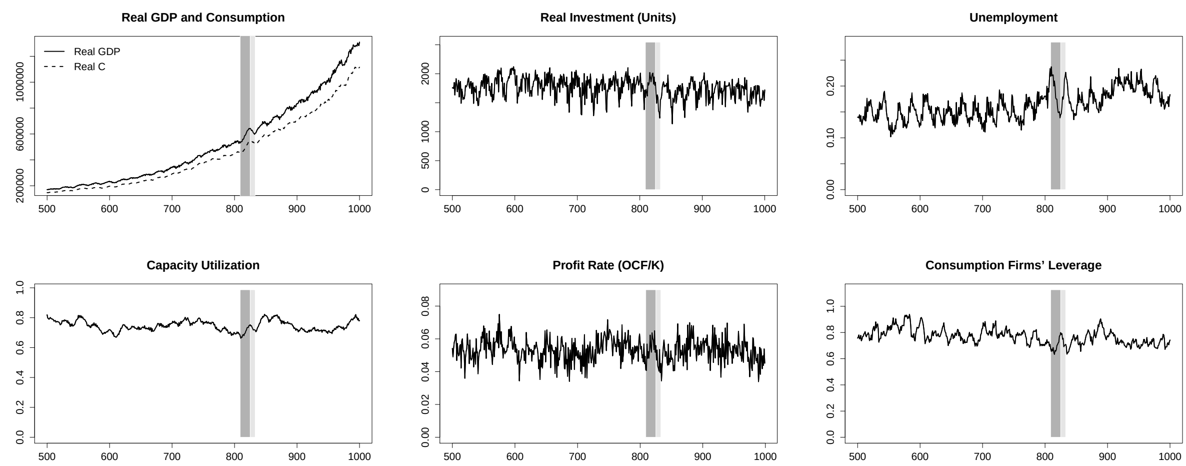

Figure 2: **Baseline Run 1** Top, Left: real GDP. Top, Center: real units of capital goods purchased. Top, Right: global unemployment. Bottom, Left: consumption firms' average capacity utilization rate. Bottom, Center: consumption firms' average rate of profit computed as OCF/capital financial value. Bottom, Right: consumption firms' average leverage

6 Policy Experiment: testing different tax regimes

6.1 Implementing a progressive tax scheme on income and wealth

Empirical evidence suggests that income and wealth inequality exert an impact on innovation and output dynamics, possibly hampering the growth process of the economy. The same seems to happen in our model where we account for the fact that different income groups are generally characterized by different propensities to consume and save, so that the distribution of income and wealth starts to exert an impact on aggregate demand. To investigate this possibility we employ the model to evaluate the impact of alternative tax regimes characterized by different degrees of progressiveness. In particular, we focus on their efficacy in redistributing income across different social groups and on the impact exerted by this redistribution on the growth of labor productivity and the overall performance of the economy.

In section 3.5 we showed that under the flat tax rates regime, each subgroup of the household sector contributes to total taxes on income and wealth for a portion equal to the share on income earned and the share of wealth owned, irrespective of the number of agents belonging to that group, that is independently of agents' personal income levels.

Instead, in order to realize a redistribution of income (wealth) a progressive tax system requires that people having income (or wealth) above the average contribute to total tax payments more than proportionally to their income (wealth) share, and vice-versa. In order to assess how much the average income (wealth) of each class of agents is above or below the global average (i.e. the average of the household sector as a whole) we can employee the ratio between the share of income SI_{Ht} (wealth SW_{Ht}) owned by each group and their numerosity over the total number of household agents (SP_h). In fact, this corresponds to the ratio between the group's average income (wealth) and the whole economy per-capita income (wealth), as shown hereunder:

$$\frac{SI_{ht}}{SP_h} = \frac{GI_{ht}/GI_t}{N_h/N_T} = \frac{GI_{ht}/N_h}{GI_{Ht}/N_T} \tag{6.1}$$

$$\frac{SW_{ht}}{SP_h} = \frac{GW_{ht}/GI_t}{N_h/N_T} = \frac{GW_{ht}/N_h}{GI_{Ht}/N_T} \tag{6.2}$$

In addition, our progressive tax regimes should also satisfy a further condition - which real world policy makers do not have to face - in order to allow for a comparison between the different tax schemes tested and to isolate the effects of a redistribution of income through taxes on the macroeconomic dynamics: they must ensure that the overall total tax load of the households sector for given income (wealth) levels and income (wealth) distributions is the same across the policy scenarios. Otherwise, it would be difficult to distinguish the influence exerted by the redistribution of income across different households from the effects generated by the change of households' total net-income (wealth) caused by a variation of households' total tax burden.

For this sake, in each period of the simulations, we first determine the overall income and wealth tax burden of households as $TI_t = GI_t\tau_{it}$ and $TW_t = NW_t\tau_{wt}$ respectively[51], and then distribute them across workers' groups.

Keeping in mind that with a flat tax rate this amount is distributed according to households sectors' shares of income SI_{Ht} (wealth SW_{Ht}) we then employ the ratio in equation 6.1 to define the following correction factors of the tax-distribution for each group h:

$$correction^i_{ht} = SI_{ht}\left(\frac{SI_{ht}}{SP_h}\right)^\theta \quad \text{with } \theta \geq 0 \tag{6.3}$$

$$correction^w_{ht} = SW_{ht}\left(\frac{SW_{ht}}{SP_h}\right)^\theta \quad \text{with } \theta \geq 0 \tag{6.4}$$

where the first equation refers to income taxes, and the second to taxes on wealth.

These correction factors are then normalized in order to compute the shares of total income and wealth taxes to charge on the four different household classes of the model:

$$tax\ burden^i_{ht} = \frac{correction^i_{ht}}{correction^i_{wt} + correction^i_{rt} + correction^i_{ot} + correction^i_{mt}} \tag{6.5}$$

$$tax\ burden^w_{ht} = \frac{correction^w_{ht}}{correction^w_{wt} + correction^w_{rt} + correction^w_{ot} + correction^w_{mt}} \tag{6.6}$$

$$\tag{6.7}$$

Knowing total taxes and the share paid by each group, we can finally compute the tax rates on income and wealth for each group using the following equation:

$$TI_{ht} = \underbrace{(GI_t\tau_{it})}_{TI_t}\,tax\ burden^i_{ht} = \underbrace{(GI_tSI_{ht})}_{GIht}\,\tau_{iht} \rightarrow \tau_{iht} = \frac{\tau_{it}\,tax\ burden^i_{ht}}{SI_{ht}} \tag{6.8}$$

Office workers and researchers, who starts with the same levels of personal income and wealth, are treated together and are then subject to the same tax rates.

Two things must be noticed about the procedure just explained. First, the parameter θ determines the degree of progressiveness of the tax scheme: greater values of θ lead to a more pronounced redistribution of income through taxes. Indeed, for positive values of θ, the higher the average income of a group compared to the global average (i.e. the higher $\frac{SI_{ht}}{SP_h}$), the higher the share of taxes paid by that group ($tax\ burden^i_{ht}$) will be.[52] The same occurs for taxes on wealth.

[51] That is, as if we were still in the flat tax rate scenario.

[52] Yet, given the need to maintain in all the scenarios the same tax burden of the households sector as a whole, for given income and wealth levels and given distribution configurations, τ_{iht} is not globally increasing in $\frac{SI_{ht}}{SP_h}$. Therefore, it can be the case that further increases of $\frac{SI_{ht}}{SP_h}$ - and consequently of $tax\ burden^i_{ht}$ - are associated with a decrease of τ_{iht}, thereby softening the original progressiveness degree of the tax scheme.

Second, for $\theta = 0$ equation 6.3 reduces to $correction^{i}_{ht} = SI_{ht}$ and equation 6.4 to $correction^{w}_{ht} = SW_{ht}$. As a consequence, $tax\ burden^{i}_{ht} = SI_{ht}$ and $tax\ burden^{w}_{ht} = SW_{ht}$ so that the progressive tax scheme presented above reduces to the original flat tax rates scheme with $\tau_{iht} = \tau_{it}$ and $\tau_{wht} = \tau_{wt}$.

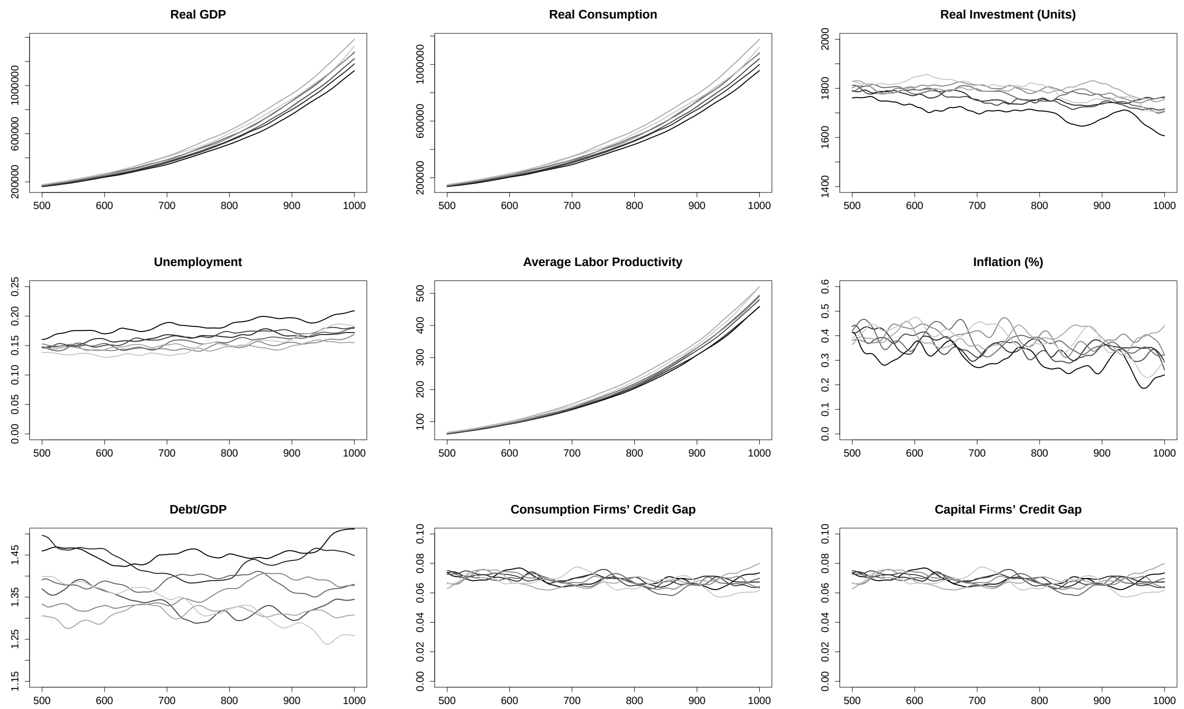

Figure 3: **Different Tax Schemes:** Lighter grey lines corresponds to higher values of θ. Top, Left: Real GDP. Top, Center: Real Consumption. Top, Right: Real Investment. Growth rates of prices have been computed using average market prices (weighted for firms' market shares). Center, Left: Unemployment. Center, Center: Average Labor Productivity (weighted for consumption firms' output shares). Center, Right: Inflation. The growth rates of prices have been computed using average market prices (weighted for firms' market shares). Bottom, Left: Government Debt/GDP ratio. Bottom, Center: Consumption Firms' Credit Gap as: Credit Demanded/Credit Received. Bottom, Right: Capital Firms' Credit Gap

For this experiment we tested 7 different values of θ ranging from 0 to 1.5 with an increment of 0.25 between subsequent scenarios. Panels 3,4,5 displays a collection of figures highlighting differences between tax regime tested in the experiment. For graphic reasons and to allow an intuitive interpretation of results the trend and cycle components of artificial time series have been separated using the Hodrick-Prescott filter and Monte Carlo average trends have been employed in the figures. All time series displayed refer to the time span 500:1000. Lighter lines refer to greater values of the parameter θ.

For a quantitative assessment of results, table 2 in the appendix provides a summary of results obtained under each tax system configuration, accompanied by the outcome of the tests for difference between data populations generated in the baseline and in each alternative scenario.

The results of our experiments suggest that introducing a progressive tax system always causes the dynamics of the system to improve: real GDP, real consumption, investment (panel 3 top line) are significantly higher than in the flat-tax rate baseline for every $\theta > 0$ scenario, while something similar also happens to labor productivity growth (second line-center), with the only exception of the $\theta = 0.25$ scenario (i.e. the most moderate progressive scheme) which displays a pattern very close to the baseline one. Conversely, despite the greater productivity of capital goods in most "progressive" scenarios, the fact that demand and output increase more than proportionally, causes unemployment to be lower on average under all scenarios with $\theta > 0$. Improved wages dynamics due to lower unemployment and higher demand in turn cause average inflation to rise slightly as we increase θ, though always remaining at moderate levels (center-right figure in 3). Finally, also public finance seems to benefit from the improved system dynamics as the debt to GDP ratio (bottom-left in panel 3) tends to decrease under more progressive scenarios. Figures in panel 4 highlight a very important aspect of these experiments: real consumption seems to increase as a consequence of a transfer of purchasing power and consumption from top managers to workmen and office workers. While the share of financially constrained consumption of the former tends to increase for greater values of θ, as a consequence of the increase in their tax rates, the financial constraint of the latter is significantly lessened (top line figures 4). As a result, lower income groups consumption markedly increases boosting real output growth. On the contrary, top managers' real consumption is left unaltered in most scenarios or even decreases in the most progressive tax regime case, where the overall growth of output is not sufficient to offset their tighter financial constraint.

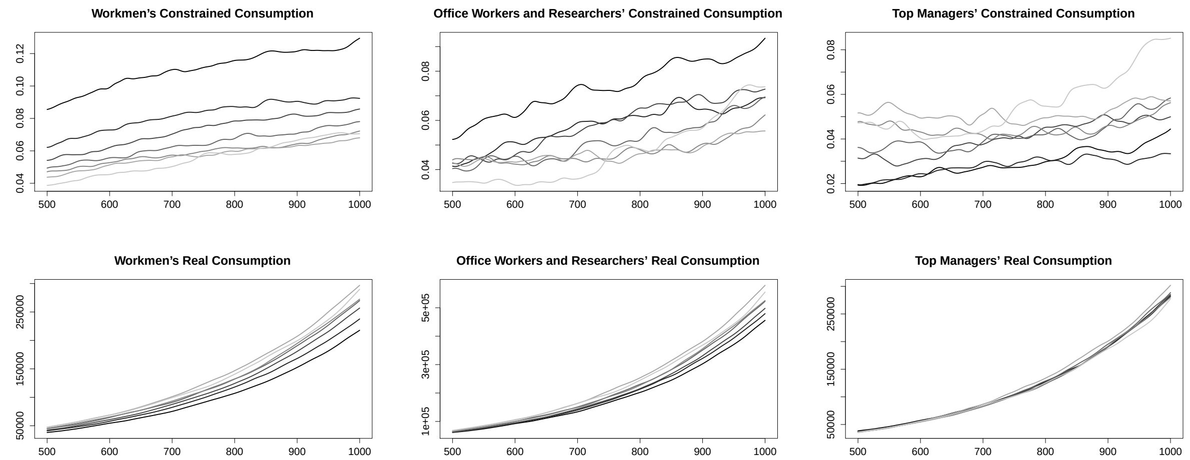

Figure 4: **Different Tax Schemes:** Lighter grey lines corresponds to higher values of θ. Top Left, Center, Right: Workmen's, Office Workers&Researchers', and Top Managers' Shares of Financially Constrained Consumption. Bottom Left, Center, Right: Workmen's, Office Workers&Researchers', and Top Managers' Real Consumption.

On the firms' side, investment increases as a consequence of greater profits margins due to higher demand and enhanced innovation dynamics, while the growth of investment tends to counteract rising output keeping average capacity utilization rates at similar levels. The overall effect of investment and profit dynamics is that firms' finance does not appear to be significantly affected by the change in the tax system. Indeed, firms' credit gap dynamics across different scenarios, which eventually depends on firms' demand for credit and firms' operating cash flows, tend to overlap (center and right figures in the bottom line of 3).

Finally, figures in panel 5 displays the Lorenz Curves and Gini Indexes associated to income and wealth in the 7 experiments performed. These plots show several important features of the model: first, the baseline is characterized by very high level of inequality for both income and wealth, the latter being considerably more pronounced than the former. Second, inequality in both income and wealth tends to decrease moving towards more progressive tax schemes. Third, despite the reduction of inequality from scenario to scenario, all experiments are characterized by a rising trend in both income and wealth polarization. Growing inequality in the distribution of income seems to depend primarily on the different pace at which wages of different groups grow, more than on profits' distributed by firms to managers. Imbalance in wages patterns of growth in turn are due to the fact that the four labor markets of the model are characterized by different degrees of competition, notwithstanding the fact that they are identically framed and despite different types of workers employ the same routines to set their reservation wage. The main reason lies in the hierarchical structure of firms: given proportions across different tiers of workers, large variations of workmen employment are required to induce a unit variation of firms' demand for office workers and researchers, and even larger variations are necessary to induce a unitary change in top managers' employment. This implies that higher tiers workers' employment is relatively more stable compared to lower ones', boosting a faster growth of wages.

In addition to the previous properties, figures in panels 3 to 5 all highlight another important aspect: while the gains of a more progressive tax scheme appears evident for low values of θ, these gains tends to fade out for further increases of the "progressiveness" parameter when θ is already high. This clearly appears by comparing the two scenarios characterized by the highest values of θ. Table 2 in the appendix for example shows that final real GDP in the $\theta = 1.25$ case is 30.59% higher than in the baseline, whereas it is only 25.95% greater in the $\theta = 1.5$ case. Similarly the Gini index calculted on income is 9.07% lower in the former case, while it is only 8.33% lower in the latter.[53]

At least two arguments can be adduced to explain the last two property. First, when the tax rate charged on lowest income households is already very low, further decreases of the tax rate do not signifi-

[53] To be thorough, this does not happens for wealth inequality measures which are consistently decreasing from scenario to scenario.

cantly increase disposable income available for consumption, and thus they are less effective in increasing demand. This also implies that when gross income growth of high and low income workers' classes proceeds at very different paces, cutting taxes to poor may not be sufficient to revert the increasing inequality trend.

However, the property observed may also be connected to the peculiar configuration of our experiments, where the tax rates of different workers groups were computed so to maintain the overall tax load on households at the same level of the baseline scenario. As already discussed, the functions adopted for this sake (eq. 6.8) imply that *tax burden*$^{i}_{ht}$ is an increasing function of $\frac{SI_{ht}}{SP_h}$, while τ_{iht} may be also decreasing if the rise of *tax burden*$^{i}_{ht}$ determined by eq. 6.3 and 6.5 is less than proportional to the rise of income share held by group h. Therefore, an increase in income polarization, though determining an increase of the tax burden for high-income groups and a correspondent decrease for low-income agents, may be accompanied by a reduction of tax rates for all groups, which softens the redistributive efficacy of the tax scheme.

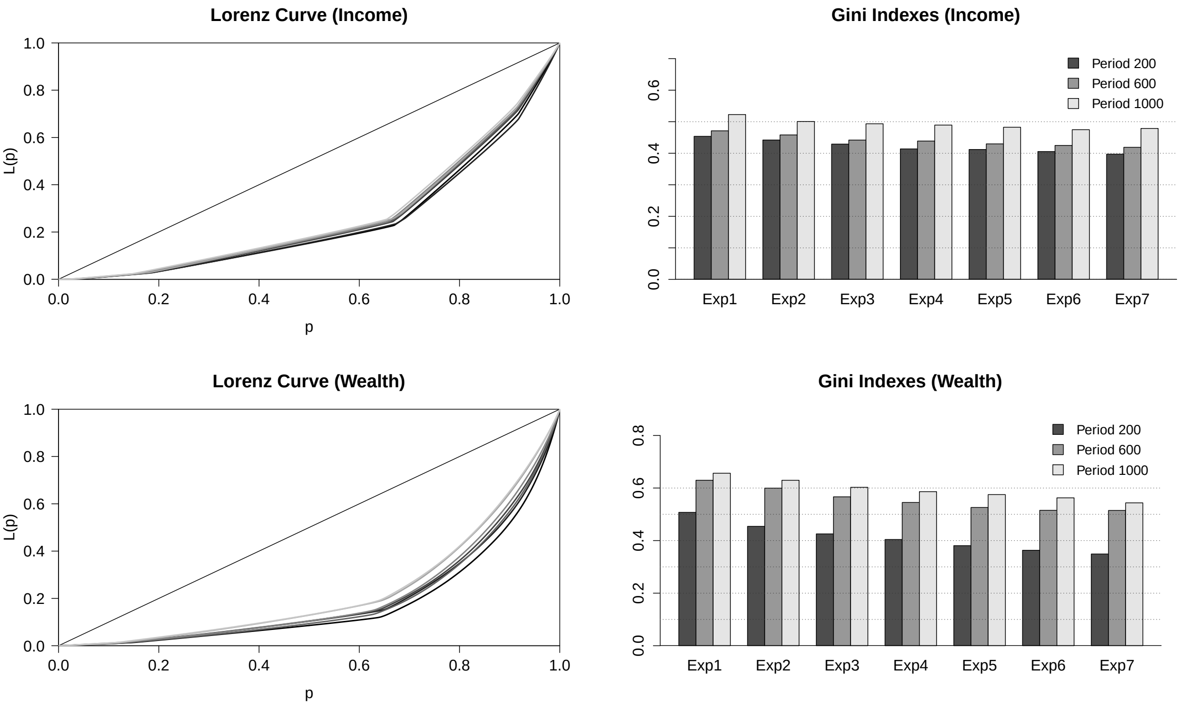

Figure 5: **Different Tax Schemes:** Lighter grey lines corresponds to higher values of θ. Top, Left: Lorenz Curve (Income) at period 1000. Top, Right: Gini indexes (Income) at different simulation time steps. Bottom, Left: Lorenz Curve (Wealth) at period 1000. Bottom, Right: Gini indexes (Wealth) at different simulation time steps.

All in all, the evidence provided by our experiments suggests that progressive taxation is an effective tool to attenuate income and wealth inequality and to foster prolonged real economic development. In particular, our results seem to provides some ground for the thesis according to which tax system reforms more favorable to high income households[54] may be called into question as one of the factors which have contributed to feed the long-lasting wave of rising inequality observed in many advanced countries. However, our experiments also suggest that ex-post reditribution of income through progressive taxation may be insufficient, alone, to stop and reverse this tendency.[55]

This motivates a quest for alternative measures which aims at tackling inequality directly in the wages determination sphere, that is on the labor markets.

[54] Among these we mention the progressive reduction of top statutory personal income tax rate and top marginal tax rates for employees occurred since the '80s. In some countries, such as the US, this drop has been of the order of more than 20% (from 70% in 1981 to 47% after 2007) according to OECD data.

[55] Admittedly, this latter result should be taken with a grain of salt in light of our previous considerations regarding the peculiarity of the experiments design.

7 Labor Market Experiments

The objective of this section is to analyze the impact on inequality and economic development of different degrees of downward rigidity of wages. For this sake we test four different values of the parameter defining the number of periods of unemployment required before workers reduce their reservation wage, which in the baseline was set equal to two (see equation 3.21). In turn, this parameter can be assumed to represent a proxy of the degree of labor coordination prevailing on the various labor markets which characterize our model. One of the possible rationale behind this configuration of the experiment lies in the interpretation of workers' competition on the labor market as a problem of coordination in a game theoretic perspective: workers compete with each other on the labor market, trying to be hired by firms, and to gain a wage. In order to increase their probability of success, they may reduce their reservation wage, though in this way they also reduce the possible gain. If they were able to coordinate with each other workers might agree to establish a lower bound to the reservation wage one can propose, or might commit themselves to delegate to a third part the definition of a common, possibly higher, reservation wage. This would make possible to move from prisoner dilemma situation, likely to bring a low-wages Nash equilibrium, to a high-wages equilibrium, in which participants are better-off. This kind of coordination is what minimum wage laws and collective bargaining practices attempt to achieve, whereas individualization of labor market relations, and wages flexibility enhancing interventions tend to depict a situation in which coordination is not possible and workers are pure competitors. Obviously, the results in the two configurations of the labor market refer to a game in which the demand of labor and the structure of payoffs is given and neither of the two implies that workers are better-off or worse-off when we widen the horizon of the game to encompass the whole economic system. One may argue that excessive bargaining power by workers may squeeze profits and reduce investment whereas more wages flexibility might free resources for investment and boost output growth and employment, with positive cascade effects on workers as well. Conversely, one may also argue that too much wages flexibility may depress aggregate demand, reducing investment opportunities, whereas a wage-led growth might foster a virtuous cycle whose positive effects may eventually trickle up to profits. Testing these alternative hypothesis is the main aim of the present section.

To accomplish this task we perform two different sets of experiments. In the first case, we change the value of the parameter t_u for all types of workers in the range 1:4, with a unitary increment between each scenario. In the second set of experiments we exclude from the parameter sweep the class of executive workers. This distinction is motivated by the fact that managers, though being formally employees, are substantially different from other types of workers in that they are profit earners as well, and represent by far the richest group in the economy. Table 3 presents the summary results of there two experiments. $t = 2$ represents the baseline case.

7.1 Adjusting wages downward rigidity of all employees

In the first set of experiment the parameter t_u is progressively increased for all types of workers. Given equation 3.21, higher values of the parameter increase the downward rigidity of wages, while making upward revisions more likely. For space reasons, we omit the plots related to this scenario. A summary of results is reported in the first four columns of table 3 in appendix.

Results suggests that variations from the baseline of main real aggregates are relatively low and do not show any clear cut monotonic tendency across scenarios[56]: the maximum variations of real GDP is less than 2.3%, 1.6% for real consumption, and approximately equal to 4% for real investment. Similar arguments apply to labor productivity, unemployment, and real consumption by different classes of households which do not display a clear-cut tendency across scenarios. The value of t_u is associated with the lowest trend in investment and the highest trend in unemployment. Still, unemployment is higher in all the alternative scenarios investigated despite the fact that the first one is characterized by greater labor flexibility while the other two by greater donward rigidity. The narrowness of these variations and the lack of any monotonic relationship between values of the parameter and real variables trend thus suggests that experiment results are far from being conclusive. The same argument applies to inequality measures: only wealth inequality shows a monotonic inverse relationship between values of the Gini indexes and values of t_u. Income inequality, on the contrary, decreases for higher values of t_u, but it is

[56]Still, summary results for the tests on the difference between populations, reported in the $p < 0.05$ and $p < 0.10$ lines of table 3, highlight that significant statistical differences between time series in the baseline and the corresponding time series (i.e. obtained with the same pseudo random number generator seed) in the alternative scenarios do exist. However, the low variations of average values observed suggest that the same value of the parameter can affect the dynamics of these variables in opposite directions, depending on stochastic effects.

slightly lower for $t_u = 1$ as well. Variations are nonetheless narrow and statistically significant only for the last scenario ($t_u = 4$). Furthermore, simulation performed in all the scenarios investigated continue to display the increasing pattern of inequality already observed in the previous experiments.

Not surprisingly, higher (lower) values of t_u instead produce significant deviations in nominal variables, causing higher (lower) levels of inflation. Interestingly, higher (lower) inflation is also connected to significant lower (higher) values of the Debt/GDP ratio of the public sector.[57]

In a nutshell, results of this first batch of experiments suggest that indiscriminately favoring wages inflation for all types of workers does not produce significant variation of main real aggregates, nor it helps to tackle income and wealth inequality in an effective way, while faster prices growth pushed by wages may help to contain the public debt burden.

7.2 Adjusting wages downward rigidity of middle and low tiers workers'

Since doubts remained about the plausibility of treating executive layers workers, i.e. top managers, as they were assimilated to other workers employed by firms, we performed a second test in which top managers are excluded from the parameter sweep performed on t_u.

Panels 6, 7, 8 provide a graphical overview of the main results obtained in this second experiment. The last three columns of table 3 in the appendix provides the usual batch of synthetic indicators to allow a quantitative assessment of variations across the four scenario.

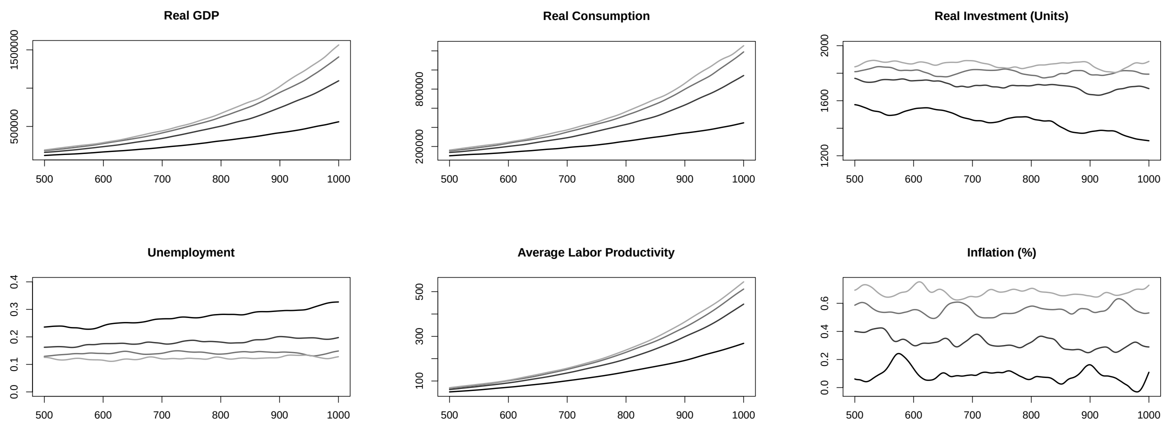

Figure 6: **Labor Market Experiment - Low-Middle Tiers Workers Only:**Lighter grey lines corresponds to higher values of t. Top, Left: Real GDP. Top, Center: Real Consumption. Top, Right: Real Investment. Growth rates of prices have been computed using average market prices (weighted for firms' market shares). Bottom, Left: Unemployment. Bottom, Center: Average Labor Productivity (weighted for consumption firms' output shares). Bottom, Right: Inflation. The growth rates of prices have been computed using average market prices (weighted for firms' market shares).

Results of the simulation clearly show that the outcome of experiments on wages downward rigidity, which in the previous configuration were inconclusive for most of variables tracked, dramatically changes when we exclude top managers. Variations of t_u now exert a huge impact on both the real and nominal sides of the economy, with a clear-cut tendency across different scenarios.

Experiments highlight that a reduction of labor coordination and middle-low level workers' bargaining power determines a significant drop in main real economic aggregates which translates in pathological high levels of unemployment. Real GDP and real consumption in the $t_u = 1$ scenario are almost half the value it attained in the baseline configuration, while investment is more than 20% lower. As a consequence, average unemployment is around 36.5%, 76% higher than in the baseline.

High unemployment and wages high downward flexibility in turn cause inflation trends to be close (or even below) zero despite the fact that labor productivity, which tends to dampen inflation by lowering unit labor costs, is 35% lower. These data clearly depicts a depressed economic context, which comes

[57] Given our previous considerations on the inconclusive impact of t_u on real variables, these deviations are more likely to be ascribed to nominal factors. Inflation indeed increases government tax revenues. At the same time, since inflation is pushed by wages, also government outlays for public servants' wages should rise accordingly. However, it is still possible that the increase in tax revenues due to inflation reduces government deficits by alleviating the burden of interests payments on bonds, since these are computed on the nominal value of the stock of debt in the previous period, while taxes are computed on current income, profits and wealth levels which has been inflated by prices growth.

to affect also public finance, being the debt to GDP ratio 45% higher: rising levels of unemployment inflate government counter-cyclical expenditure for unemployment benefits. In a context of profound wages stagnation, this measure are not sufficient to revert the fall in GDP causing a spike of government deficits and the debt-GDP ratio. This in turn calls for an upward revision of tax rates (equation 3.27). Eventually, this measures has the effect of further depressing aggregate demand. This situation goes on until the economy eventually glides and stabilizes over a path characterized by high unemployment, low productivity and low output levels from which it does not recover.

This scenario is also associated with significant higher values of inequality in both income and wealth distribution. The Gini indexes are well above the baseline, and the tendency of inequality to increase over the simulation time span is incredibly enhanced. Inequality dynamics provide the key to understand the drop of main real aggregates observed above: low consumption is a direct consequence of the loss of purchasing power by lower income-higher propensity to consume workers in favor of higher income-lower propensity to consume managers. Lower demand in turn concurs to depress investment, both as a consequence of falling capacity utilization rates (which eventually stabilizes, as much as obsolete machineries are not replaced and excess capacity is absorbed), and of reduced profit margins: even if firms' costs decreases, the overall effect of lower wages for middle and low level workers is to reduce revenues more than proportionally.[58] In addition, labor productivity dynamics is dampened by the fact that lower output and higher unemployment, which involves also researchers, hamper innovation activity.

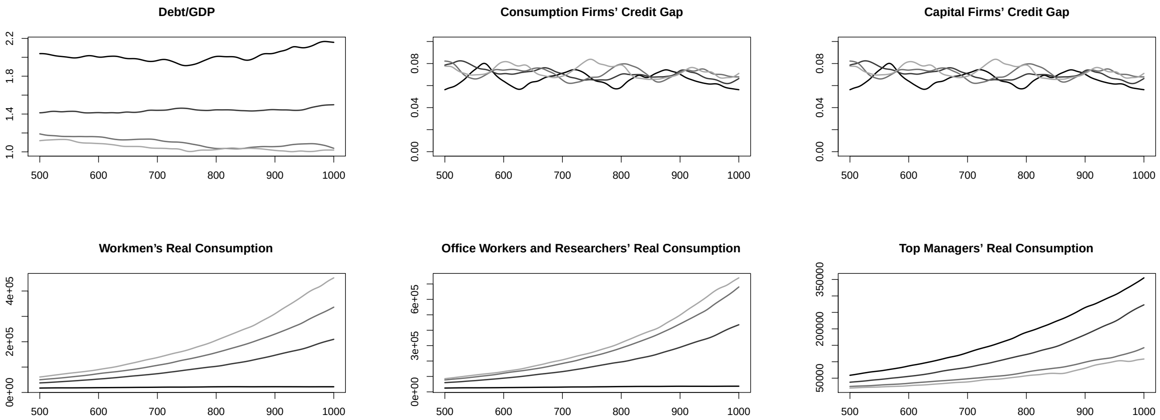

Figure 7: **Labor Market Experiment - Low-Middle Tiers Workers Only:**Lighter grey lines corresponds to higher values of t. Top, Left: Government Debt/GDP ratio. Top, Center: Consumption Firms' Credit Gap as: Credit Demanded/Credit Received. Top, Right: Capital Firms' Credit Gap. Bottom, Left, Center, and Right: Workmen, Office Workers&Researchers, and Top Managers' Real Consumption.

The situation depicted above is completely reversed in the two scenarios characterized by greater downward rigidity ($t_u = 3$ and $t_u = 4$) of workers' wages, where real output (+29% and +39%), real consumption (+29% and +39%), and real investment (+7% and +13%) are boosted by a redistribution of income in favor of lower income earners, thereby reducing average unemployment levels (-20% and -30%).

Figures on panel 7 highlight that this redistribution of income and wealth implies a redistribution of real consumption across different income groups as well with overall positive systemic effects as the rise of workmen and middle level workers' consumption more than compensates the reduction of real consumption of executives.

Higher demand and wages faster growth in turn stimulate inflation which is almost double in the third scenario and 1.4 times higher in the last one.[59] Unemployment is lower and inflation is higher notwithstanding the accelerated path of average labor productivity which is 18% and 22% higher in the last two experiments. In addition, the positive effect on public finance in the last two scenarios already observed in the previous experiment appears to be reinforced (top left of 7) as the positive effect of inflation in reducing the debt burden already discussed in the previous subsection is now backed up by

[58] On the contrary, top managers' wages dynamics, being not affected by the change in t_u, apart for the worsened economic environment, counteracts the fall in firms' variable costs, while providing a few support to aggregate demand given their high saving propensity.

[59] Still, inflation is quite mild also in this last case, being characterized by an average quarterly rate of approximately 0.79% which corresponds to an annual rate of below 2.4%.

the reduction of government's countercyclical outlays, thereby allowing to alleviate the tax burden of the economy through an undifferentiated cut of tax rates.

Finally, as in the progressive tax schemes experiment, firms' finance does not seem to be significantly affected by changes in the values of t_u: figures on the top line of panel 7 show that consumption and capital firms' credit gap trend tend to overlap across scenarios.

While the economy emerging from these two latter scenario seems to be more efficient compared to the baseline and high-wage flexibility scenarios, it is also more equal. The Gini Indexes computed on income and wealth are consistently decreasing across scenarios. Accordingly, the Lorenz Curves clearly move towards the line of perfect equality as we pass from scenario 1 to 2, and from scenario 2 to scenarios 3 and 4 though the Lorenz curves of these latter two cases computed on wealth cross with each other, suggesting that workers may be relatively better off in the last scenario, whereas office workers and researchers may be better off in the previous one.

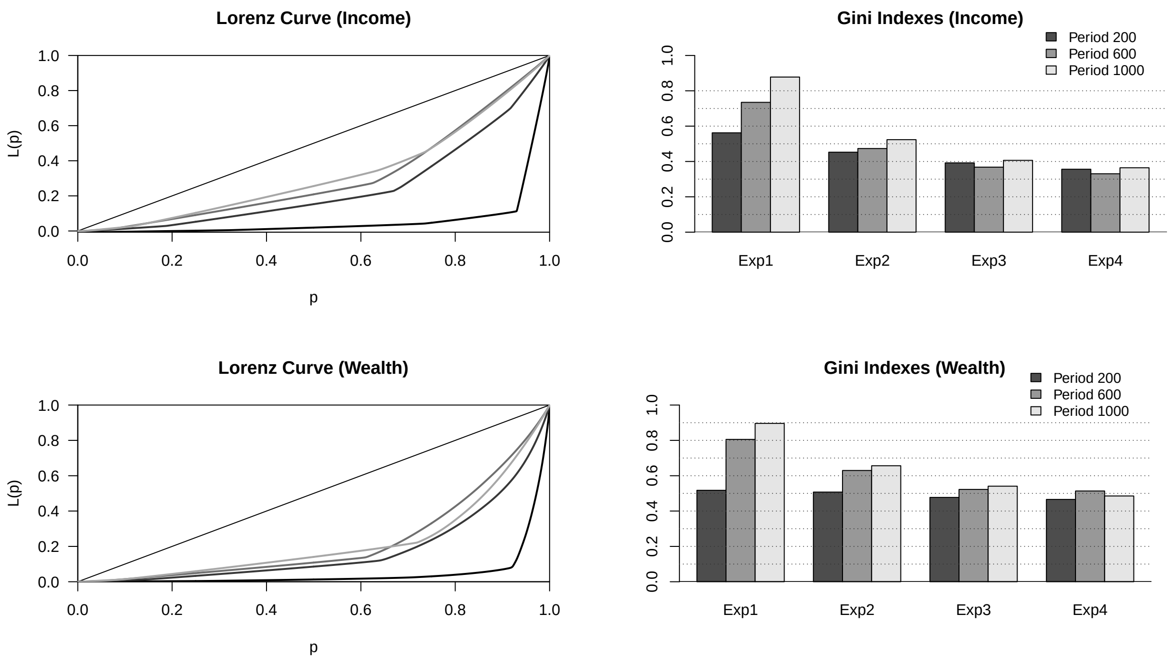

Figure 8: **Labor Market Experiment - Low-Middle Tiers Workers Only:**Lighter grey lines corresponds to higher values of t. Top, Left: Lorenz Curve (Income) at period 1000. Top, Right: Gini indexes (Income) at different simulation time steps. Bottom, Left: Lorenz Curve (Wealth) at period 1000. Bottom, Right: Gini indexes (Wealth) at different simulation time steps.

While the reduction of income and wealth inequality was achieved also in the first set of experiments, where more progressive tax systems were introduced, results of this last experiment suggests that the magnitude of this reduction can be significantly enhanced when income inequality is tackled directly on the labor market, rather than through an ex-post redistribution of income. Furthermore, the two scenarios which proxy the highest degree of labor coordination in setting wages, highlights a further important result as greater downward rigidity of wages seems to allow to significantly dampen or even stop the tendency of rising inequality observed in all the economy configurations previously investigated.

In conclusion, our results seem to suggest that institutional and labor market measures aimed at fostering greater labor coordination, for example through collective bargaining, and to reduce downward pressure on wages of low and middle income workers, for example through minimum wages laws, are effective in boosting economic development, improving both demand and supply conditions. These measures seem to be also more effective in reducing inequality compared to ex-post redistributive intervention through taxation, though the effects of a possible combination of the two strategy are still to be assessed. Conversely, the properties of the economy in the scenario where labor market competition is the highest ($t_u = 1$) seem to provide some ground for the thesis according to which labor market reforms aiming at increasing wages flexibility and the progressive demise of collective bargaining have played a crucial role in causing the long-lasting polarization of income and wealth observed in many advanced countries since the beginning of the eighties.

8 Final considerations and future investigations

The clear cut tendencies of evolution of the economy trough scenarios 1 to 7 in the progressive tax regime experiment and from scenario 1 to 4 in the workers' reservation wage rigidity experiment seem to provide very solid evidences in favor of the prevalence of a wage-led growth regime. Nonetheless, some caution is advisable, given the simplified nature of the economy depicted in the model and the germinal stage of our analysis. Several aspects of the brand new model presented here need to be deepened and further investigated.

Among these, two are particularly relevant in order to circumscribe the range of validity of the results presented in the previous section. First, the robustness of results presented in the paper should be assessed also in relation to different configurations of firms' desired growth (i.e. investment) function parameters. Indeed, the way firms look at profits and demand (i.e. the sensitivity of investment with respect to the weights γ_1 and γ_2 of the profit and capacity utilization rates in equation 3.10) in taking their investment decisions plays a decisive role in establishing either a wage or profit led growth regime.[60]

Second, different technological regimes may contribute to change the picture presented in the paper as well, either enhancing or possibly flattening and reverting the tendencies highlighted in this paper. Testing different configurations of the parameters shaping the innovation "propensity" of the economic system, in particular those referring to the magnitude and variability of productivity gains by capital firms, is thus necessary.

These two further investigations will thus be the object of analysis of future works employing the model presented here. In addition, also the effects of a combination of the fiscal and labor market measures tested here, are yet to be assessed.

However, also some amendments to the structure of the model will be necessary in the future in order to provide a more comprehensive analysis of the inequality-economic development nexus. In particular, the inclusion of a foreign sector and international trade seem to be imperative, as the patterns characterizing different workers' wages evolution are likely to exert a huge impact on the economy international competitiveness, thereby affecting net exports and output dynamics in non-trivial ways.[61] The inclusion of credit to households, which would open the possibility of a profit led-debt driven growth regime, represents another interesting possible integration of the model.

As a final remark, we would like to point out that even though the endogenous wage determination mechanism, implicit in the decentralized matching mechanism between workers and firms in the various labor markets, produces realistic results as far as the distribution of income and wealth *between* income groups is concerned, it does not allow for high income and wealth dispersion *within* each income group, that is between agents' belonging to the same class of households. This can be ascribed to the relative simplicity of the mechanism proposed and to the fact that workers are perfectly homogeneous so that their cheapness is the only criteria guiding employers' hiring decisions. The only exception is represented by the class of managers, given the multiplicative effect embedded in the dividend distribution procedure, which allows richer managers' to increase the share of dividends received from firms and banks. A smoother and more realistic distribution of individual agents' income and wealth can be achieved by increasing the number of organization layers by firms, possibly allowing them to grow endogenously with firms' dimension (in line with Ciarli et al. (2010)). However, this is somehow beyond the objectives of the present work which aimed to analyze the systemic effects of inequality, so that the focus was more on income and wealth distribution between different income groups, rather than on inequality between individual agents.

[60] The more firms give weight to profit margins the more likely is the emergence of a profit-led growth regime. As reported in table 1, for simulations analyzed in this paper, we adopted the weights of profits and capacity utilization rates γ_1, γ_2 both equal to 0.015, thus already depicting a situation theoretically favorable for a profit-led regime to emerge, as it seems reasonable that firms' generally give more weight to demand and capacity utilization rates, rather than to profits, when deciding about investment in real capital accumulation.

[61] Conversely, results displayed in this paper seem to hold for relatively closed economic systems, such as the world economy which is in aggregate a perfectly closed system, and Europe as a whole, which represents a relatively closed system since most of her exchanges occur between member states.

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A Calibration

Table 1: Parameters

Symbol	Description	Baseline	Experiment
g_{SS}: pre-SS	Nominal rate of growth in the SS	0.0075	same
λ: free	Adaptive expectations parameter	0.25	same
N_W, N_O, N_R, N_M: pre-SS	Number of workmen,office workers, researchers households, top managers	2400, 1119, 81, 400	same
$size_{\Phi_C}$: pre-SS	Number of consumption firms	100	same
$size_{\Phi_K}$: pre-SS	Number of capital firms	10	same
$size_{\Phi_B}$: pre-SS	Number of banks	10	same
$share_{cw} = share_{kw}$: free	Share of Workmen in C and K firms	0.6	same
$share_{co}$: free	Share of office workers in C firms	0.3	same
$share_{ko}$: free	Share of office workers in K firms	0.15	same
$share_{cm} = share_{km}$:free	Share of managers in C and K firms	0.10	same
SI_{w0}: free	workmen's initial share of gross income	0.3	same
$SI_{o0} + SI_{r0}$: free	Office workers' and researchers' initial share of gross income	0.4	same
SI_{m0}: free	Top managers' initial share of gross income	0.3	same
SW_{w0}: free	Workmen's initial share of pre-tax wealth	0.3	same
$SW_{m0} + SW_{r0}$: free	Office workers' and researchers' initial share of pre-tax wealth	0.4	same
SW_{m0}: free	Top managers' initial share of pre-tax wealth	0.3	same
$\alpha_w, \alpha_o = \alpha_r, \alpha_m$: free	Workmen, office workers&researchers, and managers' average propensity to consume out of income	0.95, 0.85, 0.75	same
β: free	Real consumption persistence parameter	0.9	same
u_0: pre-SS	Initial unemployment (both global and for each workers group)	0.08	same
μ_N: SS-given	Productivity of labor in K sector	6.67	same
$\{\mu_k, l_k\}$: pre-SS and SS-given	Initial productivity and (constant) capital/workmen ratio of K	$\{1, 20\}$	same
$\chi_c = \chi_k$: free	Number of potential partners on C and K goods mkts	3 , 5	same
$\chi_d = \chi_l$: free	Number of potential partners on deposit-credit mkts	3	same
$\chi_w, \chi_{o,\chi_r,\chi_m}$: free	Number of potential partners on workmen, office workers, researchers, and managers' labor mkts (for each vacancy)	10	same
$\epsilon^d = \epsilon^l$: free	Intensity of choice in deposit-credit and consumption goods mkts	4.62	same
$\epsilon^c = \epsilon^k$: free	Intensity of choice in capital goods mkt	13.86	same
ν: pre-SS	Firms' inventories target share	0.1	same
ϑ: free	Labor turnover ratio	0.05	same
μ_{c0}, μ_{k0}: pre-SS	Initial mark-up on ULC for C and K firms	0.32, 0.05	same
$(\mu_{FN_1}, \sigma^2_{FN_1})$: free	Folded Normal 1 Distribution parameters (Wages&Prices)	(0, 0.015)	same
t_u: free	Quarters of unemployment in reservation wage revision	2	1 : 1: 4
N_{gt}: pre-SS	Number of public servants (constant)	680	same
$\tau_{\pi 0}, \tau_{i0}, \tau_{w0}$: pre-SS	Profits, income, and wealth initial tax rates	0.18, 0.08, 0.05	same
θ: free	Tax system progressiveness parameter	0	0.0 : 0.25 : 1.5
def^1, def^0: free	Upper and lower deficit threshold in the tax rate revision rule	0.05, 0.02	same
υ: free	Adjustment parameter in the tax rate revision rule	0.05	same
η, κ: pre-SS	Loans and capital goods duration	20, 20	same
$\overline{r}$: SS-given	Target profit rate (Investment function)	0.04345	same
$\overline{u}$: SS-given	Target capacity utilization (C firms' investment and price functions)	0.8	same
γ_1, γ_2: free	Profit and capacity utilization rates weight (Investment function)	0.015, 0.015	same
ξ^{inn}, ξ^{imi}: free	Innovation and imitation probability of success parameters	0.015, 0.045	same
$(\mu_{FN_3}, \sigma^2_{FN_3})$: free	Folded Normal 3 Distribution parameters (Innovation Gain)	(0, 0.01)	same
σ: pre-SS	Firms' precautionary deposits as share of WB	1	same
$\rho_c = \rho_k$: pre-SS	Firms' profits' share distributed as dividends	0.9	same
ρ_b: pre-SS:	Banks' profit share distributed as dividends	0.6	same
i^l_{b0}, i^d_{b0}: pre-SS	Initial interest rate on loans and deposits	0.0075, 0.0025	same
CR^T_0, LR^T_0: SS-given	Initial banks' target capital and liquidity ratios	0.18, 0.26	same

Table 1: Parameters

Symbol	Description	Baseline	Experiment
ς_c, ς_k: free	Banks' risk aversion towards C and K firms	3.9, 21.5	same
$(\mu_{FN_2}, \sigma^2_{FN_2})$: free	Folded Normal 2 Distribution parameters (Deposits&Loans interests)	(0, 0.015)	same
ι: free	Haircut on defaulted firms' capital value	0.5	same
w_{n0}: pre-SS	Initial average wage	5	same
ω: pre-SS	Dole (share of average workmen's wages)	0.4	same
$\bar{i}^a_{cb}$: pre-SS	CB interest rates on advances	0.005	same
$\bar{i}^b$: pre-SS	Bonds interest rate	0.0025	same
$\bar{p}^b$: pre-SS	Bonds price	1	same

B Results Summary Tables

Table 2: Tax Progressiveness Experiments

Variable	Measure	**Baseline**	Scenarios					
		Exp 1: $\theta = 0.00$	Exp 2: $\theta = 0.25$	Exp 3: $\theta = 0.50$	Exp 4: $\theta = 0.75$	Exp 5: $\theta = 1.00$	Exp 6: $\theta = 1.25$	Exp 7: $\theta = 1.50$
Real GDP	MC Average	1122991.8913	+0.0963	+0.1305	+0.2093	+0.1746	+0.3059	+0.2595
	$p < 0.05$	-	64	88	72	68	68	60
	$p < 0.10$	-	72	92	76	76	84	72
	SD (cycle)	0.0175	0.0176	0.0164	0.0161	0.0161	0.0164	0.0165
	SD (across MC)	0.2092	0.1492	0.1987	0.2860	0.2292	0.2287	0.2053
Real Consumption	MC Average	956097.1279	+0.0925	+0.1294	+0.2007	+0.1697	0.3055	+0.2550
	$p < 0.05$	-	80	60	96	84	76	84
	$p < 0.10$	-	80	72	96	92	84	88
	SD (cycle)	0.0135	0.0134	0.0125	0.0119	0.0121	0.0125	0.0125
	SD (across MC)	0.2101	0.1538	0.2037	0.2908	0.2312	0.2291	0.2077
Real Investment	MC Average	1606.8524	+0.1091	+0.0768	+0.0691	+0.1063	+0.1045	+0.0761
	$p < 0.05$	-	100	76	88	88	100	96
	$p < 0.10$	-	100	80	92	88	100	96
	SD (cycle)	0.0863	0.0868	0.0841	0.0822	0.0825	0.0850	0.0841
	SD (across MC)	0.0980	0.0850	0.0892	0.0978	0.0676	0.0726	0.0639
Unemployment	MC Average	0.2091	-0.1474	-0.1025	-0.1065	-0.1489	-0.2103	-0.0698
	$p < 0.05$	-	88	88	88	88	96	100
	$p < 0.10$	-	88	88	92	92	96	100
	SD (cycle)	0.0862	0.1010	0.0958	0.0989	0.1055	0.1093	0.1106
	SD (across MC)	0.2245	0.2548	0.2152	0.2946	0.2201	0.2602	0.2307
Inflation	MC Average	0.3287	+0.0858	+0.0798	+0.1409	+0.1272	+0.1584	+0.1772
	$p < 0.05$	-	96	72	68	72	74	88
	$p < 0.10$	-	96	76	84	80	84	88
	SD (cycle)	0.4594	0.4562	0.4596	0.4529	0.4573	0.4581	0.4576
	SD (across MC)	0.1963	0.1471	0.1691	0.1530	0.1435	0.1479	0.2101
Labor Productivity	MC Average	459.3656	+0.0359	+0.0782	+0.1346	+0.1027	+0.1763	+0.1813
	$p < 0.05$	-	60	56	76	84	68	72
	$p < 0.10$	-	68	60	80	84	76	76
	SD (cycle)	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0033
	SD (across MC)	0.1815	0.1459	0.1844	0.2552	0.2204	0.2123	0.1872
Debt/GDP	MC Average	1.5119	-0.0328	-0.1018	-0.0781	-0.0778	-0.1254	-0.1560
	$p < 0.05$	-	88	80	100	88	96	96
	$p < 0.10$	-	88	80	100	88	96	100
	SD (cycle)	0.0262	0.0261	0.0261	0.0273	0.0262	0.0264	0.0274
	SD (across MC)	0.1183	0.1010	0.1137	0.1604	0.1460	0.1682	0.1750
Gini-Income	MC Average	0.5227	-0.0412	-0.0553	-0.0631	-0.0763	-0.0907	-0.0833

Table 2: Continued

	$p < 0.05$	-	56	88	96	100	100	100
	$p < 0.10$	-	64	88	100	100	100	100
	SD (cycle)	0.0154	0.0150	0.0142	0.0147	0.0125	0.0122	0.0135
	SD (across MC)	0.0295	0.0300	0.0287	0.0300	0.0260	0.0257	0.0283
Gini-Wealth	MC Average	0.6566	-0.0406	-0.0815	-0.1067	-0.1233	-0.1426	-0.1712
	$p < 0.05$	-	72	100	100	100	100	100
	$p < 0.10$	-	88	100	100	100	100	100
	SD (cycle)	0.0163	0.0134	0.0148	0.0267	0.0207	0.0238	0.0244
	SD (across MC)	0.0249	0.0213	0.0245	0.0455	0.0359	0.0422	0.0449

Table 2: "MC Average" refers to the Monte Carlo average of the correspondent variable in each scenario. In the case of Real Output, Real Investment, Real Consumption, Labor Productivity, debt/GDP, and the Gini Indexes, end of simulations values are employed. Inflation and unemployment instead refers to average values over the time-span 500-1000. For non-baseline scenarios, the deviations from the baseline average are shown instead of the absolute value, in order to better appreciate the variation from scenario to scenario. "$p < 0.05$" and "$p < 0.1$" report the percentage of MC simulations for which we can reject the null hypothesis (respectively at the 5% and 10% levels of significance) that the variable time series (in the time span 500-1000) in the given scenario and the correspondent one in the baseline (i.e. with the same *pseudo random number generator* seed) are two identical populations. In order to perform these checks, the Mann-Whitney-Wilcoxon Test was employed. "SD (cycle)" is the MC mean of the average Standard Deviations of the variable cycle component over the time span 500-1000, normalized for the trend component in order to allow a comparison on the same scale. Finally, "SD (across MC)" indicates the Standard Deviation of the values employed to calculate the Monte Carlo Averages, normalized for correspondent average value in order to allow a comparison on the same scale. Since we did not filter the Gini indexes, the rough series were employed instead of the cycle component when computing "SD (cycle)".

Table 3: Labor Market Experiments

		Baseline	Experiment Labor Market - all Workers Scenarios			Experiment Labor Market - no Executives Scenarios		
Variable	Measure	**Exp 2:** $t_u = 2$	Exp 1: $t_u = 1$	Exp 3: $t_u = 3$	Exp 4: $t_u = 4$	Exp 1 : $t_u = 1$	Exp 3: $t_u = 3$	Exp 4:$t_u = 4$
Real GDP	MC Average	1122991.8913	-0.0127	+0.0101	+0.0229	-0.4445	+ 0.2900	+ 0.3904
	$p < 0.05$	-	80	72	84	92	80	84
	$p < 0.10$	-	84	80	88	100	84	84
	SD (cycle)	0.0175	0.0169	0.0174	0.0179	0.0196	0.0172	0.0174
	SD (across MC)	0.2092	0.2356	0.1987	0.1814	0.2423	0.1904	0.1777
Real Consumption	MC Average	956097.1279	-0.0105	+0.0040	+0.0158	-0.4587	+0.2868	+0.3750
	$p < 0.05$	-	84	68	80	100	80	80
	$p < 0.10$	-	84	80	88	100	84	80
	SD (cycle)	0.0133	0.0135	0.0138	0.0144	0.0151	0.0137	0.0146
	SD (across MC)	0.2101	0.2433	0.1470	0.1806	0.2494	0.1986	0.1757
Real Investment	MC Average	1606.8524	+0.0370	+0.0402	-0.0010	-0.2159	+0.0689	+ 0.1262

Table 3: Continued

	$p < 0.05$	-	96	92	84	100	92	96
	$p < 0.10$	-	96	92	84	100	92	96
	SD (cycle)	0.0863	0.0839	0.0871	0.0886	0.0891	0.0866	0.0867
	SD (across MC)	0.0980	0.0738	0.1212	0.0798	0.1075	0.0814	0.1014
Unemployment	MC Average	0.2091	+0.0593	+0.0071	+0.0873	+0.7583	-0.1992	-0.3048
	$p < 0.05$	-	96	96	96	96	92	100
	$p < 0.10$	-	96	96	96	96	92	100
	SD (cycle)	0.0862	0.0798	0.0852	0.0771	0.0525	0.1196	0.1444
	SD (across MC)	0.2245	0.2359	0.2425	0.2083	0.1430	0.3121	0.3741
Inflation	MC Average	0.3287	-0.8495	+0.8112	+1.2428	-0.6490	+0.9736	+1.4009
	$p < 0.05$	-	96	100	100	96	100	100
	$p < 0.10$	-	96	100	100	96	100	100
	SD (cycle)	0.4594	0.4169	0.4137	0.4258	0.5908	0.3857	0.3820
	SD (across MC)	0.1963	1.9049	0.1159	0.0629	0.7226	0.1032	0.0491
Labor Productivity	MC Average	459.3656	-0.0315	-0.0194	+0.0107	-0.3525	+0.1811	+0.2233
	$p < 0.05$	-	76	60	72	100	76	72
	$p < 0.10$	-	84	60	80	100	80	76
	SD (cycle)	0.0032	0.0033	0.0032	0.0032	0.0033	0.0031	0.0030
	SD (across MC)	0.1815	0.2074	0.1067	0.1584	0.2263	0.1938	0.1824
Debt/GDP	MC Average	1.5119	+0.3398	-0.1750	-0.2364	+0.4497	-0.2572	-0.3109
	$p < 0.05$	-	100	100	100	100	96	100
	$p < 0.10$	-	100	100	100	100	100	100
	SD (cycle)	0.0262	0.0260	0.0270	0.0278	0.0344	0.0265	0.0276
	SD (across MC)	0.1183	0.1268	0.1309	0.1562	0.1162	0.1663	0.2130
Gini-Income	MC Average	0.5227	-0.0407	-0.0218	-0.0567	+0.6787	-0.2230	-0.3033
	$p < 0.05$	-	32	20	56	100	100	100
	$p < 0.10$	-	32	28	72	100	100	100
	SD (cycle)	0.0154	0.0197	0.0179	0.0184	0.0143	0.0161	0.0178
	SD (across MC)	0.0295	0.0392	0.0350	0.0373	0.0163	0.0397	0.0487
Gini-Wealth	MC Average	0.6566	+0.0124	-0.0211	-0.0437	+0.3603	-0.1799	-0.1987
	$p < 0.05$	-	4	16	52	100	100	100
	$p < 0.10$	-	20	24	56	100	100	100
	SD (cycle)	0.0163	0.0248	0.0173	0.0200	0.0049	0.0159	0.0412
	SD (across MC)	0.0249	0.0375	0.0271	0.0320	0.0055	0.0361	0.0786

Table 3: Measures presented in the table follow the same conventions adopted in table 2. Experiment 2 ($t_u = 2$), representing the baseline scenario, is common to both experiments.