



Monetary policy and inequality: A heterogeneous agents' approach

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ABSTRACT

This paper examines the influence of contractionary monetary policies (MPs) on income and wealth inequality. By developing an Agent-Based Stock-Flow Consistent model, we show that both the sign and magnitude of monetary policy effects are determined by heterogeneity in income sources and portfolio preferences. We model four transmission channels of the MPs, and their interaction: the cost push (CP), the aggregate demand (AD), the saving remuneration (SR) and the asset price (PA) channels. We show that the long-term effects of MPs are nonlinear and depend on key structural factors, including the degree of symmetry in the distribution of non-financial firms and bank shares, the labour share, unemployment subsidies, the saving rate, the aggregate share of wealth allocated to financial assets, and portfolio heterogeneity. In particular, the AD, SR, and CP channels play a dominant role in shaping long-run outcomes. The short-run effects are driven by the capital gains and losses (CGLs) on stocks and long-term bonds, alongside the financial channel. Overall, our results suggest that the potential for an equalising effect of MPs is largely confined to the short term, stemming from portfolio composition heterogeneity. In the long-run, this possibility diminishes. It becomes contingent on a more equitable distribution of bank shares relative to non-financial firms' shares and on structural factors such as a low labour share, portfolio heterogeneity, and/or a combination of a high saving rate and generous unemployment subsidies.

1. Introduction

In recent years, there has been growing concern among scholars and policymakers over the consequences that monetary policy (MP) shocks have on income and wealth inequality. Some argue that income distribution is primarily shaped by fiscal rather than monetary policy (Acemoglu and Robinson, 2008; Muinelo-Gallo and Roca-Sagalés, 2011; Neves and Silva, 2014). Because income distribution is viewed as a political rather than technical issue, the link between monetary policy and inequality has fuelled public criticism of central bank independence (Acemoglu and Johnson, 2012). The latter rests on the assumption that central banks address purely technical issues, such as the maintenance of price stability over the medium term. However, there are specific technical, non-judgemental interests for central bankers in the distribution of both income and wealth that have led them to question the extent to which distributional side effects should be tolerated, particularly during financial and economic crises or extended periods of zero lower bound constraints (Guerello, 2018).

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Although the empirical literature on this topic has been expanding, the results remain ambiguous and occasionally contradictory. In fact, scholars have identified the equalising and unequalising effects of monetary policies. Aye et al. (2019), Furceri et al. (2018), Galbraith et al. (2007), Mumtaz and Theophilopoulou (2017b), and Saiki and Frost (2014, 2018) find that contractionary monetary policies increase income inequality; while Davtyan (2016) and Villarreal (2014) show that contractionary shocks have an equalising effect. On the other hand, Hafemann et al. (2018), Herradi and Leroy (2021), and Inui et al. (2017) find that expansionary shocks worsen inequality, while Samarina and Nguyen (2024) and Taghizadeh-Hesary et al. (2020) show that these shocks reduce inequality. In general, there is no consensus in the empirical literature on the impact of monetary policy shocks on inequality (Colciago, 2011; McKay and Wolf, 2023).

Furthermore, the empirical results differ according to the inequality measure considered. Most studies adopt the Gini coefficient (Aye et al., 2019; Bunn et al., 2018; Casiraghi et al., 2018; Coibion et al., 2017; Davtyan, 2016; Furceri et al., 2018). A smaller number of researchers adopt the Theil index (Galbraith et al., 2007; Guerello, 2018), top one percent income share (Herradi and Leroy, 2021) and the interdecile ratios (Montecino and Epstein, 2015; Taghizadeh-Hesary et al., 2020). In this regard, Davtyan (2016) shows that the estimated effects of monetary policy might differ if the chosen measure of inequality does not capture all income shares, for instance, the top percent. In this line, research shows that in the US, the dynamics of income inequality are mainly driven by the variation in the upper end of the distribution (Atkinson et al., 2011; Harris et al., 2011; Kenworthy and Smeeding, 2014).

However, rather than contradictory, as argued by Dolado et al. (2021), divergent results on the effects of monetary policy on inequality can be explained by differences in the distribution of households along relevant heterogeneity dimensions. The effect of monetary policy can depend on the initial wealth distribution and the composition of household financial assets (O'Farrell and Rawdanowicz, 2017; Guerello, 2018), the initial wage share (Furceri et al., 2018), and the marginal propensity to consume (Ampudia et al., 2024). Therefore, it is *a priori* unclear how monetary policy will ultimately affect inequality.

Central banks have started to pay more attention to the heterogeneity of households (Carney, 2016; Draghi, 2016; Yellen, 2016), and inequality has become a topic that is mentioned more frequently in the European Central Bank summary reports (Bergbauer et al., 2022). These developments have been supported by recent studies on the role of household heterogeneity in the transmission of macroeconomic shocks and policies. As argued by Debortoli and Galí (2017), taking into account the heterogeneity of agents has been shown to be important to understand the transmission of monetary policy, including the relative contribution of direct and indirect effects (Kaplan et al., 2018), or its distributive effects across income groups (Auclert, 2019a). Most of these empirical studies recognise that the overall impact of monetary policy may be heterogeneous across households due to significant differences in the composition of their portfolios (which include stocks, bonds and real estate) and their sources of income (such as employment status and labour versus financial income). By estimating a Bayesian VAR model for the Euro area, Lenza and Slacalek (2018) show that the transmission of Quantitative Easing to individual households passes through three channels: income composition, portfolio composition and earnings heterogeneity. They find that the (obviously expansionary) QE in the euro area has diminished income inequality, mostly via the earnings heterogeneity channel and a sizeable reduction in the unemployment rate for the lower income groups. The Gini coefficient for gross household income drops from 43.1 to 42.9. CB's asset purchase programmes have contributed to reducing wealth inequality, albeit to an almost negligible extent. Dossche et al. (2021) estimates the transmission channel from monetary policy to consumption, studying how it varies between individual households according to the structure of their income and wealth, their marginal propensity to consume and the type of income reaction to aggregate shocks. They show that the impact of the different interest rate paths on net financial income of households (net interest rate exposure) is heterogeneous between households, depending on the composition of their asset and liability portfolios.

In light of this empirical evidence, in the present paper we develop an Agent-Based Stock-Flow Consistent model (AB-SFC) (Caiani et al., 2016; Catullo et al., 2022; Di Domenico, 2023; Reale, 2024) to study the relationship between monetary policies and income and wealth inequality. The main aim of the paper is to provide a theoretical framework that explains the ambiguous empirical evidence, overcoming the difficulties that arise in their apparently contradictory interpretations, and shedding light on how different initial conditions in the endowment structure and wealth composition guide the final impact of MPs.

AB models are naturally crafted to encompass a multitude of heterogeneous agents and offer an appealing option for analysing distributional issues. They have been widely used to study economic phenomena emerging from the heterogeneity of economic agents (Dosi et al., 2013; Riccetti et al., 2015; Fagiolo and Roventini, 2016; Dosi and Roventini, 2019; Papadopoulos, 2019; Tarne et al., 2022) along with the analysis of the impact of monetary policies (Petrović et al., 2020; Dosi et al., 2015), and can be turned into a mature forecasting and policy evaluation tool (Poledna et al., 2023; Hommes et al., 2025). On the other hand, the SFC approach provides a sound macroeconomic and monetary framework within which the behavioural equations of the agents operate consistently with associated monetary flows, and the stringency between the different balance sheets is described. The SFC framework allows for a rigorous representation of the monetary dimension of the production process, treating the real and financial sides of the economy in an integrated way (Nikiforos and Zezza, 2017). All transactions are explicitly realised in money terms, and agents must equip themselves with currency before carrying out their "trades" in each period. The determination of real quantities goes hand in hand with the dynamic of money circulation. As a result, the process of money creation, circulation, and destruction is explicitly represented throughout sequential macroeconomic accounting. The key features of the SFC approach can be summarized as follows: (a) the consideration of both flow and stock variables and the related macro-accounting consistency constraints; (b) unlike real assets, financial assets held by an agent or sector have an accounting counterpart in the liability side of the balance sheets of other agents or sectors; (c) the explicit formalization of a sequential process where all agents/sectors have to realize their transactions in monetary terms; (d) the use of dynamic macroeconomic models, where endogenous variables move forward non-ergodically in historical time; (e) each financial stock is associated with its own flow, meaning that the former is continuously fuelled by (and, in turn, fuels) the latter (Fontana et al., 2020). In parallel, each flow comes from and goes somewhere, there are no black holes. This is consistent with

the principle of “quadruple accounting”, according to which any economic transaction requires at least four recorded entries for the accounting matrices to be balanced (Copeland, 1949; Godley and Lavoie, 2006).

The integration of the AB and SFC approaches allows us to combine a high degree of heterogeneity of households in terms of balance sheet structures, revenue sources, portfolio choices, and asset composition (and more tractable heterogeneous dimensions) with a macro framework that explicitly incorporates the dynamic impact of monetary policy on macroeconomic activity and household assets/liabilities. Moreover, in AB-SFC models, balance sheets expand through endogenous money creation by the banking sector. This allows us to carry out an accurate analysis of the impact of monetary policies and of the process of asset/liability accumulation.

Within the AB literature, most papers focus on the transmission channels of monetary policies (Schasfoort et al., 2017; Delli Gatti and Desiderio, 2015; Alexandre et al., 2023), however, few of them address the impact of monetary shocks on income inequality. To our knowledge, only Fierro et al. (2023) studies how income inequality can constrain central bank operations. However, while the authors study the linkage that goes from inequality to monetary policy, AB models studying the causality that goes from monetary policies to income inequality are still absent.

In this context, the contribution of the present paper is twofold: i) providing a comprehensive theoretical framework on the transmission mechanisms of monetary policies capable of reconciling seemingly conflicting results observed in empirical studies; and ii) introducing the first AB model explicitly aimed at studying the impact of monetary policies on inequality.

The model focusses on the short- and long-run distributional effects of contractionary monetary policies as a function of different endowment distributions across the population and different degrees of heterogeneity in the preferences of the household portfolio. Gatt (Gatt, 2024), also using a heterogeneous agent model, examines the varying distributional effects of loans-to-value ratio policies at different levels of initial wealth inequality.

In our model, households are characterised by varying degrees of heterogeneity in terms of revenue sources, wealth composition, and portfolio preferences. The various dimensions of inequality related to different types of income factors are determined endogenously, stemming from the initial distribution of firms and bank shares across the population. Agents interact in six markets: capital, consumption, labour, credit, equity, and bond markets. Monetary policies can affect inequality through the following transmission channels: aggregate demand (AD), cost-push (CP), saving remuneration (SR) and asset price (PA). It should be noted that housing plays a central role in the transmission of monetary policy in many economies, as housing is a component of household wealth and as housing prices and mortgage markets may well be relevant transmission channels. To preserve the overall tractability of an already complex model, we chose not to include housing. Introducing a housing market would have required modelling an additional asset class with its own pricing dynamics, ownership structure, potential rental markets, and wealth effects. This would introduce additional mechanisms of transmission of monetary policy that, by interacting with other channels, would make the interpretation and presentation of the results even more cumbersome.

We consider different measures of inequality (Gini, Theil index, Atkinson index, and the interdecile ratio) to show how monetary policy affects income and wealth inequality differently depending on the representativeness of each share of the population characterised by each index. Such an approach is necessary because the effect of monetary policy may depend on the share of the population affected. Subsequently, we use factor decomposition to identify which income sources drive changes in inequality. This approach relates to the identification of assets whose distribution is predominantly responsible for the variation in income inequality due to monetary policy. The change in the contribution will be contingent on both the different weight of each income source in GDP and the intra-group inequality occasioned by the MP. Furthermore, it is a coherent and explanatory approach that can account for empirical findings indicating significant variation in income components between different levels of household income.

The model shows that the possibility of observing unequalising or equalising effects of contractionary monetary policy depends on the different distribution of households along relevant heterogeneous dimensions. Consistent with empirical evidence, the model shows that the impact of monetary policy is nonlinear. In detail, the paper points out five main results: i) The sign and magnitude of the distributive effects depend on the initial inequality in the distribution of endowments across households, the labour share, the saving rate, the aggregate percentage of wealth allocated to financial assets, the degree of portfolio heterogeneity, and the size of the unemployment subsidy. In particular, the degree of symmetry in the distribution of bank and firm shares plays a key role in determining the long-run sign of the effect. ii) Financial yields directly affect income inequality only if portfolio preferences are heterogeneous. The financial channel indirectly affects income inequality, also through a change in saving relationships between agents caused by other transmission channels. iii) The short-run effects on wealth inequality due to capital gains/losses (CGLs) on long-term bonds are correlated with the degree of heterogeneity in the portfolio preferences of households. In the long-run, such an effect vanishes. The short-run effect is null in the case of zero heterogeneity. iv) CGLs in the stock market affect wealth inequality through heterogeneity and saving effects. The first one generally has an equalising effect. The second one depends on the impact of AD and CP channels on the accumulation of personal savings. v) The higher the labour share, the greater the impact of monetary policy on inequality.

Given the theoretical nature of this paper and since one of its main objectives is precisely to show how the impact of monetary policy changes with variations in the parameters that describe the institutional and market conditions of the economy, the model has not been calibrated to a specific country. Instead, scenario analysis illustrates how the sign of the policy impact can change depending on parameters such as the markup, unemployment benefits, household consumption propensity, the aggregate share of wealth held in different asset types, and the degree of heterogeneity in portfolio preferences. For all other parameters that are not institutionally or market-relevant, a sensitivity analysis was performed (see Fig. D.27).

The remainder of the paper is organised as follows. Section 2 discusses transmission channels and how they are treated by existing theoretical models. Section 3 presents the behavioural equations and the monetary structure of the AB-SFC model. Section 4 analyses the different distribution endogenously produced by the model in a stationary state using the income factor decomposition. Section 5

presents a general assessment of the impact of MPs on income inequality, considering different initial distributions of firm and bank shares, labour share, and the level of unemployment benefits. Section 6 presents the short- and long-run impact of MPs and a detailed description of the transmission mechanisms considering specific scenarios in the initial distribution of non-financial firm and bank shares, and different degrees in portfolio heterogeneity. Section 7 concludes. The results of the paper can be reproduced using codes and datasets published here: <https://github.com/LorenzoDiDomenico/Monetary-policies-and-inequality>.

2. Transmission channels and theoretical models

The most studied channels through which monetary policy can affect income distribution are: i) savings remuneration; ii) asset price; iii) cost-push; and iv) aggregate demand channels.

The savings-remuneration channel arises from differences in the size and composition of household balance sheets. Due to these differences, a change in interest rates will have opposite effects on net borrowers and net savers, and asymmetric effects through the distribution of liquidity preferences among households (Auclert, 2019b; O'Farrell and Rawdanowicz, 2017; Monnin, 2017; Kaplan et al., 2018).

The asset price channel originates from the heterogeneity of household portfolios and the various capital gains (or losses) that are produced when the monetary policy stance changes. In this respect, asset price changes induced by expansionary policies are more likely to benefit the wealthy (and, in some cases, the middle class) to the extent that they hold longer-duration assets and stocks. Through this channel, the impact of monetary policy on wealth inequality depends on the composition of households' portfolios (Ampudia et al., 2018; Bivens, 2015; Montecino and Epstein, 2015; Kaplan et al., 2018; Doepke and Schneider, 2006; Adam and Tzamourani, 2016).

The cost-push channel is related to the fact that interest rates enter firms' costs. It represents a funding cost for firms and directly affects prices and functional income distribution (Panico, 1988; Pivetti, 1991; Barth and Ramey, 2002; Chowdhury et al., 2006; Cantore et al., 2020; Gaiotti and Secchi, 2006; Rochon and Setterfield, 2008). The comovement of prices and interest rates has also been referred to as the Gibson paradox (Keynes, 1930), the Cavallo-Patman effect (Taylor, 1983), and the "price puzzle" (Bernanke, 1990; Eichenbaum, 1992; Hanson, 2004; Castelnuovo and Surico, 2010). If the non-financial sectors strive to preserve their markup over production costs, any increase in the long-term interest rate translates into a general increase in the price level and a reduction in real wages (Colciago, 2011; Sylvio Kappes and Vallet, 2024; Cantore et al., 2020; Gaiotti and Secchi, 2006). That is, a tight monetary policy would lead to a redistribution from wage earners to bank shareholders (Christiano et al., 1994; Barth and Ramey, 2002; Adolfson et al., 2005; Dedola and Lippi, 2005; Deleidi and Leviero, 2020). Only if all sectors keep prices nearly constant by compressing margins would restrictive MP leave real wages unchanged, implying redistribution between industry and banking. Of course, a combination of the mentioned effects can generally take place.

The aggregate demand channel, through employment dynamics and profits, has an asymmetric effect on income distribution, affects inequality across workers and between wage and profit incomes (Galí, 2015; Blanchard and Galí, 2010; Heathcote et al., 2010; Merckaert, 2015; Kaplan et al., 2018; Coibion et al., 2017; Ampudia et al., 2024). Regarding labour income inequality, wages and employment dynamics tend to be more volatile for lower-income earners (Amberg et al., 2022; Mumtaz and Theophilopoulou, 2017a; Broer et al., 2022). In fact, during monetary tightening, often accompanied by recessions, these individuals are more severely affected, amplifying inequality dynamics. Empirical studies highlight a significant association between expansionary monetary policies and a reduction in wage inequality, primarily due to wage growth at the lower end of the income distribution (see Beqiraj et al. (2024)). In general, expansionary monetary policies lower the unemployment rate, which benefits poorer households the most (Draghi 2015, quoted in Furceri et al. 2018). Studies in the EU show that such policies can significantly increase the income of the lowest quintile compared to higher-income groups. As a result of changes in the unemployment rate, the income of the lowest quintile increases by more than 3%, while that of other quintiles increases by around 0.5% (Coibion et al., 2017).¹

A significant portion of earnings accruing to high-income households typically come from profits and dividends, as well as financial market transactions. In contrast, low-income households often primarily rely on wage income, supplemented by subsidies and government transfers. Data for the Euro area show that moving from the lowest to the highest income quintile, the share of income from financial and rental sources increases from 34% to almost 72%. In contrast, the share of transfers and unemployment benefits declines between the income quintiles, from approximately 20% to approximately 3% (HFCN, 2016).

Although business and financial income are closely related to the decisions of monetary authorities, this is less directly the case for subsidies and for labour income, especially among middle- and high-income workers (Galí, 2015; Christiano et al., 2005a; Woodford, 2003). Studies indicate that the contractionary effects of restrictive monetary policy can disproportionately impact households with substantial capital income, as dividends tend to decline more sharply than wages (Bernanke and Gertler, 1995; Coibion et al., 2017). This effect is particularly relevant when considering the differential impact on high- and middle-income workers who retain their jobs after a monetary shock. Consequently, tightening the MP can harm high-income households more than others, thus contributing to a reduction in inequality. In contrast, easing MP tends to increase inequality by driving stronger income growth among affluent households.

These two mechanisms imply non-monotonic responses between monetary policies and inequality dynamics, since both high- and low-income households tend to react more strongly than to middle-income households (Amberg et al., 2022).

¹ Mechanically, individuals are impacted by the overall decrease in the unemployment rate in many different ways, with households in the lowest quintile generally benefitting the most from it.

In general, monetary policy can affect aggregate demand in the following ways. i) Investment channel: Higher bank lending rates discourage business investment. This mechanism is operative if, at the aggregate level, firms are not able to pass through higher rates to prices. In this case, the discounted value of future cash flows is a decreasing function of the interest rate. ii) Consumption channel: changes in interest rates could affect household consumption decisions through a wealth effect, as interest rate hikes affect asset values (Lettau et al., 2002) or depress credit to consumption and residential investments (Góes and Deleidi, 2022). iii) Value of the multipliers: Higher interest rates can benefit profit-makers, reducing the average propensity to consume and leading to a lower value of the multiplier and long-run output and employment levels; on the other hand, higher interest rates can increase debt costs for governments, forcing them to cut primary spending, leading to lower capital or recurrent expenditures with higher multiplier values. For example, under the scheme of rules developed initially in the 1992 Maastricht Treaty and reinforced later in the 2012 Fiscal Compact, monetary tightening has severely contracted the fiscal space of European countries by increasing public debt interest payments. iv) Banking channel: Higher interest rates can make it harder for businesses to borrow money as they reduce their value and increase the risk for banks. Consequently, there will be a reduction in the net worth of banks (typically, the value of deposits does not change while the value of equities or public bonds decreases), leading to potential credit crunches. Thus, MP can directly impact income inequality by affecting employment levels and indirectly by influencing union bargaining power. Contractionary policies can increase inequality by reducing jobs, whereas expansionary policies can decrease inequality by creating jobs. However, the impact on income distribution also depends on firm pricing and markups.

Although these channels have been examined in the empirical literature, there is a lack of theoretical analysis exploring how these transmission mechanisms and their interactions shape the impact of monetary policy on inequality. In this regard, traditional models based on the representative agent hypothesis, which characterises standard DSGE models, are unable to account for distributional dynamics. In a one-agent economy, the distribution of personal income cannot be studied. In these models, the impact of monetary policy can be divided into two distinct effects: a direct effect, which spreads from the change in consumption due to general equilibrium forces, and a direct effect, which stems from the intertemporal substitution of consumption. Moreover, as argued by Kaplan et al. (2018), in the Representative Agent New Keynesian (RANK) model, monetary policy works almost exclusively through a substitution effect, while the effects of income and wealth are small.

A recent literature comprises Heterogeneous-Agent New Keynesian (HANK) models (Kaplan et al., 2018) with a simpler alternative known as Two Agents New Keynesian Models (TANK) (Debortoli and Galí, 2017; Bilbiie, 2008; Boitani and Punzo, 2019). HANK models incorporate diverse consumer behaviour and a continuum of agents characterised by a distribution of wealth and marginal propensities to consume. TANK models present two types of consumers: “Ricardian” and “Keynesian”. Ricardian consumers are traditional utility maximisers who use financial markets to smooth consumption, whereas Keynesian consumers spend all of their disposable income each period. In some TANK models, a portion of agents have zero net wealth, while the rest evenly share aggregate wealth. So far, much of the HANK literature has focused on how inequality alters the transmission of monetary policy. For example, it stresses that aggregate demand responds differently to shocks and policies when households are borrowing-constrained (Kaplan et al., 2018; Auclert, 2019a) or engage in precautionary savings in response to idiosyncratic income risk (e.g. Challe et al., 2017; Acharya and Dogra, 2020). However, while these models have been used to study how wealth inequality can impact the transmission of monetary policies (Acharya and Dogra, 2020), the effect of these on income inequality has not yet been studied using HANK models. To our knowledge, an attempt has been made by Komatsu (2023) who studies the impact of monetary policy on consumption inequality. Following the model proposed by (Debortoli and Galí, 2017), the author develops a TANK model in which a fraction of households are credit-constrained and consume hand-to-mouth, and search-and-matching frictions are included. He finds that expansionary monetary policy shock decreases consumption inequality between those two households through three channels: (i) the income composition channel, through fluctuations in labour and profit income; (ii) the savings redistribution channel, through fluctuations in real interest rate; and (iii) the earnings heterogeneity channel, through fluctuations in unemployment.

Within the AB-SFC literature, most papers study the transmission channels of monetary policies and their impact on main macroeconomic variables. Schasfoort et al. (2017) developed an AB macroeconomic model to study the transmission channels of monetary policies. Their model is able to reproduce the interaction of four main transmission channels: bank lending, investment, consumption, and cost. Their results show that bank lending is the strongest channel, although the overall effect of monetary policy is weak. Delli Gatti and Desiderio (2015) develop an AB model to study the impact of monetary policy on the business cycle and GDP. They find that monetary policy is non-neutral, while the main transmission mechanism is the credit channel. Alexandre et al. (2023) study how the shock to the policy interest rate affects some key topological measures of a bank-firm credit network, such as density and degree distribution. However, none of them addresses the relationship between monetary policy and the inequality dimension. To our knowledge, only Fierro et al. (2023) study how income inequality affects monetary policy through the inequality-household debt channel. Their results show that inequality can constrain the central bank, even when it is not explicitly targeted.

3. The model

The macroeconomy is populated by firms operating in the capital sector (K), firms producing consumption goods (C), households (H), Government (G), Central Bank (CB) and a commercial bank (B) interacting in six markets: Consumption market, Capital market, Labour market, Credit market, Equity and Bond markets.

The household sector consists of a multitude of heterogeneous agents. The initial income heterogeneity depends on the initial distribution of different types of endowment, namely bank and firm shares. Then, the income of agents is made up of wages, dividends from non-financial firms and bank shares, interests on deposits and public bonds, and capital gains from equity and bond markets.

Households hold their wealth in the form of deposits, public equities, and public bonds. The initial distribution of private equity and bank shares defines the starting level of inequality in society. Financial inequality is endogenous.

C-firms produce the consumption good by means of labour and capital, while the capital sector is a vertically integrated sector in which firms produce using labour as only external input. C-firms define the level of production based on the expectations of future demand and the desired level of inventories. They adjust the productive capacity to satisfy the expected demand at a target degree of capacity utilisation. Investments are realised if the net present value is positive. Once K-firms receive the order, they fix current production depending on the number of periods needed to produce a single capital good. The price of the goods is set according to the normal cost of production, and the markup is applied over normal - unitary costs. Markups evolve according to the attractiveness of goods and target market shares. Price clears only the equity market.

The number of firms is fixed, while their size varies endogenously depending on the evolution of aggregate demand and its distribution between firms. In each sector, firms start with the same technical conditions (capital-to-output ratio, labour productivity, and target degree of capacity utilisation). Depending on the leverage target, firms finance production decisions through a mix of self-financing, loans, and issuing equities. Commercial bank approves loans based on borrowers' actual ability to cover future debt service obligations. Firms that are unable to repay debts and are not eligible for further lending go bankrupt. The bankrupt firm is replaced by a new firm with a lower expected quantity to be produced. The interest rate on the loan includes a premium risk which depends on the financial exposure of each individual firm. There is one commercial bank that provides credit to firms and collects household deposits. The interest rate on deposits and loans depends on the rate set by the monetary authority. The government issues public bonds to finance the deficit. The share of public bonds not acquired by households is held by CB which acts as a lender of last resort. The Government's direct public spending is distributed among C firms proportionally to their productive capacity. Public spending and investments financed by debt creation represent the injection of purchasing power into the system. The first is partially exogenous², the second is fully endogenous. Below are the behavioural and accounting equations of the agents in the various sectors. Appendix B presents the balance sheet and the transaction matrices describing the model's SFC structure (see Table B.2 and Table B.3). The table reporting the parameter values used in the scenario and the sensitivity analysis is reported in Appendix D³. Supplementary material reports the table specifying that the values of parameters used in the baseline are in line with (Caiani et al., 2016).

3.1. Consumer sector

The C firms employ labour and capital as inputs and fix the current production ($y_{t,f}^d$) based on the expected demand ($q_{t,f}^e$). In addition, firms consider a store of inventories to address the discrepancies between expected demand and realised demand. The expected demand and the desired production are defined as follows:

$$q_{t,f}^e = q_{t-1,f}^e + \beta_f(q_{t-1,f}^r - q_{t-1,f}^e) \quad (1)$$

$$y_{t,f}^d = \max \left\{ 0, q_{t,f}^e (1 + \sigma^T) - inv_{t-1,f} \right\} \quad (2)$$

where β_f is the expectation parameter, $q_{t-1,f}^r$ is the amount of sales realised in the previous period, σ^T is the desired ratio of inventory on sales, and $inv_{t-1,f}$ is the amount of inventories from the previous period. The degree of capacity utilisation in correspondence to the planned production is as follows:

$$\omega_{t,f}^e = \min \left\{ 1, \frac{y_{t,f}^d v_{t,f}^*}{k_{t,f}} \right\}, \quad (3)$$

where $v_{t,f}^*$ is the capital-to-output ratio at full utilisation of productive capacity. Given the amount of capital needed to produce $y_{t,f}^d$ and the labour intensity ($l_{t,f}$), firms determine labour demand:

$$N_{t,f}^d = \frac{y_{t,f}^d l_{t,f}}{h_m}, \quad (4)$$

where h_m is the maximum amount of working hours that each worker can afford in a period and $l_{t,f}$ is the number of working hours per unit of output.

The production function is characterised by fixed coefficients of production (Leontief technology). The feasible production is:

$$y_{t,f} = \min \left(y_{t,f}^d, \frac{N_{t,f} h_m}{l_{t,f}}; \frac{k_{t,f}}{v_f^*} \right) \quad (5)$$

² Primary public spending is exogenous, while debt service and unemployment benefits are endogenous.

³ The Supplementary Material provides a specific sensitivity analysis for bank risk aversion, also including the effects on the credit rationing-to-granted loans ratio and the credit rationing-to-GDP ratio.

C-firms adjust their productive capacity to satisfy expected demand at the normal (desired) degree of capacity utilisation (in the period in which the capital will be available, that is, in $t + 1$). The investment function is:

$$i_{t,f} = \max \left\{ 0; q_{t+1,f}^e (1 + \sigma^T) v_{t,f}^n - k_{t+1,f} \right\} \quad (6)$$

where $v_{t,f}^n$ is the normal capital-to-output ratio, $k_{t+1,f}$ is the residual capital stock in the period in which the ordered capital good would be installed if investments were not made. Firms make investments if the net present value (NPV) is greater than zero.

$$NPV(I_{t,f})_e = \sum_{j=1}^{t+d_k+z} \frac{\mathbb{E}_t [P_{j,f}] \Delta q_{j,f} - W B_j - OF_j}{(1+r)^j} - I_{t,f} \quad (7)$$

$$\Delta q_{j,f} = \frac{k_{t,f}^d}{v_{t,f}^n} a \quad (8)$$

where $\mathbb{E}_t [P_{j,f}]$ is the expected price, $\Delta q_{j,f}$ is the additional amount of production in each period given by the capital investment, $W B_j$ is the wage bill, r is the interest rate, and OF_j are the financial charges. The profits are computed as follows:

$$\pi_{t,f} = q_{t,f}^r p_{t,f} - w_t L_{t,f} - \Lambda_{t,f} \quad (9)$$

where $\Lambda_{t,f}$ represents the amortisation costs and includes financial charges⁴ (see Appendix A.1). The operating cash flow are defined as the difference between revenues and wage bill plus total debt service:

$$OCF_{t,f} = q_{t,f}^r p_{t,f} - w_t L_{t,f} - SD_{t,f} \quad (10)$$

where $SD_{t,f}$ is the total debt service including interests and principal payments.

3.2. Capital sector

The quantity that K-firm wishes to produce and labour demand are:

$$y_{t,f}^d = \sum_{j=1}^t I_{t, index K=f} \quad (11)$$

$$N_{t,f}^d = \frac{y_{t,f}^d l_f}{h_m} \quad (12)$$

where the sum corresponds to the capital demand of firms that have selected firm i as their supplier.

3.3. Price setting

Firms apply a markup on the normal unit cost of production (Andrews, 1949; Andrews and Brunner, 1975). The unit cost is defined in correspondence with the normal degree of capacity utilisation, amortisation is computed by adopting the effective cost methodology⁵ and takes into account that the capital stock is made up of different vintage capital goods. The unit cost of the capital good is:

$$c_{t,f} = w_t^h l_{t,f} \quad (13)$$

The unit cost of the consumer good is:

$$c_{t,f} = w_t^h l_{t,f} + \frac{\frac{1}{a} \sum_{j=t-z+1}^t p_{k_j} k_j^{ins} (1 + r_j b l_j) (j + z - t)}{\frac{1}{v_{t,f}^n} \sum_{j=t-z+1}^t k_j^{ins} \left(\frac{j+z-t}{z} \right)} \quad (14)$$

where w_t^h is the hourly nominal wage, $l_{t,f}$ is the direct amount of labour per unit of output, p_{k_j} is the price of the capital acquired in period j , a is the multiplicative factor to calculate total debt service and amortisation, z is the useful life of the capital good and the repayment time of loans, r_j is the interest rate on the loans granted in period j , l_j is the leverage of the loan granted in period j .

⁴ Financial charges are computed only on the share of capital financed through loans.

⁵ The amortization includes the borrowing costs.

C firms increase their markup ($\varphi_{t,f}^{uc}$) if two conditions are met: (1) the market share has been higher for $\rho^{\lim,inc}$ consecutive periods than the target level (s^T); (2) the weighted average of the degree of capacity utilisation has been above the normal during these periods (see Caiani et al., 2016). Firms reduce the markup in case the market share has been lower than the target for $\rho^{\lim,dec}$ consecutive periods and the weighted average of the degree of capacity utilisation has been lower than the normal one. In all other cases, C-firms keep markups constant. These conditions are formalised as follows:

$$\varphi_{t,f}^{uc} = \begin{cases} \varphi_{t-1,f}^{uc}(1 - FN) & \text{if } (\bar{u}_{t-1,\dots,t-s}^r < u_n \wedge \rho_{t-1,f}^{r,dec} > \rho^{\lim,dec}) \\ \varphi_{t-1,i}^{uc}(1 + FN) & \text{if } (\bar{u}_{t-1,\dots,t-s}^r > u_n \wedge \rho_{t-1,f}^{r,inc} > \rho^{\lim,inc}) \\ \varphi_{t-1,i}^{uc} & \text{otherwise} \end{cases} \quad (15)$$

where FN is drawn from a Folded Normal Distribution with parameters $(\mu_{FN}, \sigma_{FN}^2)$; $\rho_{t-1,i}^{r,dec}$ is the number of consecutive periods during which the market share has been lower than the target; $\rho_{t-1,f}^{r,inc}$ is the number of consecutive periods during which the market share has been higher than the target; $\bar{u}_{t-1,\dots,t-s}^r$ is an exponentially decaying weighted average of the degree of capacity utilisation achieved.

3.4. Equity, loan demand and debt service

Firms have a leverage target to achieve over time. They can finance investments using retained profits, loans, or issuing equities. A proportion (σ) of the investments of firms is financed by issuance of equity. The supply of equity is:

$$e_{t,f}^s = e_{t-1,f} + \frac{I_{t,f}\sigma}{p_{e,t,f}} \quad (16)$$

where $p_{e,t,f}$ is the equity price and σ is the share of investments financed through equity emission. In case C-firms have enough liquidity (deposits, equity, and retained profits), they finance investments with the desired leverage; otherwise, they increase the share of investments financed by loans (the realised leverage can be higher than the target). In cases where firms have negative net wealth, they cannot access credit and their investment plans cannot be fully satisfied⁶. Loan demand is defined as follows:

$$I_{t,f}^d = \begin{cases} I_{t,f}\zeta^T & \text{if } CF_{t-1,f} + E_{t,f}^c + RP_{t,f} \geq I_{t,f}(1 - \zeta^T) \\ I_{t,f} - CF_{t-1,f} - E_{t,f}^c - RP_{t,f} & \text{otherwise} \end{cases} \quad (17)$$

$$RP_{t,f} = \begin{cases} I_{t,f}(1 - \sigma - \zeta^T) & \text{if } OCF_{t,f} \geq I_{t,f}(1 - \sigma - \zeta^T) \\ OCF_{t,f} & \text{otherwise} \end{cases} \quad (18)$$

$$SD_{t,f} = \frac{1}{az} \sum_{j=t-z}^{t-1} L_{j,f}(1 + br_j)(j + z - t) \quad (19)$$

where $L_{t,f}^d$ is the loan demand, $CF_{t,f}$ is the disposable cash, $E_{t,f}^c$ is the amount of liquidity collected through the emission of equity, $WB_{t,f}$ is the wage bill, $RP_{t,f}$ are the retained profits, $S_{t,f}$ are the total revenues and $SD_{t,f}$ is the total debt service (including debt repayment and financial charges). Financial charges are computed on the outstanding stock of debt and debt instalments are decreasing over time. This is consistent with the evolution of capital depreciation.

The net wealth of firms is the following:

$$NW_{t,f} = am_{t,f}^{residual} + CF_{t,f} - L_{t,f} + inv_{t,f}uc_{t,f}^h \quad (20)$$

where $am_{t,f}^{residual}$ is the residual value of the capital stock and $inv_{t,f}uc_{t,f}^h$ is the value of inventories.

3.5. Households

The household sector is composed of a multitude of agents which receive income from labour, dividends, and interests on public bonds and deposits. The initial distribution of firm and bank shares is described by a power-law:

$$y = ax^k \quad (21)$$

⁶ Given that the model includes multiple transmission channels and related feedback loops, we deliberately opted for a parsimonious formulation to avoid introducing additional mechanisms that would substantially increase complexity and make it harder to disentangle the contribution of the channels that are the focus of this study in shaping aggregate dynamics

where k describes the degree of inequality and $a = \frac{1}{\sum_{j=1}^n x^k}$.⁷ Financial wealth is held in form of public bonds, stocks and deposits. The initial financial wealth is equal to zero. The disposable income in each period is:

$$YD_{t,i} = \left(w_{t,i} + M_{t-1,i}r_t^m + \sum_{j=t-T^b}^{t-1} B_{j,i}^h r_{b_j}^h + s_i^h \sum_{j=1}^{NF} \text{div}_j^h + s_i^b \sum_{j=1}^{NB} \text{div}_j^b + s_{t,i}^e \sum_{j=1}^{NF} \text{div}_j^e \right) (1 - \tau) \quad (22)$$

where $w_{t,i}$ is the nominal wage, $M_{t-1,i}$ is the stock of deposits, τ the tax rate, $\sum_{j=t-T^b}^{t-1} B_{j,i}^h r_{b_j}^h$ is the amount of interests accrued on the stock of public bonds held by the household, s_i^h is the share of private equity held by household i and $\sum_{j=1}^{NF} \text{div}_j^h$ is the total amount of dividends generated by private equities, s_i^b is the percentage of bank shares held by household i and $\sum_{j=1}^{NB} \text{div}_j^b$ is the total amount of dividends distributed by banks, $s_{t,i}^e$ is the share of public equity held by household i and $\sum_{j=1}^{NF} \text{div}_j^e$ is the total amount of dividends generated by public equities.

Consumption demand is a function of disposable income and wealth:

$$C_{t,i} = YD_{t-1,i}c_{1,i} + V_{t-1,i}c_{2,i} \quad (23)$$

where $c_{1,i}$ is the propensity to consume out-of-income and $c_{2,i}$ ⁸ is the propensity to consume out-of-wealth. Unemployed workers get an unemployment benefit:

$$w_{t,i} = \begin{cases} w_t^h h_{t,i}^{\text{work}} & \text{if employed} \\ w_{\text{gov}} & \text{otherwise} \end{cases} \quad (24)$$

where $h_{t,i}^{\text{work}}$ is the number of hours worked in each period, w_t^h is the hourly wage and w_{gov} is the unemployment benefit. The wealth stock is made up of deposits $M_{t,i}$, public bonds $B_{t,i}$, and firms' equity $E_{t,i}$:

$$V_{t,i} = M_{t,i} + B_{t,i}^h + E_{t,i}^h = V_{t-1,i} + YD_{t-1,i} - C_{t,i} + CG_{t,i}^{\text{Equity}} + CG_{t,i}^{\text{Bond}} \quad (25)$$

$$M_{t,i} = M_{t-1,i} + YD_{t-1,i} - C_{t,i} - (e_{t,i} - e_{t-1,i})p_{e_{t,i}} - \Delta B_{t,i} \quad (26)$$

The wealth stock is made up of equity, deposits, and bonds. Furthermore, this value corresponds to the wealth carried over from the previous period plus new savings (nominal income minus nominal consumption) and the capital gains/losses generated on bonds and equities. The stock of deposits in each period is equal to the stock of deposits from the previous period plus new savings (nominal income minus nominal consumption) minus the new liquidity converted into bonds and equities. Likewise, the deposit stock can be calculated as the residual between total wealth and the demand for bonds and equities.

3.6. Portfolio decisions

Portfolio equations are based on Tobinesque principles. The portion of wealth held in the form of each financial asset is defined by an autonomous component, the rate of return on that asset (positive effect), the rates of return on other assets (negative effect), and the disposable income to net wealth ratio (negative effect, except for cash). The latter is a proxy for the liquidity preference of investors. The demand for public bonds, equities, and deposits is:

$$B_{t,i}^h = \lambda_{10,i} V_{t,i} + \lambda_{11,i} V_{t,i} r_t^b + \lambda_{12,i} r_t^m + \lambda_{13,i} V_{t,i} r_{e_t} + \lambda_{14,i} YD_{t,i} \quad (27)$$

$$E_{t,i}^d = \lambda_{20,i} V_{t,i} + \lambda_{21,i} V_{t,i} r_t^b + \lambda_{22,i} V_{t,i} r_t^b + \lambda_{23,i} V_{t,i} r_{e_t} + \lambda_{24,i} YD_{t,i} \quad (28)$$

$$M_{t,i}^d = \lambda_{30,i} V_{t,i} + \lambda_{31,i} V_{t,i} r_t^b + \lambda_{32,i} V_{t,i} r_t^m + \lambda_{33,i} V_{t,i} r_{e_t} + \lambda_{34,i} YD_{t,i} \quad (29)$$

where $\lambda_{j0,i}$ is the autonomous share of the asset j with the total wealth held by the household i , while $\lambda_{j1,i}$, $\lambda_{j2,i}$, $\lambda_{j3,i}$ links the share of asset j to total wealth with the rate of return on public bonds, deposits and equities, respectively.⁹ The value of each λ_{k,f_i} is a negative function of household wealth. They are defined in such a way that heterogeneity increases and the aggregate percentage of

⁷ $\sum_{j=1}^n y = 1$, that is the sum of the shares held by each household has to be equal to one.

⁸ We perform simulations with both heterogeneous and homogeneous propensities to consume across the population.

⁹ Notice that λ s are defined in such a way that:

a) $\lambda_{j1} = -(\lambda_{j2} + \dots + \lambda_{j3})$ for $j = 1, 2, 3$ (horizontal constraints on coefficients of rates of return for the j -th financial asset);
b) $\lambda_{1k} + \lambda_{2k} = 0$ for $k = 1, 2, 3$ (vertical constraints for cross-asset coefficients of rates of return); and
c) $\lambda_{10} + \lambda_{20} < 1$ (vertical constraints for autonomous shares of assets to total wealth). The latter is lower than unity because households can also opt for deposits.

each asset relative to total wealth remains constant. The λ s associated with public bonds or stocks are determined using the following system:

$$\begin{cases} \lambda_{10_1} = \alpha + \beta V_1 \\ \lambda_{10_2} = \alpha + \beta V_2 \\ \vdots \\ \lambda_{10_n} = \alpha + \beta V_n \\ \sum_{i=1}^n \lambda_{10_i} V_i = \gamma^{ex} \sum_{i=1}^n V_i \end{cases}$$

where α is the degree of heterogeneity, γ_b^{ex} is the aggregate bond-to-wealth ratio and $\alpha \leq \gamma_b^{ex}$. When $\alpha = \gamma_b^{ex}$, portfolio preferences are homogeneous. The same mechanism applies to define the λ_s associated with the demand of public equity. Finally, the parameters λ_{k,f_i} obey the standard constraints for asset demand functions. Formally:

$$\lambda_{00_i} + \lambda_{10_i} + \lambda_{20_i} = 1 \quad (30)$$

$$\lambda_{01_i} + \lambda_{11_i} + \lambda_{21_i} = 0 \quad (31)$$

$$\lambda_{02_i} + \lambda_{12_i} + \lambda_{22_i} = 0 \quad (32)$$

$$\lambda_{03_i} + \lambda_{13_i} + \lambda_{23_i} = 0 \quad (33)$$

$$\lambda_{04_i} + \lambda_{14_i} + \lambda_{24_i} = 0 \quad (34)$$

The symmetry constraint is:

$$\lambda_{01_i} = \lambda_{23_i}; \lambda_{02_i} = \lambda_{13_i}; \lambda_{11_i} = \lambda_{22_i} \quad (35)$$

Through this mechanism, the demand for each asset is a function of its relative return. If this increases, then its demand grows, while the demand for other assets decreases.

3.7. Equity market

The equity market is centralised. Price clears demand and supply. The demand of equity results from the aggregation of each household demand. The supply of equity results from the aggregation of the shares of investments that firms plan to finance issuing equities. Therefore, there is one homogeneous price for all equities of firms belonging to the same sector. The clearing price is:

$$p_{e_t} = \frac{\sum_{i=1}^N E_{t,i}^d - \sum_{f=1}^{n_f} I_{t,f} \sigma}{\sum_{f=1}^{n_f} e_{t-1,f}} \quad (36)$$

The amount of equity is:

$$\sum_{f=1}^{n_f} e_{t,f} = \sum_{f=1}^{n_f} e_{t-1,f} + \frac{\sum_{f=1}^{n_f} E_{t,f}^s}{p_{e_t}} \quad (37)$$

The total amount of money collected by firms by issuing equities is:

$$E_t^c = p_{e_t} \left(\sum_{f=1}^{n_f} e_{t,f} - \sum_{f=1}^{n_f} e_{t-1,f} \right) \quad (38)$$

This is distributed to each firm according to its share in the equity supply.

3.8. Supplier selection

Households and firms choose the supplier with the lowest price. In model initialisation, C-firms and households are matched randomly with suppliers. In each period, buyers visit a subsample of potential suppliers and select the cheapest one. Following [Delli Gatti et al. \(2010\)](#), the probability that the firm would change its supplier depends on the price differential between the previous supplier and the cheapest supplier in period t :

$$Pr_{t,f} = \begin{cases} 1 - e^{-\frac{\epsilon(p_{t,\text{indexC}} - p_{t,\text{indexC}_{t-1}})}{p_{t,\text{indexC}}}} & \text{if } p_{t,\text{indexC}} < p_{t,\text{indexC}_{t-1}} \\ 0 & \text{otherwise} \end{cases} \quad (39)$$

where ϵ express the degree of customer loyalty, $p_{t,indexC}$ is the price of the firm selected at time t and $p_{t,indexC_{t-1}}$ is the price offered by the supplier of the previous period. The higher value of the parameter ϵ increases the probability that a firm would change its supplier. The same matching mechanism applies to all markets. If the selected firm does not have sufficient production, the agent chooses another firm with positive inventories following the same principle. In this sense, it is not possible for a situation to arise where supply is positive, while demand remains unmet.

3.9. Labour market

We model a simple labour market with aggregate bargaining and homogeneous wages. Labour skills are homogeneous across firms and workers and are constant over time. The nominal wage growth rate depends on the level of the unemployment rate and the difference between the real wage target (w^T) and the actual real wage (w^r):

$$g_t^w = \begin{cases} \frac{(w_t^T - w_{t-1}^r)}{w_{t-1}^r} + \mu E_t & \text{if } w_t^T > w_{t-1}^r \\ \mu E_t & \text{otherwise} \end{cases} \quad (40)$$

where the parameter μ represents the semi-elasticity of the nominal wage growth rate with respect to the level of employment. In each period, depending on labour demand, firms can fire or hire workers. In labour market matching, firms randomly pick up an unemployed worker and hire her. Firms repeat this operation until they have satisfied their labour demand. There are no frictions in the labour market, that is, each firm can fire or hire workers whenever it needs.

3.10. Government

The public sector has a direct and exogenous component of expenditure consisting of consumer goods demand and an endogenous component linked to unemployment benefits and debt service. Direct public expenditure is constant, while unemployment benefits and debt service result to be countercyclical:

$$G_t = G_{t-1}(1 + \pi_t) \quad (41)$$

$$G_t^{tot} = G_t + U_t w_{G_t} \quad (42)$$

where G_t is direct public expenditure (demand for consumption goods), g_G is the real growth rate of direct public expenditure, π is the inflation rate, and U_t is the number of unemployed. The unemployment benefit (w_{G_t}) is a percentage of the expected average wage paid by the private sector. Government accounting is:

$$S_t = G_t - \sum_{i=1}^N y_i \tau_i + \sum_{j=t-T^b}^{t-1} B_j^s r_{b_j} - F_t^{cb} \quad (43)$$

where F_t^{cb} are the profits distributed by the CB, τ_i is the tax rate, B_i^s is the nominal value of the bonds issued in period i , T^b is the maturity of bonds. The supply of public bonds is the following.

$$B_t^s = b_{t-T^b} + S_g \quad (44)$$

The price of public bonds depends on the expected returns:

$$p_t^{bonds} = \sum_{j=1}^T \frac{1}{(1+r)^j} \quad (45)$$

The stock of public debt is:

$$SB_t = \sum_{j=t-T^b+1}^t B_j^s \quad (46)$$

3.11. Commercial bank

The banking sector consists of one single commercial bank. It supplies credit to firms and collects household deposits. The asset of the bank consists of loans, government bonds, and reserves. Banks must hold minimum reserves against deposits:

$$H_t = \gamma M_t \quad (47)$$

where H_t is the reserve stock and γ is the reserve requirement ratio. The bank liabilities consist of deposits and CB advances. The bank applies a markup on the rate set by the central bank to fix the normal interest rate on loans and deposits.

$$r_t^l = r_t^{CB}(1 + \chi_l + r_{t,i}^p) \quad (48)$$

$$r_t^m = r_t^{CB}(1 + \chi_m) \quad (49)$$

Where r_t^{CB} is the policy rate, $\chi_l > \chi_m$ and $r_{t,i}^p$ is the premium risk that the bank applies over the normal rate depending on each specific financial position of firms:

$$r_{t,f} = r_t^{CB} \left(\frac{NW_{t,f}}{L_{t,f}^d} \right)^v \quad (50)$$

Following [Caiani et al. \(2016\)](#), the bank grants the loan depending on the expected return of the credit project, which is based on the future operating cash-flow capacity of the firm to repay the principal and pay interest.

The bank evaluates the probability of multi-period default of the applicants under the hypothesis that the loan requested is granted. The loan is approved if the sum of expected payoffs, net of the loan outlay, is greater than zero. If it is negative, the bank can still ration the amount and grant a certain amount of loan such that the expected value becomes non-negative. The expected return on the credit project is defined as follows:

$$E[\Pi_z] = -L_0 + \sum_{j=1}^z E[CF_j] \quad (51)$$

$$E[CF_j] = (1 - pr_f)^{j-1} \left[(1 - pr_f) SD_f + pr_f \delta_j L_{j,f} \right] \quad (52)$$

where SD_f is the total debt service in each future period associated with the new loan, and $L_{j,f}$ is the residual debt stock in period j . In case of default, the bank expects to recover a share δ_j of their outstanding loan from the collateral of the firms. The capital stock serves as collateral for the C-type. The share is defined as follows:

$$\delta_j = \min\left(1; \frac{(1 - \alpha_x) K_{t,f}}{L_{j,f}}\right) \quad (53)$$

where $K_{t,f}$ is the value of the capital stock. The probability of default is computed using a logistic function, based on the percentage difference between expected borrowers' OCFs¹⁰ and the debt service:

$$pr_f = \frac{1}{1 + \exp\left(\frac{OCF_f - \sigma_x SD_f}{SD_f}\right)} \quad (54)$$

where σ_x expresses the risk aversion of banks in lending to firms.¹¹

The profits of a commercial bank are as follows:

$$F_t^b = \sum_{i=1}^n \sum_{j=-z}^t \left(L_{j,f} r_j^l + H_t r_t^h - M_t r_t^m - A_t r_t^a \right) \quad (55)$$

3.12. Central bank

The Central Bank directly fixes the policy rate, which is treated as an exogenous variable. The CB acts as the lender of last resort in the public bonds market:

$$B_t^{CB} = B_t^s - \sum_{j=1}^n B_{t,j}^h \quad (56)$$

where $\sum_{i=1}^n B_{t,i}^h$ is the nominal amount of bonds purchased by households and B_t^s is the supply of public bonds. Indirectly, the amount of public bonds held by CB is a function of the reserve ratio. Central bank profits depend on the interests earned on public bonds, advances, and interests paid on reserves:

$$F_t^{cb} = \sum_{j=t-T^b}^{t-1} B_j^{CB} r_{b,j}^b r_{t-1}^b - H_{t-1} r_{t-1}^h + A_{t-1} r_{t-1}^a. \quad (57)$$

See [Appendix A](#) for all the equations concerning stock-flow consistency, bankruptcy, accounting, and sequence of events.

¹⁰ As with the other variables, the expectations function is adaptive.

¹¹ The Supplementary Materials present the effects of varying bank risk aversion on the credit gap and the credit rationing-to-GDP ratio, together with a sensitivity analysis of the monetary shock's impact on inequality.

3.13. Sequence of events

The sequence of events within each period is:

1. Computing unit costs and fixing markups;
2. Firms-C set desired production, labor and capital demand;
3. Matching in the capital market;
4. Firms-K set the desired production and labor demand;
5. Matching in the labor market;
6. Production start: If labour demand has been satisfied, the working hours are equally distributed among employees in such a way as to produce exactly the desired quantity. In case labour demand has remained unsatisfied, workers will work full-time, and production is rationed;
8. Based on the quantity produced in sector K, the capital goods demand is satisfied;
9. Firms determine the demand for credit and the supply of equities; payment of capital goods and wages (unemployed workers receive government subsidies). The commercial bank evaluates applicants' ability to pay future debt services and grants loans;
10. Matching in the consumption market, firms realise revenues;
11. Cash flows and profits computation, debt repayment, interest and dividends payment. Some firms, if necessary, can apply for additional financing, those that do not meet the requirements go bankrupt;
12. Accounting of CB, Public sector and Commercial bank;
13. Matching in the bond and equity markets;

4. The contribution to inequality: The decomposition by income factor

We now explore the determinants of income inequality using the income factor decomposition (Rani and Furrer, 2016; Heshmati, 2004; Fräßdorf et al., 2011). This approach is relevant to study the channels through which monetary policy affects income inequality. The initial distribution of wealth is defined by the distribution of firms and bank shares among households. These are described by power-law functions and the value of the power (k) defines the initial level of inequality (eq. 20).¹² The initial distribution of firms and bank shares, together with the markup and the interest rate, endogenously determines the distribution of income, which, in turn, affects the distribution of financial wealth. The latter will also be influenced by the saving rate and portfolio preferences of households. In the first period, all financial stocks are zero. While markup, interest rate, and the distribution of saving rates determine the values of income shares (labour share, non-financial profit share, bank profit share, and financial share), the distribution of non-financial firms and bank shares determines the intra-group inequality.¹³

Keeping the interest rate, the markup, and the saving rate constant¹⁴, we perform model simulations to show how income distribution and the contribution of each income source change as the initial inequality in the distribution of firm and bank shares increases.

Fig. 1 reports the different income distributions generated by the model in the stationary state as the inequality in the initial distribution of firms and bank shares increases (the lowest value is at the top, the highest at the bottom of the graph). The two k -powers move together; hence, the two distributions are symmetric.



Fig. 1. Income distributions for different values of k -power.

¹² When k is equal to zero, assets are equally distributed across households. The initial inequality increases as the k -power increases.

¹³ The intra-group inequality is the inequality within each source of income.

¹⁴ We are assuming a homogeneous saving rate across the population. That is, the saving rate is not a function of income level

Fig. 2 (a) displays the log values of different inequality measures of the distributions reported in Fig. 1. We adopt four measures of inequality: Gini coefficient, interdecile ratio, Theil-H and Atkinson indexes. Fig. 2 (b) reports the decomposition of total inequality by income factors (wage¹⁵, firm dividends, bank dividends, and financial rents). We adopt the decomposition factor of the generalised entropy index, and the formulation for each income factor is the following:

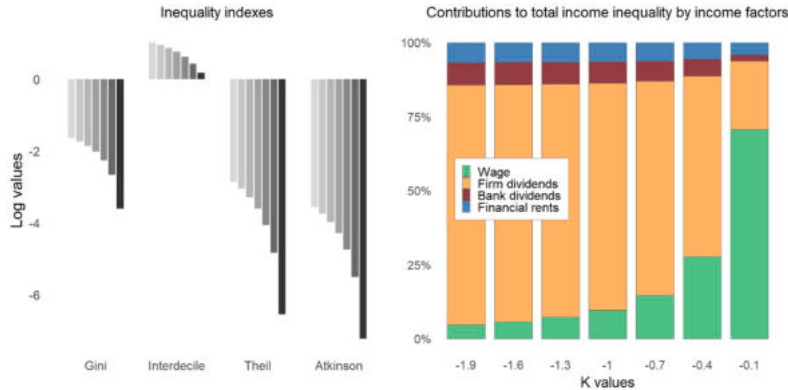


Fig. 2. Log-values of the inequality indexes (a) and inequality decomposition by income source (b).

Note: The value of each index is reported as the k-power decreases moving from the right side to the left side.

$$s_k(I) = \frac{\text{cov}(X^k, X)}{\sigma^2(X)} \quad (58)$$

where X^k is the distribution of income by factor k and X is the general distribution of income. As shown in Shorrocks (1982), such ratio gives us a unique decomposition rule for any inequality measure. Moreover, it gives the relative importance of different income components, independent of the choice of inequality measure. Table C.4 reports also the values of Theil-L ($c = 0$) and Theil-H ($c = 1$) index decompositions. The formulations of the contribution of each income factor are, respectively:

$$s_k(I_0) = \frac{\sum_{i=1}^N \frac{x_i^k}{x_i} \log\left(\frac{\mu}{x_i}\right)}{\sum_{i=1}^N \log\left(\frac{\mu}{x_i}\right)} \quad (59)$$

$$s_k(I_1) = \frac{\sum_{i=1}^N x_i^k \log\left(\frac{x_i}{\mu}\right)}{\sum_{i=1}^N x_i \log\left(\frac{x_i}{\mu}\right)} \quad (60)$$

Measures expressed in eq. (55) and (57) respect the additive decomposability principle, but are non-unique and peculiar of the inequality measure considered.

As initial inequality in the distribution of non-financial firms' and bank shares increases, personal income inequality rises. The factor decomposition shows that the distribution of non-financial firm shares is the main driver of income inequality. Indeed, the non-financial profit share presents the highest value in the ratio between the GDP share and intra-group inequality. Although labour income represents a relevant share of the cake, it shows a lower level of intra-group inequality. Therefore, its contribution to total inequality is much lower. Conversely, concerning the contribution of the banking sector to total income inequality, although it presents the highest intra-group inequality, its contribution to total income inequality is lower because the profit share of the banking sector is relatively low compared to the non-financial profits share. Finally, the distribution of financial rent is the result of wealth disparities originating from other sources of income. As a result, the inequality in the distribution of financial wealth and income is mostly explained by the distribution of firm shares and markup (which determine the labour share). It is worth noticing that any factor decomposition requires that we examine each income component separately and neglect the feedback effects on other income sources (Shorrocks, 1982). In this sense, the real contribution of firms' shares to total income inequality is higher since it indirectly determines inequality in financial rents.

These properties are easily detectable by looking at the factor decomposition: the contribution of labour income increases as the inequality in the distribution of firms and bank shares decreases (see Table C.4 in Appendix C). For values of k-power close to zero, wage inequality, although low, begins to represent the ultimate source of inequality in the economy.

For high levels of initial inequality in the distribution of non-financial firms' and bank shares, the personal income distribution is strongly correlated with the functional distribution, and the share of income from non-financial firms' dividends accounts for the

¹⁵ Wages also include unemployment benefits.

largest contribution to total inequality. In such a case, the interest rate and markup, which modify the functional distribution of income, are the main determinants of inequality. As equality in the initial asset allocation increases (shifting from left to right in the plot), the relationship between the functional and personal income distribution is broken and wages become the factor with the greatest contribution to inequality.

5. Endowments distributions and the impact of monetary policies on inequality

This section presents a general assessment of the impact of a restrictive monetary policy on income inequality, considering different combinations in the initial distribution of firms and bank shares across the population. Restrictive monetary policy is implemented by increasing the policy rate by 30%. We continue the analysis contextually with the study of the role of labour share, unemployment subsidies, the saving rate, the aggregate share of wealth allocated to financial assets, and portfolio heterogeneity. Such combinations produce a plethora of starting distributions characterised by different degrees of heterogeneity in the income sources of households. The heterogeneity increases as the initial inequality in the distribution of firm and bank shares increases, and the degree of asymmetry between these two distributions expands.

In Section 6, given specific values of k_i , a detailed description of the short and long-term impacts of restrictive MPs is provided, both for the transmission channels and the way they interact.

Fig. 3 reports the impact of monetary policy on the Gini income coefficient for any given combination of the initial inequality in the distribution of firm and bank shares¹⁶. Appendix C reports the results of the simulation for the interdecile ratio, Theil and Atkinson indexes.¹⁷ The k-powers (k_f and k_b) defining the initial inequality in the distribution of each asset range between -2.5 and 0. The z-axis reports the percentage change in the Gini coefficient due to the implementation of the monetary policy. Each point on the z-axis expresses the difference between the pre- and post-shock stationary states. The green plane corresponds to zero values, that is, no effect of monetary policy.

The results show that monetary policy has a nonlinear impact on income inequality. The values below the green plane reveal that, in correspondence with those combinations of k_f and k_b , the monetary policy has an equalising effect (bottom right corner). In contrast, in correspondence with the combinations of k_f and k_b where the value of Gini is above the green plane, the monetary policy has an unequalising impact. The magnitude of the impact is an inverse convex function of the initial inequality in the distribution of firm shares, while it is a concave function of the initial inequality in the distribution of bank shares.

We first analyse how the nonlinearity emerges. Then we study the relationship between the percentage change in the Gini coefficient and the starting topology of inequality.

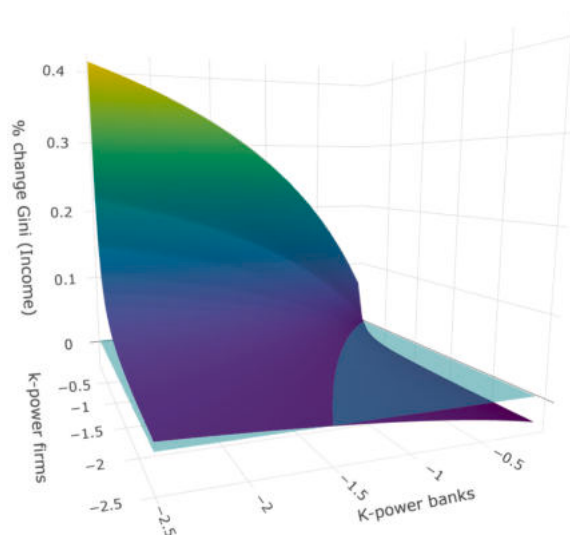


Fig. 3. The impact of monetary policy on Gini income for different combinations of the initial inequality in the distribution of firms and bank shares.

Note: The z-axis reports the percentage variation in the Gini coefficient; the y-axis reports the k-power describing the initial inequality in the distribution of firms shares; the x-axis reports the k-power describing the initial inequality in the distribution of bank shares.

Monetary policy affects long-run income inequality by modifying the weight of each income source on GDP and intra-group inequality. Sign and magnitude depend on the initial inequality in the distribution of endowments across households, along with the

¹⁶ Fig. C.17 reports the impact on the Gini wealth.

¹⁷ The results related to the Theil and Atkinson indexes are almost similar to those characterising the Gini coefficient. In addition, the Gini coefficient is a measure of generalised entropy, as well as the Theil and Atkinson indexes (Biró and Nédá, 2020).

labour share, unemployment benefit, the saving rate, the aggregate percentage of wealth allocated to financial assets, and the degree of heterogeneity in portfolio preferences.

Two potentially contrasting forces operate in determining the long-run sign of the impact of MPs. As will be shown in Section 6, restrictive monetary policy expands intra-group inequality and affects intergroup inequality. On the one hand, the AD channel generally increases labour inequality and affects wage-profit differentials. The SR channel increases income inequality, acting as an echo chamber, that is, a mechanism that magnifies and perpetuates the effects of wealth disparities introduced by other channels. The CGLs in the stock market have a negative impact on wealth inequality through the “saving effect” and a positive impact through the “heterogeneity effect”. Usually, the “heterogeneity effect” dominates the saving effect; however, the PA channel has a negligible impact in the long-run, and the AD plus the SR channel lead to a worsening in inequality (the description “saving” and “heterogeneity effects” is reported in Sect. 6). Finally, any increase in wealth inequality, whether directly through the PA channel or indirectly through changes in income inequality through the AD and SR channels, creates a self-reinforcing effect on income inequality by altering the ownership structure of firms. In fact, a shift in the distribution of savings growth rates across the population also leads to changes in the number of shares owned by each agent and, consequently, in the distribution of dividends associated with them.

On the other hand, through the CP channel, the MPs modify the share of the cake belonging to each income source: bank and financial shares rise, while labour and non-financial profit shares decrease (see Fig. 4). On the empirical level, the link between monetary policies and labour share has been investigated in Cantore et al. (2020), Di Bucchianico and Lofaro (2023) and Sylvio Kappes and Vallet (2024). The rise in the interest rate is discharged into an increase in prices leading to a reduction in the real wage and the share of labour (Colciago, 2011; Gaiotti and Secchi, 2006), whereas the non-financial profit share drops due to the reduction in GDP. In this context, a restrictive MP can reduce inequality by lowering the weight of those income factors characterised by higher intra-group inequality. We will refer to this effect as the “cake share” effect. Since restrictive MPs increase the share of the banking sector, MPs worsen income inequality if the banking sector presents higher intra-group inequality compared to other income sources. In this case, both the change in intra-group inequality and income shares concur in increasing income inequality. Conversely, if the banking sector presents lower intra-group inequality, such a channel has an equalising effect.

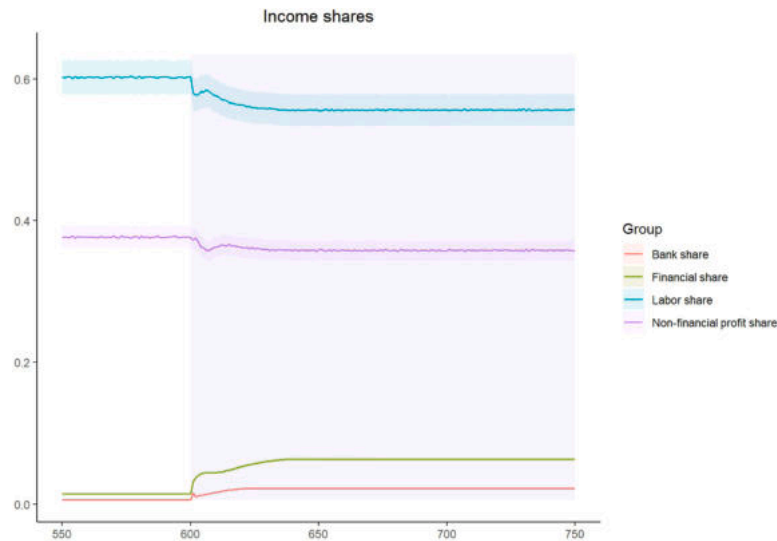


Fig. 4. The impact of restrictive monetary policy on income shares.

Overall, the possibility of realising an equalising effect depends on the ability of the “cake share” effect to outweigh the increase in inter- and intra-group inequality generated by the other transmission channels. The value of the labour share, the size of the unemployment subsidies together with the saving rate, the aggregate percentage of wealth allocated to financial assets, and the degree of heterogeneity in portfolio preferences play a key role in this context¹⁸.

Fig. 5 shows the contour plots of the impact of the restrictive MP on the Gini coefficient for different combinations in the initial distribution of firm and bank shares. Fig. 5.a shows the results for different levels of the unemployment subsidy. Fig. 5.b displays the results for different values of the markup. Appendix C, Fig. C.20, presents the contour plots corresponding to different values of the saving rate, the aggregate percentage of wealth allocated to financial assets, and the heterogeneity level in portfolio preferences. In these simulations, the initial inequality in the distribution of bank shares is lower than the inequality in the distribution of firm shares. The dark blue zone represents the area where the equalising effect materialises, and it reduces when the unemployment benefit and markup decrease.

¹⁸ In the simulation, we are considering constant elasticity of aggregate demand with respect to the interest rate (which depends, for instance, on fiscal multipliers) and constant elasticity of employment with respect to aggregate demand (labour productivity is constant). Of course, lower values of elasticity concur in increasing the likelihood of an equalising effect

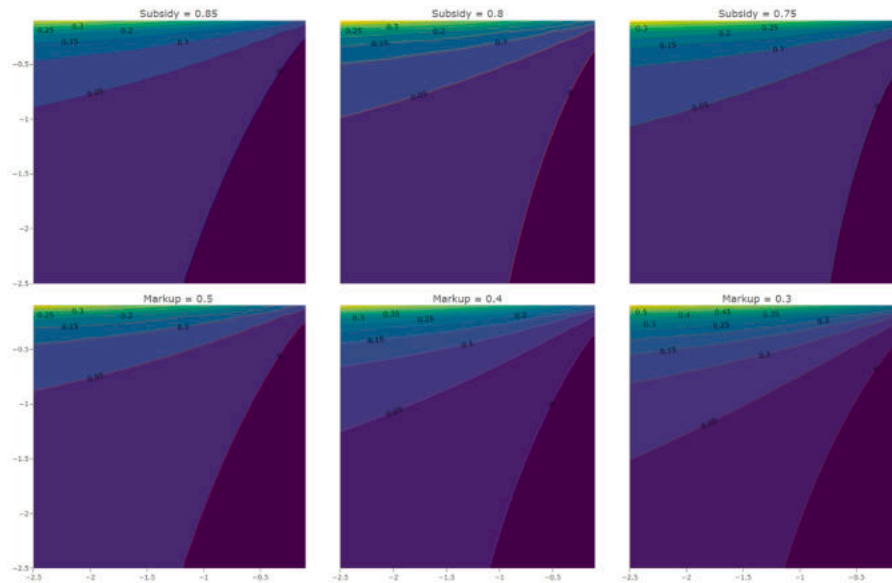


Fig. 5. Non-linearity thresholds for different values of markup and unemployment subsidies.

Notes: Each contour plot displays the effect of the MP for a specific value of markup/unemployment subsidy. The x-axis reports the k-powers describing the distribution of bank shares. The y-axis reports the k-powers of non-financial firm shares.

The value of the unemployment subsidy influences the impact of the AD channel on labour inequality and the gap between non-financial profit and wage earners.¹⁹ The higher the unemployment benefits, the lower the increase in intergroup and intra-group inequality following the restrictive MP. For instance, taking an extreme example, if the unemployment benefit were equal to the market wage, restrictive policies would have an equalising effect by not affecting labour inequality and reducing profit-wage differentials (the profit pool decreases due to reduced sales, while the income of the working class remains unchanged).

The value of the markup, which determines the labour share, influences the impact of the aggregate demand channel on the change in the Gini coefficient through the “population effect” and, ad for the unemployment subsidy, the change in “wage-profits” differentials. Higher levels of the markup (or lower levels of the labour share) reduce the negative impact that the aggregate demand channel has on the Gini coefficient through the “population effect”. Indeed, the Gini coefficient is more sensitive to changes (albeit small) in the income of the agents located in the centre of the distribution. That is, Gini is more sensitive to the change in incomes that have higher frequencies. When the markup is reduced, a higher share of total income is concentrated across a larger group, and the percentage change in Gini is higher. Conversely, the Gini becomes less responsive when the bulk of income is concentrated across a small group of the population. For these reasons, the impact of MP on Gini increases as the markup decreases. Of course, the relevance of the markup for studying the impact of MP depends on the initial distribution of non-financial firms’ shares. In equal societies (as in the CC scenario reported in Section 6), it is irrelevant.

Fig. 6.a reports the impact of restrictive MP on the Gini coefficient, the interdecile ratio, and the unemployment rate for different values of the markup when the distribution of firms and bank shares is symmetric and the k-power is equal to 0.5. Fig. 6.b shows the change in the contribution of each income factor to the overall inequality. Appendix C reports the same results for different initial distributions of endowments (see Fig. C.21 and Fig. C.22).

It is worth noticing that, to have an equalising effect of monetary policy, it is not required that the intergroup inequality lowers dominating the increase in intra-group inequality. It is required that the markup and the unemployment benefits be sufficiently high to generate a sufficiently weak negative impact of AD, SR and PA on overall income inequality. Of course, the lower the increase in intergroup and labour inequality, the wider the marlaboror generating an equalising effect of restrictive MPs.

In addition, the potential equalising effect of restrictive MPs is highly dependent on the degree of heterogeneity in the portfolio preference of households, the aggregate share of wealth held in bonds and equities, and the overall saving rate. These characteristics of the economic system shape how wealth accumulation influences income inequality, and consequently wealth inequality. A higher saving rate and/or a greater aggregate share of wealth allocated to financial assets amplify the concentration of financial income within a smaller segment of the population. As a result, through the “population effect”, this mechanism increases the potential for an equalising impact of restrictive MPs. In contrast, a greater degree of heterogeneity in portfolio preferences reinforces the role of the financial channel in worsening intra-group inequality, thereby diminishing the scope for an equalising effect (see Appendix C, Fig. C.19).

¹⁹ By profit and wage earners, we mean the agents whose income mostly depends on dividends or wages, respectively.

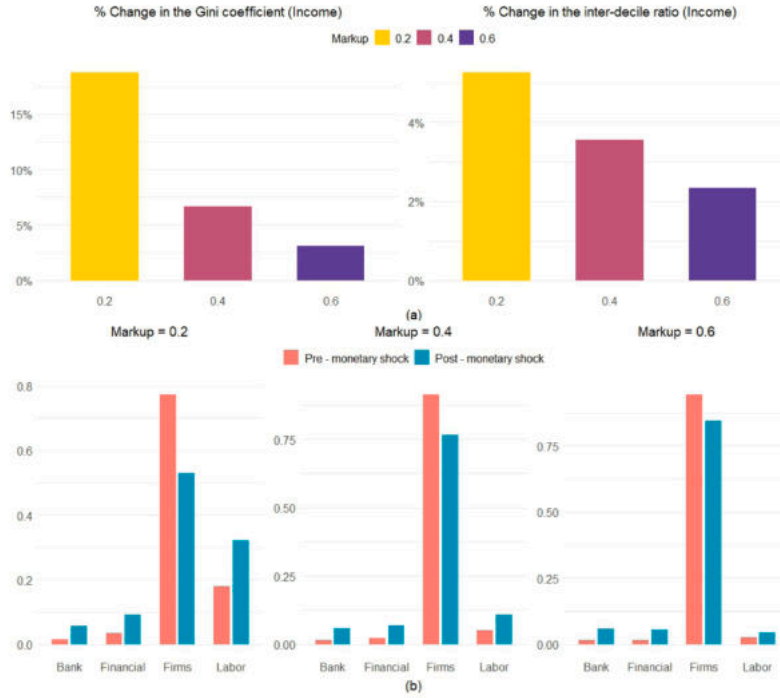


Fig. 6. The impact on inequality measures for different values of the markup ($k_b = k_f = -0.5$).

Notes: Fig. 6a reports the impact of MP on different inequality measures; Fig. 6b reports the changes in income factor decomposition caused by the MP.

In sum, the necessary, but not sufficient, condition for the realisation of an equalising effect is the negative asymmetry in the distribution of bank shares with respect to non-financial firms' shares. That is, the inequality in the distribution of bank shares must be much lower than the inequality in the distribution of non-financial firms' shares. Once this condition is satisfied, the possibility of having an equalising effect of restrictive MPs depends on the value of the markup, unemployment benefits, saving rate, the aggregate percentage of wealth allocated to financial assets, and the degree of heterogeneity in portfolio preference. These factors determine the possibility that the "cake share" effect dominates the increase in intra-group inequality.

To capture the inequality outcomes of our agent-based simulations in a compact and tractable way, we construct an analytical approximation that expresses the variation in income inequality (as measured by the Gini index) as a function of the concentration of ownership in the banking and non-financial sectors, respectively denoted by k_b and k_f . We adopt exponential transformations of k_f and k_b to reflect the nonlinear and convex relationship between ownership concentration and inequality outcomes. This choice also ensures the positivity of the function components and improves the flexibility and empirical fit of the approximation. The resulting expression allows us to identify threshold conditions under which monetary policy has an equalising or unequalising effect.

The approximated function, which describes the variation in Gini as a function of the inequality in the distribution of bank and firm shares, is the following:

$$z = a + b(e^{k_f})^c - [d + f(e^{k_f})^g] \cdot (e^{k_b})^{h+i(e^{k_f})^j} \quad (61)$$

where $a, b, c, d, f, g, h, i, j$ have been estimated accordingly (see Appendix D, Fig. D.24, Fig. D.25 and Fig. D.26). For example, we find that for the given set of parameters, the threshold over which the MP has an equalising effect is $k_f/k_b = 1.4$.

When $|k_f| > |k_b|$, income inequality is mainly driven by disparities in the distribution of non-financial firms' shares. This reflects both the greater weight of non-financial profits and the higher intra-group inequality from their dividends. In this scenario, a rise in interest rates can have an equalising effect if its impact on labour and wage-profit inequality is limited. This occurs because restrictive policy shifts income towards bank dividends - characterised by lower intra-group inequality - at the expense of non-financial firms' dividends, which exhibit higher inequality. Here, the CP channel equalising effect outweighs the aggregate demand channel unequalising effect.

In contrast, when $|k_f| \leq |k_b|$, restrictive monetary policy increases the weight of banking profits, marked by greater intra-group inequality, while reducing the share of income from less unequal sources. A similar effect arises when k_f and k_b are comparable. In both cases, workers cannot offset real wage losses through bank dividends, and all transmission channels contribute to the worsening of income inequality.

These results can be understood by looking at the variations in the contribution of each income factor to total inequality after the implementation of the monetary policy (Figs. 7 and (8)). In Fig. 7, $k_f = -2.6$ and k_b ranges between -2.6 and -0.2 .²⁰ In Fig. 8, $k_b = -2.6$, and k_f range between -2.6 and -0.2 . When $k_f = -2.6$ (Fig. 7), as k_b approaches zero, the relative inequality between the groups increases and the magnitude of the impact of restrictive monetary policy decreases. In particular, above a certain threshold, it starts having an equalising effect.

In contrast, when $k_b = -2.6$ (Fig. 8), the magnitude is negatively correlated with the initial degree of inequality in the distribution of non-financial firm shares and the non-linearity does not emerge. Here, intra-group inequality characterising the shares of the banking sector is always higher than that characterising non-financial firms' shares. As a result, restrictive monetary policy, by increasing the share of the banking sector, worsens income inequality.

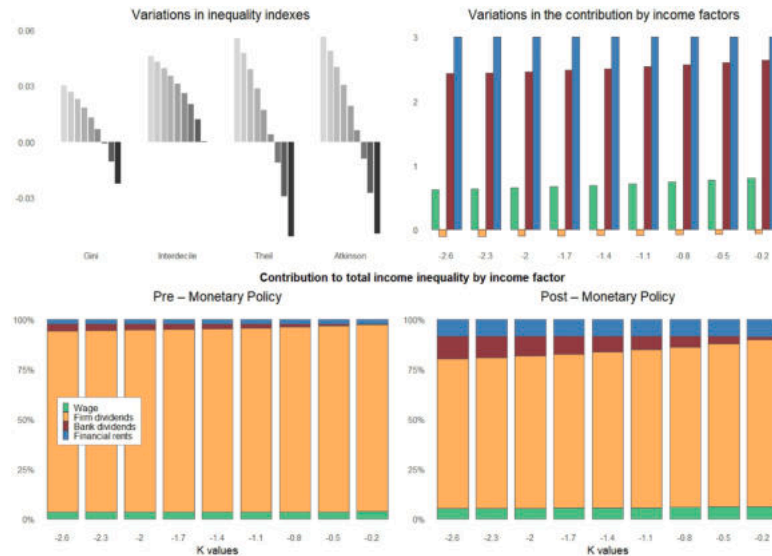


Fig. 7. Variation of inequality measures and variation in the contribution of income factors after the implementation of restrictive monetary policy. $k_f = -2.6$; $k_b \in [-2.6, -0.2]$.



Fig. 8. Variation of inequality measures and variation in the contribution of income factors after the implementation of restrictive monetary policy. $k_b = -2.6$; $k_f \in [-2.6, -0.2]$.

²⁰ The results generated by each possible combination of k_b and k_f are provided in supplementary materials.

Lastly, we discuss the shapes of the functions described in Fig. 3. The magnitude of the impact is an inverse convex function of the initial inequality in the distribution of firm shares, while it is a concave function of the initial inequality in the distribution of bank shares. That is, keeping constant the inequality in the distribution of bank shares, the magnitude of the impact of monetary policy is negatively correlated with the inequality in the distribution of non-financial firms' shares (the slope of the curve in Fig. 3 increases as k_f decreases). This is due, again, to the fact that the Gini coefficient suffers of the population effect: the greater the initial inequality in the distribution of non-financial firms' shares, the higher the concentration of income in a few hands, and the smaller the variation in the Gini coefficient as the policy rate increases. As a result, the percentage variation in Gini is maximum when the inequality in the distribution of non-financial firms' shares is at its lowest level, and it is minimum when it is at its highest value (see Fig. 3).

In contrast, while the distribution of non-financial firms' shares remains constant, the impact of monetary policy is positively correlated with the degree of inequality in the distribution of bank shares. In this case, the net effect almost depends on the winner (and the extent of the win) in the trade-off between the CP channel and other transmission channels. When k_b is low, the contractionary MP, on the one hand, reduces the income inequality by increasing the income share that characterises the lowest intra-group inequality (that is, the banking sector); on the other hand, it raises the income inequality by negatively affecting the employment rate. In this scenario, the first effect can be relevant and can even dominate the second. In any case, when k_b is low, the battle between the two opposite forces is significant, and as a result, the impact of monetary policy on income inequality is 'weak'. When k_b increases, the first effect fades and the sign of the impact begins to change, leading to an increase in inequality. As k_b increases, the trade-off between the two channels also disappears.

The results change slightly when considering the interdecile ratio, which does not suffer from the population effect. The sign inversion emerges at different degrees of inequality at inception depending on the indicator used (see Fig. 7 and Appendix C, Figs. C.16, C.18). In particular, the interdecile exhibits the nonlinearity threshold for a significantly lower value of k compared to the Gini, Atkinson and Theil indexes. Indeed, the interdecile is more sensitive to income differential between the tails of the distribution, is strongly affected by the variation in unemployment and the income of bank shares' holders.

6. Short- and long-term effects of monetary policy

In this section, we study in detail the transmission channels of restrictive MPs for specific initializations in the distribution of banks and non-financial firms' shares. In particular, we investigate the short- and long-term impacts²¹ of monetary policies on income and wealth inequality considering two different scenarios: "Concentrated and symmetric ownership" (CSO) and "Cooperative Capitalism" (CC). In the first scenario, firms and bank shares are concentrated within a small subgroup of households and the distribution is symmetric ($k_f = k_b = 2$), in the second, they are equally distributed throughout the population ($k_f = k_b = 0$). The "Concentrated and asymmetric ownership" (CAO) scenario is reported in Appendix C, Fig. C.19²².

Fig. 9 reports the effect of monetary policy tightening on Gini coefficients and macroeconomic variables for different degrees of heterogeneity in the composition of household portfolios in the CSO scenario. The impact on the interdecile ratios is reported in Appendix C, Fig. C.23. The heterogeneity in portfolio preferences is related to the share of public bonds and equity in total wealth. This share is positively correlated with the wealth level. The yellow line is the scenario with zero heterogeneity and the blu line is the scenario with maximum heterogeneity.

In the CSO scenario, the tightening of monetary policy worsens the inequality of income and wealth. The sign of the short- and long-run impact on income inequality is independent of the degree of heterogeneity in portfolio preferences. In contrast, portfolio heterogeneity plays a role in the short-term impact of MP on wealth inequality. In particular, the higher the heterogeneity in portfolio preferences, the greater the short-run equalising effect of the MP. We will provide a detailed explanation of the key mechanisms outlined in Section 5.

In the model, monetary policies affect income inequality through the cost-push channel (CP), the aggregate demand channel (AD), the saving remuneration channel (SR) and the asset price channel (PA). The overall effect on long-term income inequality is due both to a change in the weight of each income source in GDP and to intra-group inequality. The first effect passes through the CP channel, and the second passes through the AD and SR channels.²³ The impact on wealth inequality is related to the channels that determine income inequality and the PA channel. Table 1 summarises the specific mechanisms through which monetary policy is transmitted across the various channels, distinguishing between short- and long-run effects. In brackets is the sign of the effect in the CSO scenario. Below, a detailed description of each mechanism and of the dynamics resulting from opposing forces.

Since the interest rate represents a financing cost for firms, monetary policy directly affects distribution by modifying income shares (CP channel). If markups are constant, the non-financial profit rate is not affected and the increase in the interest rate is fully discharged into an increase in prices and the real wage is reduced²⁴. As a result, as shown in Fig. 4, the labour share and the non-financial profit share drop while the banking and financial share grow.

²¹ In what follows, we will refer to short-run as a transition phase, and with long-run as the permanent policy effect.

²² In the CAO scenario, bank shares are more equally distributed than non-financial firm shares and the equalising effect of the restrictive MP takes place.

²³ Note that, since markup are constant, we are not considering the effect of changes in the unemployment rate on the functional income distribution.

²⁴ The positive effect of the interest rate on prices can be considered as generally valid only in a closed economy. When considering an open economy, an increase in the interest rate, by positively affecting the exchange rate, can decrease the domestic price level by lowering the price of imported goods. The resulting effect depends on the input-output structure of the economy

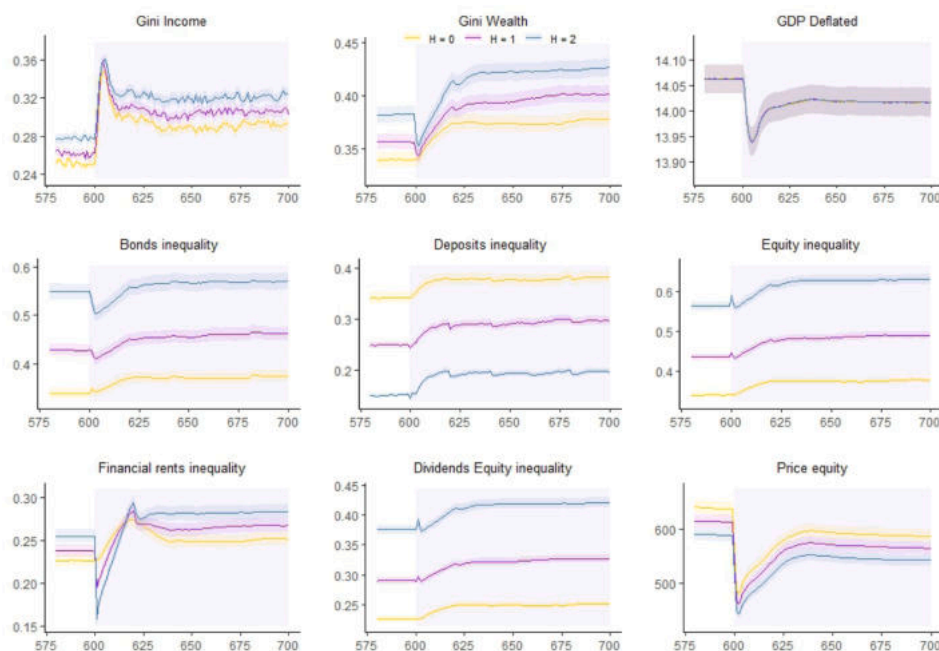


Fig. 9. The impact of restrictive monetary policy (CSO scenario).

Notes: Each color represents a different degree of heterogeneity in portfolio preferences. Yellow represents zero heterogeneity, while blue represents maximum heterogeneity.

Table 1
Transmission channels and mechanisms.

	Short-run	Long-run
Financial	URES (-)	Heterogeneity effect (B) (+) Saving effect (B) (+)
Asset Price	Heterogeneity effect (LTB) (-)	Heterogeneity effect (E) (-) Saving effect (E) (+)
Output (AD)	Unemp (+) Δ Wages-NF Profits (+)	Unemp (+) Δ Wages- NF Profits (+)
Cost-Push	Income shares (+)	Income shares (+)

Notes: URES: unhedged risk exposures; LTB: Long-term bonds; B: Bonds; E: Stocks

But how does an increase in the interest rate, aside from causing a reduction in real wages, lead to a redistribution of nominal incomes? Initially, the rise in financing costs is passed on to prices, then, through the endogenous money process, monetary aggregates adjust to the new price level (the nominal value of investments and autonomous spending components rises). As a result, the nominal value of profits recorded by firms increases while nominal wages remain constant. The banking sector appropriates this change in the total profit pool through the payment of interest by the non-financial sector. At the same time, the concurrent decrease in GDP results in a reduction in the non-financial profit share, even though the markups in this sector remain unchanged.

In the CSO scenario, because firms and bank dividends are concentrated across a small subgroups of households, the dynamic of personal income inequality is strictly linked to the labour share, and the MP leads to an increase in overall inequality.

The AD channel modifies both intra-group and intergroup inequality. On the one hand, the expansion in the unemployment rate causes an increase in labour income inequality. On the other hand, it modifies intergroup inequality by lowering the income differential between non-financial profit earners and wage earners. In fact, it reduces the income of the wealthy, while it leaves unaffected the income of households that do not lose their jobs and whose income mainly depends on wages²⁵. The first effect dominates on the second and, as a result, the AD channel contributes to the increase in inequality. The AD effect is due to a decrease in public spending multipliers and a negative wealth effect. In economies with constrained public spending, the rise in debt service causes a decrease in primary spending in favour of the latter, leading to a reduction in public spending multipliers. The negative

²⁵ For example, if we assume an unemployment benefit equal to the market wage, an increase in the interest rate, via the aggregate demand channel, would have an equalising effect. In fact, it would reduce the income of the profit earners, leaving the income of the wage earners unchanged

wealth effect is due to both the increase in the price level and the capital losses registered by the holders of bonds and shares²⁶. The wealth effect has a short-term impact on consumption and GDP.²⁷

The financial channel has a long-run unequalising effect, while its short impact is equalising in the case of heterogeneous portfolio preferences. The latter is due to different response speeds of portfolio returns to changes in interest rates across the population. Richer households hold a higher portion of wealth in the form of bonds with long maturities; therefore, they can only benefit from the interest rate increase on a smaller percentage of wealth, i.e. that related to new purchases. In the short term, most of the wealth has a return linked to past interest rates. In contrast, the returns of “more liquid” households or those with a higher percentage of wealth in the form of deposits are more responsive to interest rate changes. Once the rollover on bonds is exhausted, such an effect vanishes. These results are in line with [Auclert \(2019a\)](#), showing that exposures to unhedged interest rates (UREs), that is, the difference between all maturing assets and liabilities at a certain point in time, are the correct measure of households’ balance sheet exposures to changes in real interest rates. In this sense, agents whose financial wealth is primarily invested in short-term deposit certificates tend to have positive UREs, while those with large long-term bond investments or adjustable-rate mortgage liabilities tend to have negative UREs. A drop in the real interest rate causes a redistribution from the first group toward the second.

In the long-run, the change in financial inequality is due to the ‘heterogeneity effect’ and the ‘saving effect’. Through the ‘heterogeneity effect’, high-income households with a higher percentage of their wealth in terms of bonds will have a higher increase in their income compared to “more liquid” households. Note that such a mechanism is not time-dependent and is different from the above-mentioned impact of heterogeneous preferences on the response speed of portfolio returns. It refers to different growth rates in financial yields produced by different portfolio compositions.

Through the ‘saving effect’, the financial channel is indirectly activated by the AD and CP channels. These modify the ratios in which the savings variations of different agents are distributed. At this point, the financial channel acts as an echo chamber for the wealth disparities created by the other transmission channels. If high-income households, through the AD and CP channels, realise a higher growth rate or lower negative growth rate of their savings, financial rent will exacerbate income inequality. For such reasons, in the case of homogeneous preferences, the permanent expansion in financial inequality is fully explained by the change in saving relationships between households.

In general, the impact of the CP, AD, and FC channels on wealth inequality always occurs through changes in income inequality. Then, variations in wealth inequality further amplify income inequality and wealth distribution itself through the financial channel (saving effect). Furthermore, an additional mechanism that amplifies inequalities, linking changes in wealth inequality to income inequality, is triggered by the stock market. In fact, shifts in the distribution of savings cause further changes in the equity distribution, thus altering the subsequent distribution of dividends they generate.

Finally, through the PA channel, the MP affects wealth inequality via the ‘heterogeneity’ and ‘saving’ effects. As for the financial channel, MP directly influences wealth inequality when portfolio preferences are heterogeneous. The “heterogeneity effect” refers to capital gains and losses (CGLs) in both the stock and bond markets, albeit through different mechanisms. The “saving effect” applies only to the stock market.

As shown in [Fig. 9](#), the MP has a short-term equalising effect on wealth inequality in the case of heterogeneous preferences. This is mainly due to the CGLs in the bond market. Since an increase in the interest rate causes a reduction in the price of bonds, wealthier agents (i.e. agents with a higher percentage of wealth in the form of bonds and equity) experience a higher percentage decline in the value of their wealth compared to agents holding the greatest part of their wealth in the form of deposits. However, because bonds at maturity are repaid at their nominal value, the distributional effect of CGLs is transitory. Once the rollover is exhausted, the pre-shock nominal value of wealth is restored.²⁸ In the case of homogeneous portfolio preferences, all households experience, in the same proportion, a decrease in the value of assets as the interest rate increases, and the short-run equalising effect is absent.

The CGLs channel in the stock market affects wealth inequality when portfolio preferences are heterogeneous or because of a change in saving relationships across households. As for the financial channel, the first effect is directly activated by the MP, the second one is indirectly activated by the CP and AD and CP channels.

[Fig. 10](#) shows the distribution of CGLs in the bond and stock market in the scenario of homogeneous and heterogeneous preferences. Through the “heterogeneity effect”, if richer households have a higher percentage of equity in their portfolio, the decrease in equity prices caused by MS has an equalising effect. Households on the right-hand side of the distribution register higher capital losses-to-wealth ratios. If preferences are homogeneous, this channel is not active.

Through the “saving effect”, heterogeneous CGLs-to-wealth ratios can be generated by a change in saving relationships, also in the case of homogeneous preferences. In this sense, households that contribute the most to the change in equity demand (in relative terms) will benefit from a lower capital gains-to-wealth ratio. For example, if all households increase their savings after the shock (and, proportionally, their demand for equity), but the growth rate of the savings of richer households is higher than other agents, the price of equity will rise and the richest will register lower capital gains to wealth ratios²⁹. In fact, low-income households will benefit from an increase in price that is not fully due to their relative change in the contribution to the equity market.³⁰ The same applies

²⁶ The negative wealth effect caused by a reduction in bond values depends on the presence of market price illusion. If households compute their wealth stock considering the value at maturity of the securities, such an effect is absent. In contrast, if they consider the price of the market, a negative effect of wealth on consumption emerges. However, once the rollover is exhausted, such an effect disappears.

²⁷ Once, through the endogenous money process, the wealth stock adjusts to the new price level, the negative effect vanishes.

²⁸ The corresponding amount is held in terms of more bonds at a lower price.

²⁹ This is valid also considering the CGLs-to-lagged wealth ratio, to esclude the contemporaneous effect on the denominator.

³⁰ In this case, we are assuming that the elasticity of assets demand to the policy rate is homogenous across the population.

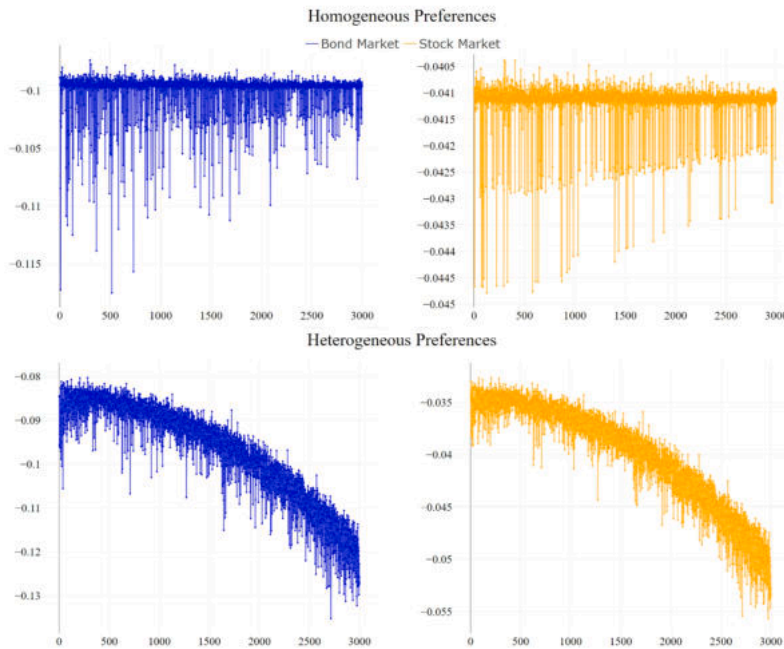


Fig. 10. Distributions of CGLs in bond (blue) and stock (yellow) markets.

Notes: The y-axis displays the CGLs of households, ordered from the poorest on the left to the richest on the right along the x-axis.

in the case of a reduction in the equity price. The households that contribute the most to the drop in the equity price (because of a higher reduction in their savings) will experience a higher capital loss-to-wealth ratio. In this sense, if the monetary shock penalises the incomes of agents in the lower tail of the distribution, the saving effect and the heterogeneous effect have two opposing impacts. The first is equalising; the second is unequalising.

As shown in Fig. 10 (homogeneous scenario), the relative contribution of low-income households is higher and they will register higher capital losses. The MP has an unequalising effect. In the case of heterogeneous preferences, the HE dominates the SE and the MP has an equalising wealth effect. In this regard, it is worth noticing that, in the homogeneous scenario (yellow line), wealth inequality grows also in the short-run because the heterogeneity effect is absent, and both the change in income distribution and the SE in the stock market contribute in rapidly boosting wealth inequality. Finally, the equalising impact of the heterogeneity effect is dampened when wealthier agents have a higher sensitivity to interest rate changes. In such a case, as the interest rate increases, they generate a smaller relative change in equity demand, thereby increasing the weight of agents further to the left in the distribution in driving the variation in equity prices.

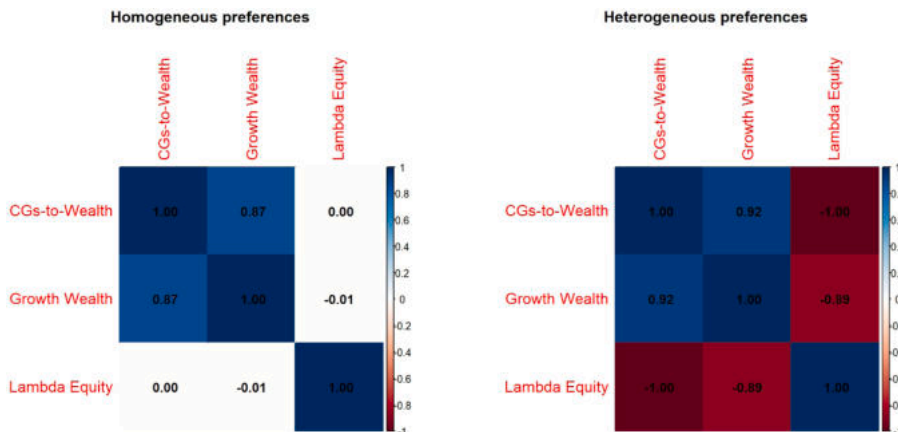


Fig. 11. Factors explaining CGLs distribution in the stock market.

Fig. 11 resumes such relationships reporting the correlation between CGLs-over-wealth, the distribution of saving growth rates, and portfolio preferences in the two scenarios. As shown, in the case of homogeneous preferences, the distribution of CGLs would

be fully explained by changes in the distribution of savings growth rates. In the case of heterogeneous preferences, both HE and SE contribute to determining the overall change in wealth distribution, but the heterogeneity effect is stronger. In sum, within the PA channel, CGLs in the bond market have a short-term equalising effect on wealth inequality through the heterogeneity effect. CGLs in the stock market have a permanent equalising effect if the saving effect is dominated by the heterogeneity effect. However, our results show that the direct impact on wealth inequality through the CGLs is weak, in the long-run the overall impact is dominated by the other channels (AD, CP and SR). These results are consistent with the findings of the empirical literature. For example, [Lenza and Slacalek \(2018\)](#) show that non-standard monetary policy has only negligible effects on wealth inequality. In contrast, expansive monetary policy compresses the income distribution, since many households with lower incomes become employed. In particular, they find that the policy temporarily increases the value of stocks of wealthier households. The effects of quantitative easing on net wealth tend to be stronger for leveraged households, relative to their wealth level, although low-income households have a lower level of net wealth, and the effects of QE relative to the wealth level do not immediately translate into the effects on inequality. Finally, the overall change in inequality can be understood in light of the change in factor contribution to total inequality (see [Fig. 12](#)).

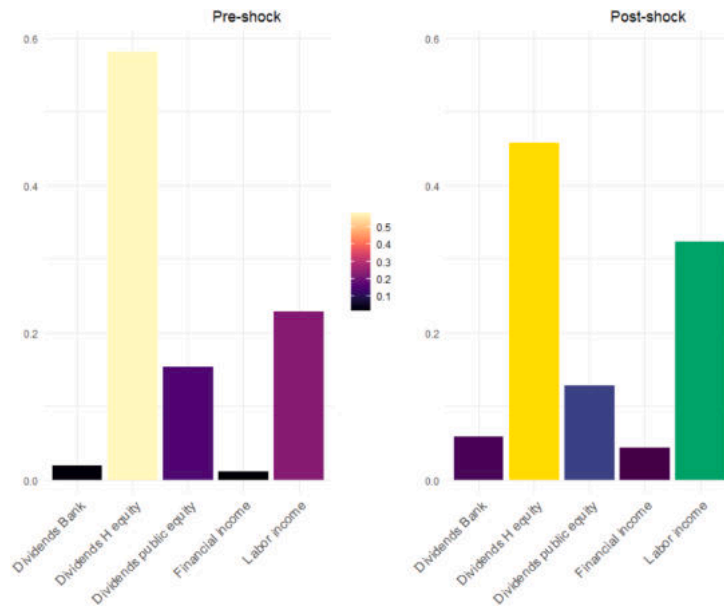


Fig. 12. The change in income factor contribution (CSO scenario).

The contribution of the banking sector to income inequality increases due to a rise in the banking share of GDP, while the associated intra-group inequality remains unchanged. Although the labour share drops, the contribution of labour income increases due to the increase in labour inequality (AD channel). The contribution of financial income increases as a result of both an increase in the financial share and intra-group inequality (SR channel). Since the non-financial profit share decreases, the contribution of dividends from private and public (non-financial) equities diminishes as well. However, it should be noted that the change in the contribution of public equities is significantly smaller than the change in the contribution of private equities. This is because the expansion of wealth inequality has also led to a shift in the ownership structure of public equities, favouring households on the right-hand side of the distribution. As a result, the inequality between groups in the distribution of dividends from public equities is increasing. In sum, in the CSO scenario, the worsening in income distribution is due to both an increase in intra-group inequality and an increase in the weight of those income sources characterised by the highest intra-group inequality.

In conclusion, if portfolio preferences are homogeneous, the movements in wealth inequality are almost explained by the changes in income inequality. However, through the saving effect, changes in wealth inequality further affect income inequality (and wealth inequality itself) through the financial and asset price channels. In this case, the financial channel and the stock market act as amplifiers of the inequality generated by the other channels. When portfolio preferences are heterogeneous, wealth inequality is directly affected by the MP through the PA channel. In this case, also the financial channel directly affects income inequality through the heterogeneity effect. These mechanisms add to the previous ones, and the resulting balance between opposing forces determines the direction of the overall impact. The transmission channels of monetary policies and their interaction in affecting the inequality of income and wealth are summarised in [Fig. 13](#). Both scenarios of homogeneous and heterogeneous preferences are considered.

Through the CP and AD channels, the MP directly influences income and, as a consequence, wealth inequality. The financial and PA channels are not activated directly by the MP when the portfolio preferences are homogeneous. However, they 'return through the window' via the 'saving effect', which means that they are indirectly activated by the AD and CP channels.

In contrast, in the case of heterogeneous portfolio preferences, the MP directly activates the financial and PA channels. In this case, the heterogeneous effect combines with the saving effect to shape financial inequality, giving rise to a feedback loop between these two effects.

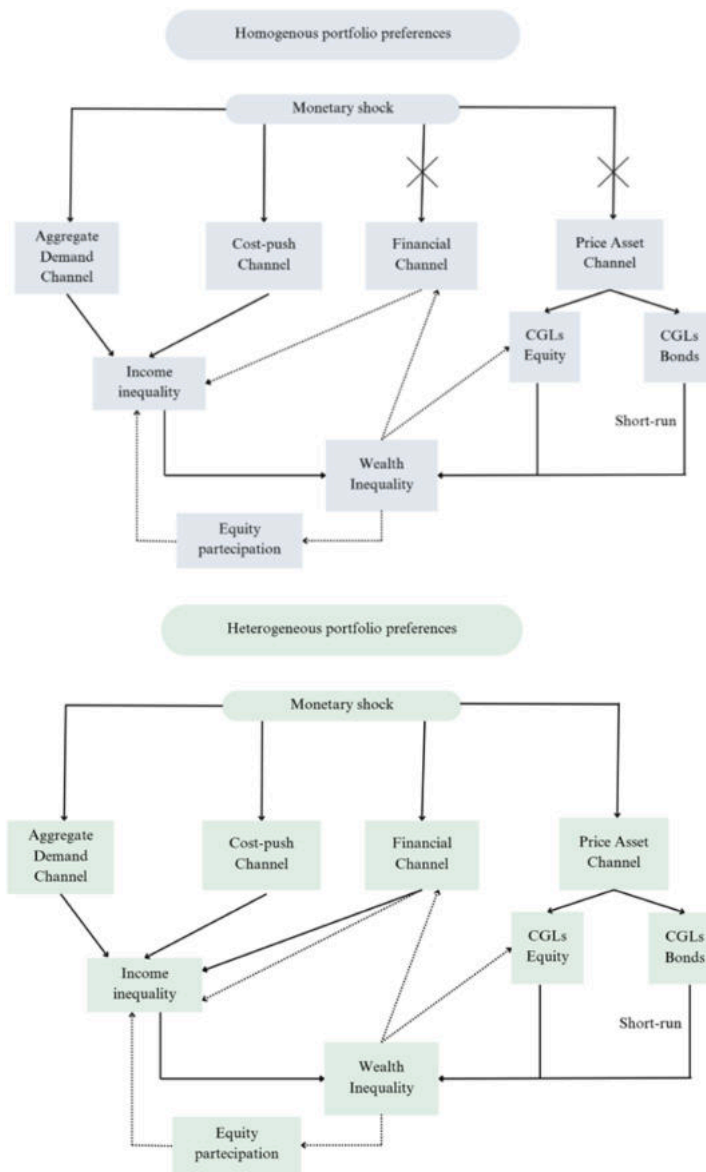


Fig. 13. Transmission channels of the monetary shock.

The second (and extreme) scenario we are considering in the dynamic analysis is the CC scenario. Here, restrictive monetary policy continues to have a long-term unequalising effect (Fig. 14). However, the CP channel is absent, while the AD channel plays a key role. Due to the very low value of wealth inequality, the SR and PA channels have a negligible impact.

In this scenario, workers are able to recover the fall in real wages through the dividends of the banking sector. The class structure of society and the connection between the share of labour and the inequality of personal income are largely overlooked.

The AD channel primarily affects labour inequality, while inter-income factor inequality, arising from the differential between wage and profit earners, remains very low. This is mainly attributable to changes in equity participation of workers who lose their jobs. The AD channel also fully determines, through the SE, the effects that pass through the SR and PA. Due to the low level of wealth inequality, the HE effect is almost negligible. As shown in Fig. 15, the overall inequality is almost explained by labour inequality, and the change in inequality is almost due to the increase in labour inequality, which is reinforced by financial yields and the change in the distribution of non-financial firms' shares.

If we examine other inequality measures (see results in Appendix C), while the Theil and Atkinson indexes exhibit the same behaviour as the Gini index, the interdecile ratio (D90/D10 ratio) proves to be particularly sensitive to the AD channel. On the one hand, this channel mainly affects the income of the bottom 10% by altering the employment status of agents within this group. On the other hand, the AD channel significantly impacts households whose income is primarily dependent on firm profits (top 10%). In

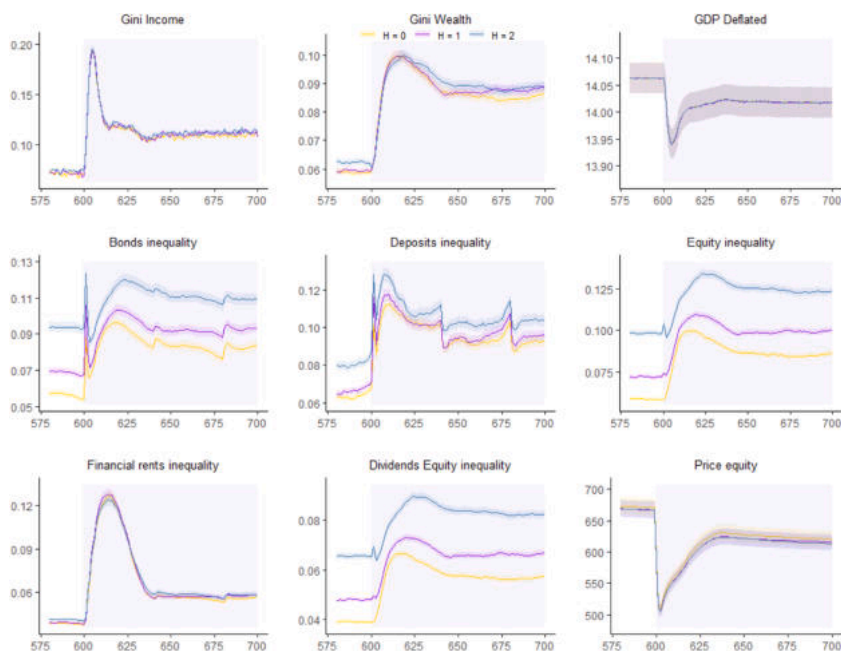


Fig. 14. The impact of restrictive monetary policy (CC scenario).

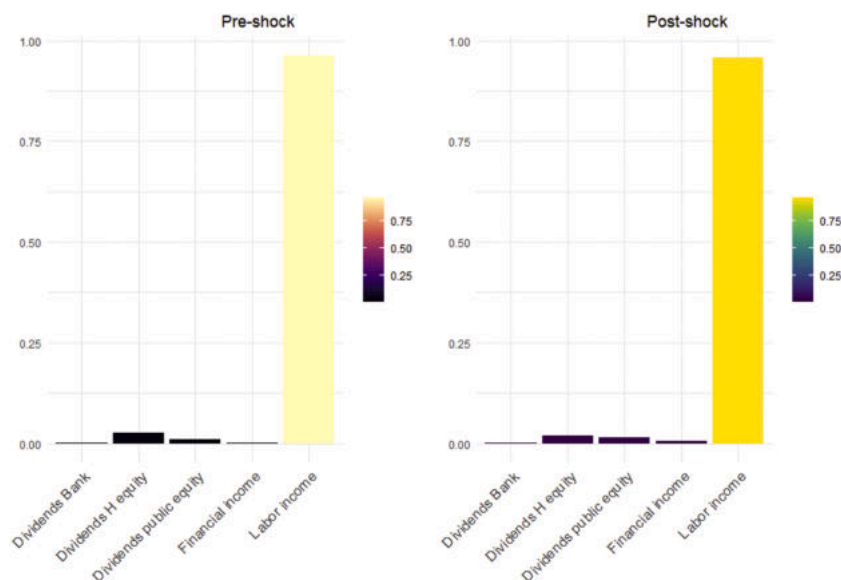


Fig. 15. The impact of restrictive monetary policy (CC scenario).

contrast, the income of households concentrated in the middle of the distribution is less dependent on profits and subject to a lower probability of job loss. Consequently, the impact of changes in aggregate demand on these groups is less pronounced.

Apart from the degree of symmetry in the initial distribution of firm and bank shares, the potential for an equalising or unequalising effect on the interdecile ratio also depends on the initial level of unemployment. For example, in unequal societies with high unemployment levels, contractionary monetary policies can reduce the interdecile ratio. In such cases, the decline in labour income among the bottom decile is less pronounced than the reduction in dividends distributed to the top 10 percent, driven by lower aggregate demand.³¹ Conversely, when unemployment rates are low, the increase in labour income inequality can outweigh the impact of reduced total profits, leading to a rise in the interdecile ratio.

³¹ If the majority of households in the bottom 10% are already unemployed, the AD channel will have minimal effect on their income.

7. Conclusions

The literature on the relationship between restrictive monetary policies and inequality presents controversial and often contrasting findings (Aye et al., 2019; Galbraith et al., 2007; Mumtaz and Theophilopoulou, 2017b; Saiki and Frost, 2014, 2018; Villarreal, 2014; Hafemann et al., 2018; Herradi and Leroy, 2021; Inui et al., 2017; Samarina and Nguyen, 2024; Taghizadeh-Hesary et al., 2020). Empirical studies reveal equalising and unequalising effects, while the results diverge depending on the measure of inequality taken into account (Davyan, 2016). By developing an AB - SFC model, this paper addresses the role of different initial conditions in the distribution of endowments across households, wealth composition, and heterogeneity in portfolio choices.

Overall, our results show that the possibility of having an equalising effect is tied to the short term and stems from the heterogeneity in portfolio preferences. The latter is due to financial yields and CGLs in the bond and stock markets when high-income households held a higher percentage of their wealth in terms of bonds and equities. However, in the long-run, the latter effect is negligible, while the financial channel changes sign, resulting in an unequalising effect. In the long term, this possibility is more constrained and depends on a more equitable distribution of bank shares compared to non-financial firms' shares, as well as a low labour share and portfolio heterogeneity, and/or a combination of a high saving rate, aggregate percentage of wealth allocated to financial assets, and unemployment subsidies. These factors allow the "cake effect" to cancel out the increase in intra-group and intergroup inequality induced by the monetary shock.

In the model, MPs affect long-run inequality by modifying the weight of each income source on GDP and intra-group inequality. The AD channel, which increases labour inequality and affects wage-profit differentials, mostly affects the tails of the distribution and generally has an unequalising impact. Such an effect tends to disappear when the unemployment subsidy rises and/or labour share reduces. Moreover, the SR channel has a short-term equalisation impact, while it has a long-run unequalisation effect through the "heterogeneity effect". Through the 'saving effect', the SR channel operates as echo chamber for the wealth disparities created by the other transmission channels. Through the PA channel, capital gains and losses (CGLs) in long-term bonds have a short-term equalising effect that is positively correlated with the degree of heterogeneity in the preferences of the portfolio of households. In the long-run, this effect vanishes. The CGLs in the stock market impact wealth inequality through the "heterogeneity" and "saving effects". The first generally has an equalising effect. The second depends on the impact of other MP transmission channels on personal saving accumulation. As for the financial channel, the stock market exacerbates the wealth disparities created by other transmission channels. In fact, an increase in wealth inequality, leading to a change in the ownership structure of firms, provokes a higher concentration of dividends distribution across the population. The CP channel affects the inequality between groups by altering the income shares. The direction of its impact depends on the degree of symmetry in the distribution of non-financial firm and bank shares. It may reduce income inequality by increasing the weight of those income factors characterised by lower intra-group inequality. Since contractionary MPs increase the share of the banking sector, reducing the non-financial profit share and labour share, inequality worsens if the intra-group inequality of this sector is higher compared to the one characterising the distribution of nonfinancial firm shares. Conversely, if the banking sector presents lower intra-group inequality, MPs can have an equalising effect.

In general terms, in the long-run, AD and SR have a long-run unequalising effect, while the effect of PA is negligible. Ultimately, the potential to achieve a long-run equalising effect depends on the strength of the cost-push channel. Empirical studies indicate that this channel is particularly strong in the USA (Christiano et al., 1999, 2005b; Cucciniello et al., 2022), while in Europe its impact varies significantly between countries.

We conclude by arguing that the various dimensions of heterogeneity in factor income distribution and wealth composition play a crucial role in shaping the impact of monetary policies. As heterogeneity increases, the transmission of monetary policy becomes more complex due to the interaction of multiple, often competing channels, making the overall impact less predictable. In contrast, in more equal societies with lower levels of heterogeneity, the effects of monetary policy tend to be more predictable and are primarily driven by labour income inequality and the aggregate demand channel.

These results are in line with the empirical findings (see Dolado et al. (2021) for a review), showing that the ambiguous results in the empirical literature are due to the different distribution of households in relevant heterogeneity dimensions. In this regard, the effect of monetary policy on inequality has been shown to depend on the initial wealth distribution, the composition of household financial assets (O'Farrell and Rawdanowicz, 2017; Guerello, 2018) and the initial wage share (Furceri et al., 2018).

One of the main limitations of the model is the absence of the housing market. However, this choice stemmed from the need to strike a balance between realism and tractability, so as not to overcomplicate the interactions and feedback loops triggered by the transmission channels on which this study focuses.

The future development of this research will proceed in three main directions. First, we aim to investigate how the duration of restrictive monetary policy episodes affects the persistence of inequality dynamics over time, a dimension that is currently underexplored in both theoretical and empirical work. Second, we plan to incorporate inflation expectations into the nominal wage-setting process to explicitly account for the inflation channel. Finally, while this paper has focused on providing a general theoretical explanation for the different impact that monetary policy can have depending on the specific country, a natural next step is to subject the model to empirical validation. In particular, a cross-country approach (panel) would allow us to systematically link institutional and structural heterogeneity to inequality outcomes and to assess which transmission mechanisms are most empirically significant.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

A previous version of this paper was presented and at the ABM4 policy workshop at the European Central Bank, at the Wehia 2024 Conference at the University of Bamberg (Germany), at EAEPE Conference held at University of Bilbao (Spain), at the 2024 Forum in Macroeconomics and Macroeconomic Policies in Berlin (Germany), and at the 2024 meeting of the Italian Economic Society held in Urbino (Italy). The paper has also been presented in a seminar at the Bank of England (UK), the University of Greenwich (UK) and the Università Cattolica del Sacro Cuore, Milan (Italy). The authors are grateful to the participants for their helpful comments and suggestions. The usual disclaimer applies. Giorgio Ricchiuti gratefully acknowledges Queen Mary University and the Warburg Institute in London for providing a stimulating environment and generous hospitality.

Supplementary material

Supplementary material associated with this article can be found in the online version at [10.1016/j.jedc.2026.105296](https://doi.org/10.1016/j.jedc.2026.105296).

Appendix A. Appendix A

Capital stock, amortisation and unit costs computations The capital stock in period t is composed of the residuals of capital goods installed in the previous $z + 1$ periods (vintage capital goods), with z representing the useful life of the capital good:

$$k_{t,i} = \sum_{j=t-z+1}^t k_{j,i}^{ins} \left(\frac{j+z-t}{z} \right),$$

where $k_{j,i}^{ins} = I_{t-d_{k,i}}$ is the amount of capital installed in period j and corresponds to the gross investment carried out in d_k previous periods. The absolute deterioration is constant, the total deterioration ($\zeta_{t,i}$) in each period is composed of the sum of the deterioration of capital goods installed in the previous z periods (including the current one):

$$\zeta_{t,i} = \sum_{j=t-z+1}^t \frac{k_{j,i}^{ins}}{z}.$$

The amortization for computing unit cost includes both the cost of capital and the cost of debt service considering the full leverage. The amortisation for computing profits considers the realised leverage and is defined as follows:

$$\Lambda_{t,i} = \frac{1}{a} \sum_{j=t-z+1}^t p_{i,indexK} k_{j,i}^{ins} (1 + r_j b l_j) (j + z - t),$$

where r_j e l_j represent, respectively, the interest rate in the period in which the debt was contracted and the *leverage* realised in purchasing the capital good. $K_{j,i}^{ins}$ is the installed capital in period j from firm i and $p_{i,indexK}$ is its price (because z is the useful life of the capital good, the computation of amortisation and depreciation go back up to a maximum of z periods). $a = \sum_{i=1}^z \frac{i}{z}$ e $b = \frac{1}{a} \sum_{i=1}^z \frac{i^2+i}{2}$ are the multiplying factors for the calculation, respectively, of the interest accrued on the loan granted in a given period and the (potential) cumulated production (in correspondence with the normal degree of capacity utilisation) over the useful life of the capital good. See Di Domenico (2020) for an explanation of amortisation and unit cost computation and why this should be preferred to others commonly used within the AB literature.

Appendix B.

Table B.2

Balance sheet matrix.

Assets	Households	Firms K	Firms C	Banks	Government	CB	Σ
Check deposits	M_h^c	M_k^c	M_c^c	$-M^c$			0
Time deposits	$+M_h$			$-M$		0	0
Reserves				$+H_b$		$-H$	0
Advances				$-A$		$+A$	0
Loans			$-L_c$	$+L$			0
NPL			$+N L_c$	$-N L$			0
Fixed capital			$+K$				$+K$
Inventories			$+INV$				$+INV$
Equities	$+p_e E$		$-p_e E$				0
Public bonds	$+B_h$			$+B_b$	$-B$	$+B_{CB}$	0
Net Wealth	$-V_h$	$-V_k$	$-V_c$	0	$+V_G$	$-V_{CB}$	$-K_f$
Σ	0	0	0	0	0	0	0

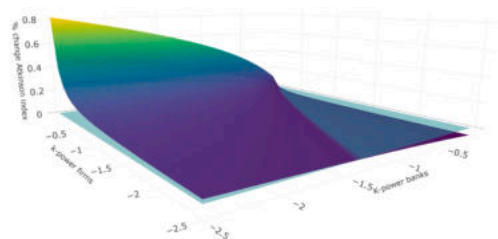
Table B.3
Transactions Matrix.

Flows	Households	Firms K	Firms C	Gov.	Bank	CB		Σ
					Current	Capital	Current	Capital
Consumption	$-C$		$+C$					0
Investments		$+I$	$-I$					0
Public exp.			$+G$	$-G$				0
Unemp. Benefit	$+U$			$-U$				0
Wages	$+W$	$-W_k$	$-W_c$					0
Tax	$-T$			$+T$				0
Dividends Firms	$+Div_F$	$-Div_k$	$-Div_c$					0
Dividends Bank	$+Div_B$				$-Div_B$			0
Profits CB				$+F_{CB}$			$-F_{CB}$	0
Recapitalization	$-K_r$		$+K_r$					0
Int. Deposits	$+r_m M_{h,t-1}$				$-r_m M_{t-1}$			0
Int. Loans		$-r_l L_{k,t-1}$	$-r_l L_{c,t-1}$		$+r_l L_{t-1}$			0
Int. Bond	$+r_b B_{h,t-1}$		$-r_b B_{t-1}$		$+r_b B_{t-1}^b$		$+r_b B_{CB,t-1}$	0
Int. Reserves					$+r_r H_{t-1}$		$-r_r H_{t-1}$	0
Int. Advances					$-r_a A_{t-1}$		$+r_a A_{t-1}$	0
Δ Check deposits	$-\Delta M_h^c$	$-\Delta M_K^c$	$-\Delta M_C^c$			$+\Delta M^c$		0
Δ Time deposits	$-\Delta M_h$					$+\Delta M$		0
Δ Loans		$+\Delta L_k$	$+\Delta L_c$			$-\Delta L$		0
Δ Bond	$-\Delta B_h$			$+\Delta B$		$-\Delta B_b$		0
Δ NPL			$-\Delta NPL_c$			$+\Delta NPL$		0
Δ Equities firms	$-\Delta e_c p_e$		$+p_e(\Delta e_c - \Delta e_c^f)$					0
Δ Reserves						$-\Delta H$		0
Δ Advances						$+\Delta A$		0
Σ	0	0	0	0	0	0	0	0

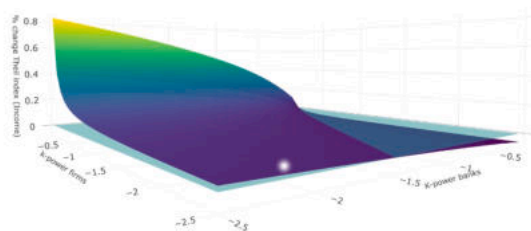
Appendix C.**Table C.4**

Factor contribution for different measures of inequality as the initial distribution in non-financial firms' and bank shares increases.

Unique contribution to inequality				Generalized Entropy (C = 0)				Generalized Entropy (C = 1)			
Wage	Div. F.	Div. B.	Fin. r.	Wage	Div. F.	Div. B.	Fin. r.	Wage	Div. F.	Div. B.	Fin. r.
0.014	0.811	0.076	0.099	1.710	-0.740	-0.069	0.099	-0.523	1.301	0.122	0.099
0.016	0.809	0.076	0.099	1.726	-0.755	-0.071	0.099	-0.525	1.303	0.122	0.099
0.019	0.806	0.075	0.099	1.742	-0.769	-0.072	0.099	-0.525	1.304	0.122	0.099
0.023	0.802	0.075	0.099	1.755	-0.781	-0.073	0.099	-0.524	1.302	0.122	0.099
0.030	0.796	0.075	0.099	1.762	-0.788	-0.074	0.099	-0.518	1.297	0.121	0.099
0.040	0.787	0.074	0.099	1.759	-0.785	-0.074	0.099	-0.504	1.284	0.120	0.099
0.061	0.768	0.072	0.099	1.728	-0.757	-0.071	0.099	-0.468	1.252	0.117	0.099
0.113	0.720	0.067	0.099	1.613	-0.651	-0.061	0.099	-0.366	1.158	0.108	0.099
0.352	0.502	0.047	0.099	1.051	-0.138	-0.013	0.099	0.125	1.709	0.066	0.099



(a) % Change in Atkinson index



(b) % Change in Theil index

Fig. C.16. The impact of monetary policy on Atkinson (a) and Theil (b) indexes for different combinations of the initial inequality in the distribution of firms and bank shares.

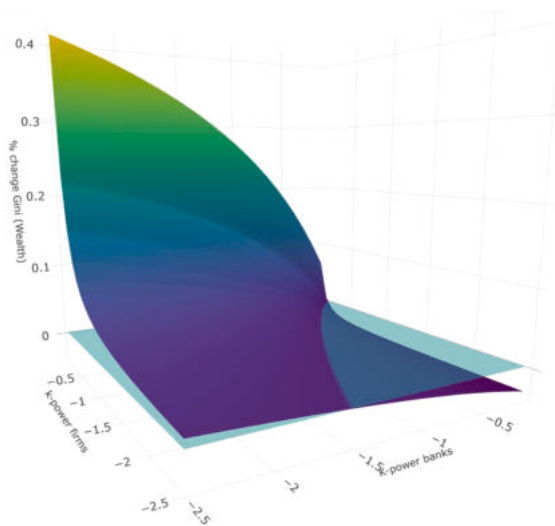


Fig. C.17. The impact of monetary policy on the Wealth Gini coefficient for different combinations of the initial inequality in the distribution of firms and bank shares.

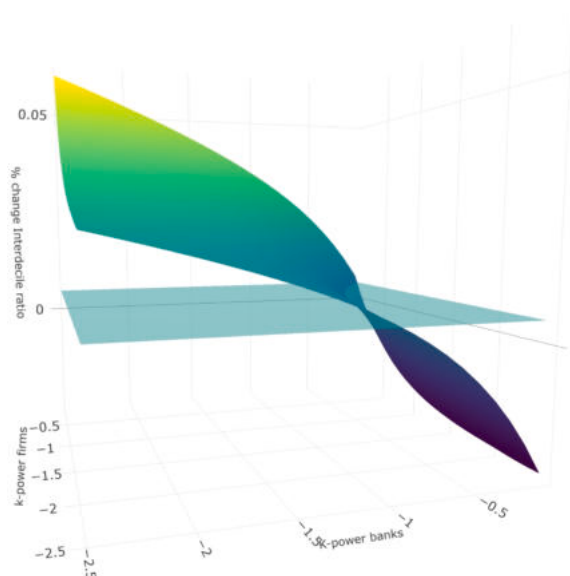


Fig. C.18. The impact of monetary policy on the interdecile ratio for different combinations of the initial inequality in the distribution of firms and bank shares.

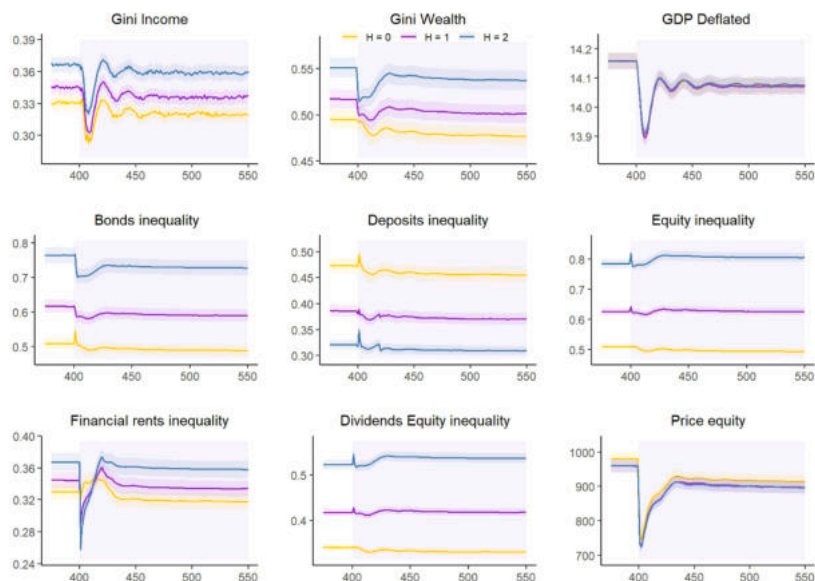


Fig. C.19. The impact of monetary policy in the scenario with concentrated and asymmetric ownership.

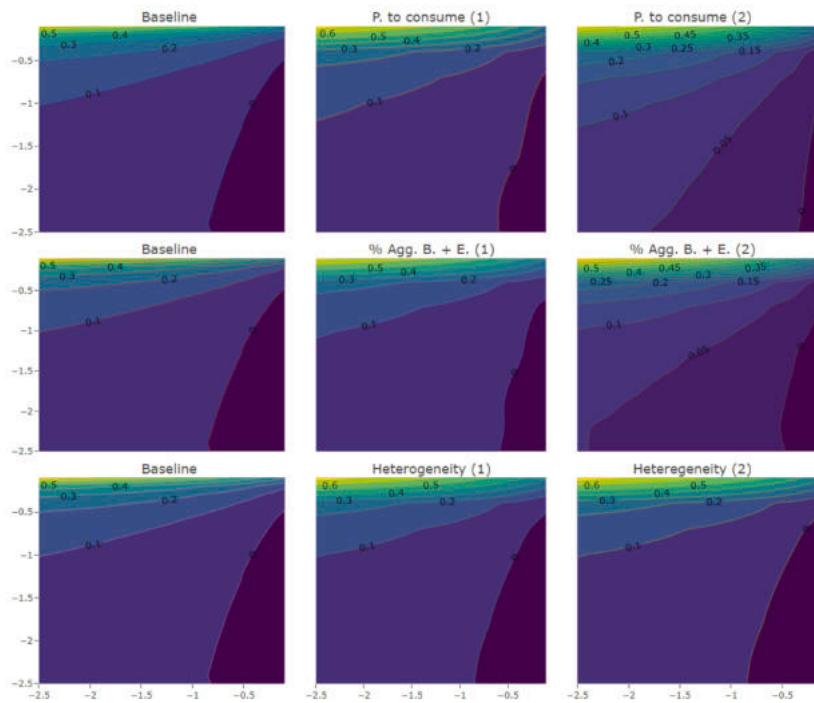


Fig. C.20. The impact of monetary policy in three different scenarios: (a) decrease in the saving rate; (b) decrease in the aggregate percentage of wealth held in terms of bonds and equity; (c) increase in the degree of heterogeneity in portfolio preferences.

Notes: Each contour plot displays the effect of the MP for a specific value of saving rate, aggregate percentage of wealth held in terms of bonds and equity, degree of heterogeneity in portfolio preferences. The x-axis reports the k-powers describing the distribution of bank shares. The y-axis reports the k-powers of non-financial firm shares.

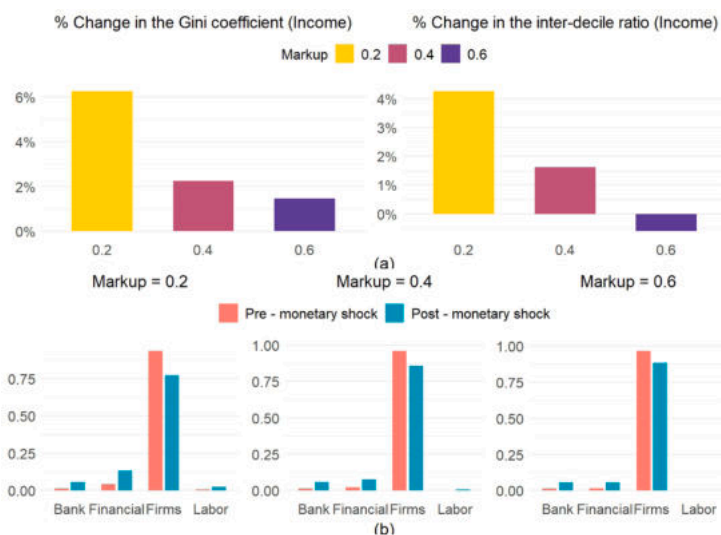


Fig. C.21. The impact on inequality measures for different values of the markup ($k_b = k_f = -2$).

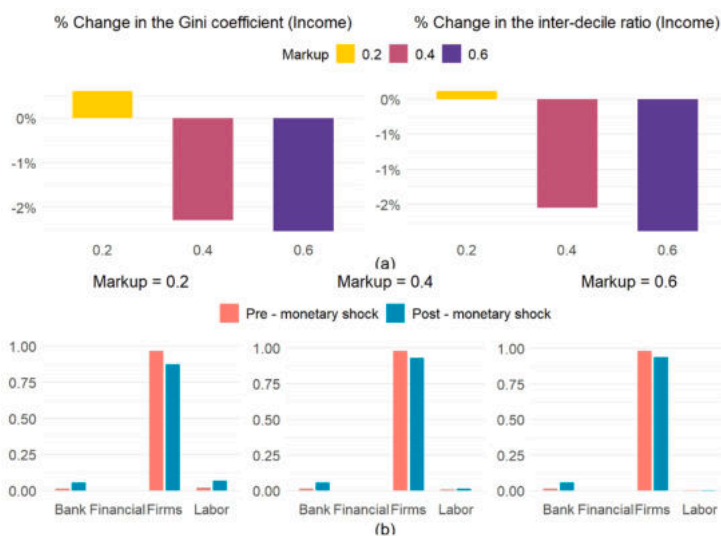


Fig. C.22. The impact on inequality measures for different values of the markup - $k_b = 0$; $k_f = -2$.

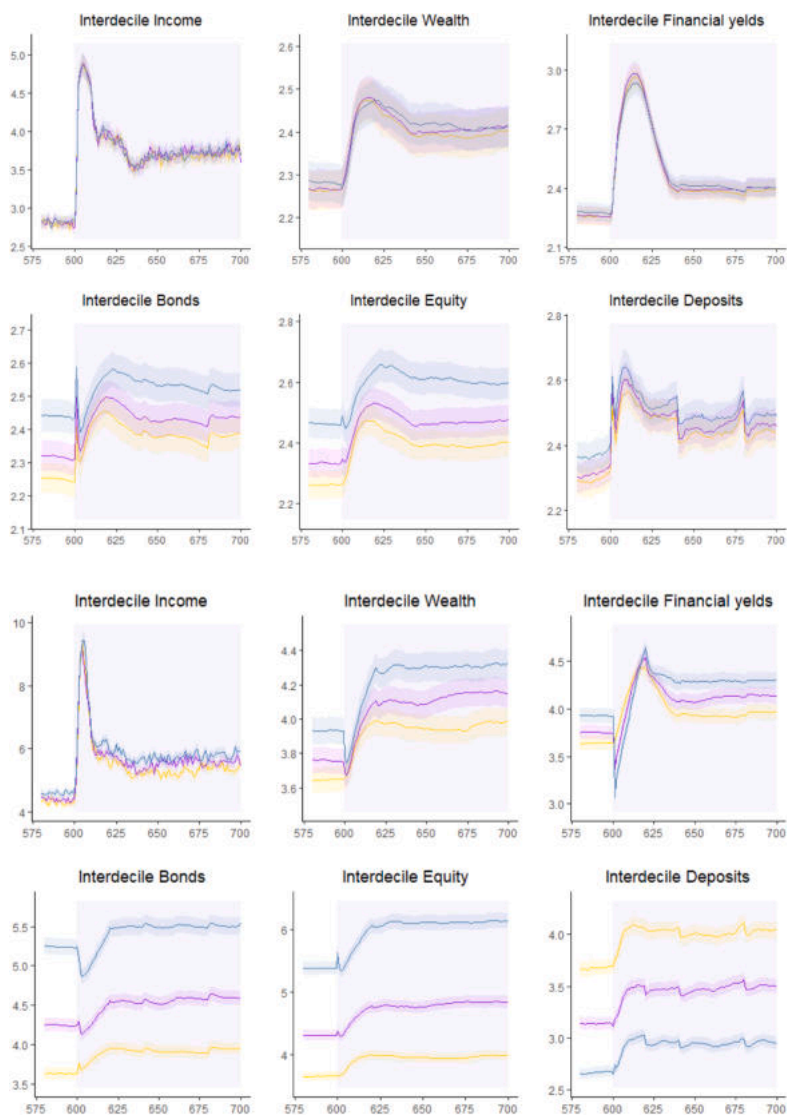


Fig. C.23. The impact on interdecile ratios - CC (a) and CSO (b) scenarios.

Appendix D.

The relationship between z (% Gini variation) and x (k_b) is well-approximated by the following function: $z = a + b(e^x)^c$. The relationship between z and k_b for different values of k_f is reported in the following Figure.

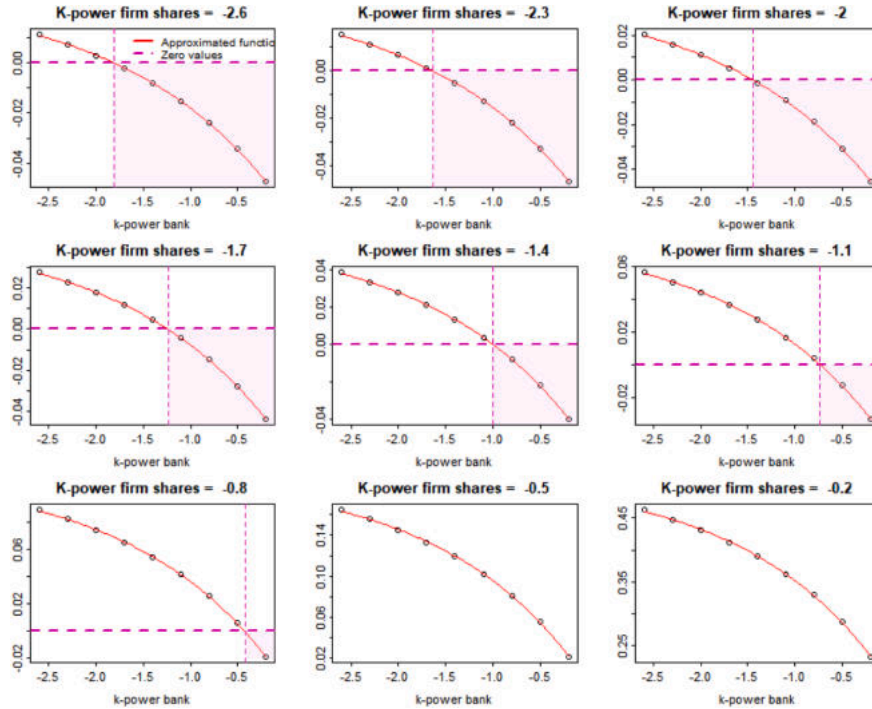


Fig. D.24. Approximating % Gini variation in function of k_b .

Then, z can be rewritten as a function of k_b and k_f estimating a , b , and c as a function of k_f : $z = a(y) + b(y)(e^x)^{c(y)}$. The graphical results of the estimation are reported in the following figure:

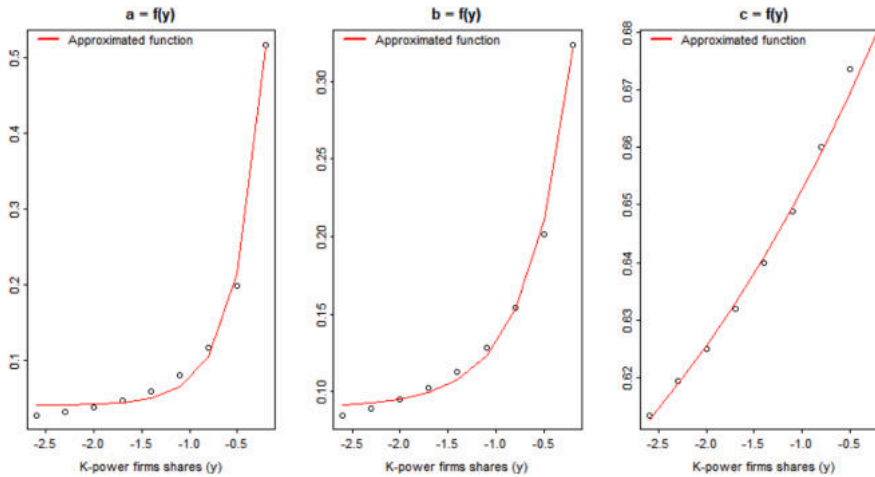


Fig. D.25. Approximating a , b and c in function of k_f .

The general approximating function is:

$$z = a + b(e^{k_f})^c - [d + f(e^{k_f})^g] \cdot (e^{k_b})^{h+i(e^{k_f})^j} \quad (\text{D.1})$$

The values of $a, b, c, d, f, g, h, i, j$ have been estimated using the above-reported nonlinear function, and the following tables report the estimated results.

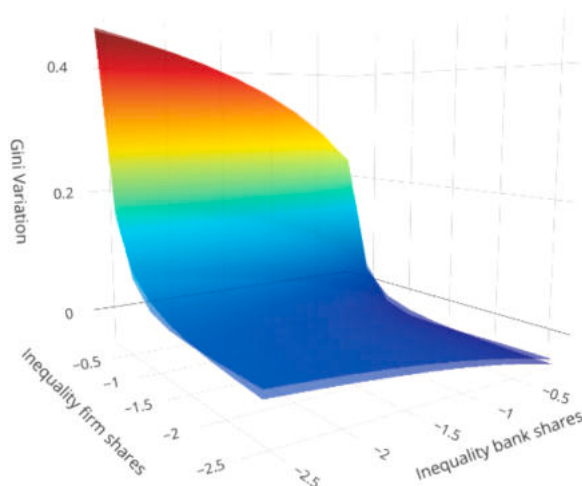


Fig. D.26. The impact on the Gini coefficient - estimated and simulated functions.

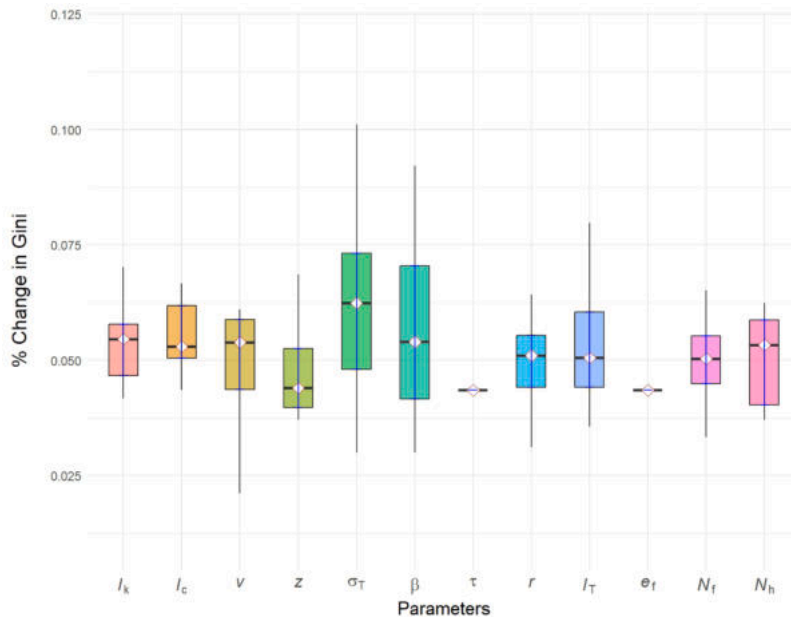
Notes: The rainbow surface represents the estimated function. The blue surface represents the simulated function.

	Estimate	Std. Error	t value	Pr(> t)
a	0.92	0.05	17.22	0.00
b	0.04	0.01	6.87	0.00
c	3.33	0.24	13.76	0.00

	Estimate	Std. Error	t value	Pr(> t)
d	0.35	0.01	24.95	0.00
f	0.09	0.00	25.56	0.00
g	2.16	0.15	14.78	0.00

	Estimate	Std. Error	t value	Pr(> t)
h	0.15	0.03	4.31	0.01
i	0.54	0.04	15.15	0.00
l	0.28	0.10	2.79	0.03

The approximated and simulation resulting functions almost overlap (see next Figure).

Fig. D.27. Sensitivity analysis for $k_b = k_f = 0.5$.

Notes: The plot displays the change in Gini coefficient of income following the monetary shock. The range of parameter values is reported in Table D.5.

Table D.5

Values of parameters in the baseline, sensitivity and scenario analysis.

Description	Symbol	Value	Scenario	Sensitivity
Montecarlo replications	MC	50	-	-
Time sample	T	800	-	-
Number of firms in the capital-good sector	F_k	70	-	40:100
Number of firms in the consumption-good sector	F_c	200	-	115:285
Number of households	N_h	5000	-	4000:6000
Number of potential partners on C and K goods markets	e_f	10	-	5:15
Intensity of choice in K and C markets	ϵ	0.9	-	-
Firms markup	ϕ_c	0.3	0.3:0.5	-
Target degree of capacity utilization	u_n	0.8	-	-
Capital-to-output ratio	v^*	0.4	-	0.2:0.6
Labor intensity in the capital sector	l_k	0.5	-	0.3:0.7
Labor intensity in the consumption sector	l_c	1.5	-	1:2
Capital-good lifetime	z	30	-	25:35
Desired inventories-to-sales ratio	σ^T	0.05	-	0.025:0.075
Expectation parameter	β	0.2	-	0.1:0.6
Tax rate	τ	0.2	-	0.1:0.6
Unemployment subsidy rate	ρ	0.6	0.6:0.85	-
Policy rate	r^{CB}	0.02	-	0.01:0.06
Interest on public bonds	r^b	0.04	-	0.03:0.08
Normal-loan markup	χ_l	0.5	-	-
Normal-deposit markup	χ_m	0.1	-	-
Aggregate bond-to-wealth ratio	γ_b^{ex}	0.3	0.1:0.4	-
Aggregate equity-to-wealth ratio	γ_e^{ex}	0.3	0.1:0.4	-
Payback time of loans	z_z	30	-	25:35
Dividends distribution rate	ω	1	-	Adapt.
Desired leverage	ζ^T	0.7	-	0.35:0.9
Share of investments financed by equity emission	σ	0.3	-	Adapt.
Initial public expenditure rate	$\bar{\tau}$	0.1	0.1	0.1
Propensity to consume out-of-income	c_1	0.7	0.5:0.9	-
Propensity to consume out-of-wealth	c_2	0.05	-	-
Per-capita working hours	h_m	0.14	-	-
Bank risk aversion	σ_x	3.9	-	3.9:33.9
Collateral depreciation	α_x	0.2	-	-

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