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Does the financial accelerator accelerate inequalities?

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Does the financial accelerator accelerate inequalities?[*]

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Abstract

This study examines the redistribution effects of a conventional monetary policy shock among households in the presence of production-side financial frictions. A Heterogeneous Agents New Keynesian model featuring a financial accelerator is built after empirical evidence for consumption inequality. The results show that the presence of financial frictions significantly increases the magnitude of the Gini coefficient of wealth and other wealth inequality measures after contractionary monetary policy, compared to a scenario in which such frictions are inactive, proving that firms' financial characteristics affect household wealth inequality. Consumption dynamics are also affected: financial frictions have a significant impact on how households consume and save after a monetary contraction, because they rely differently on labor income to smooth consumption. The relative increase in consumption inequality confirms the empirical results obtained in this study.

Keywords: heterogeneous agents, financial frictions, monetary policy, New Keynesian models, inequalities, proxy-SVAR.

JEL codes: C32, E12, E21, E44, E52, G51

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1 Introduction

Macroeconomists, in particular those interested in theoretical models, did not raise much concern about the redistribution effects of monetary policy until recently. However, over the last decade, there has been an increasing interest in this topic for several reasons. The Great Recession has intensified the rise in wealth inequality that has been ongoing since the 1980s,[1] reaching a point where ignoring it could lead to missing important aspects of monetary transmission mechanisms. As a consequence, policymakers have expressed serious concerns about this issue (e.g. Bernanke, 2015).

The increasing power of computer processors and the development of new numerical techniques have made it possible to solve models featuring agent heterogeneity in a relatively short time. In the past, such models were highly time-consuming or simply impossible to solve. Fueled by these premises and building on frameworks developed by Huggett (1993), Aiyagari (1994) and Krusell and Smith (1998), a new strand of Heterogeneous Agents New Keynesian (HANK) models took off in recent years, trying to assess the effects of aggregate shocks of different types on household wealth distribution and how the shape of this distribution could affect the propagation of such shocks.[2]

While the literature on the impact of monetary policy on inequality has blossomed in the last decade, very little has been said about the role of financial frictions in this regard, especially when these frictions affect the production side of the economy. Standard New Keynesian models aimed at studying monetary policy usually ignore the production sector's financial structure, in light of the Modigliani and Miller (1958) theorem of capital structure irrelevance. However, several recent findings indicate that firms' financial structure plays a significant role in the business cycle. For instance, Jordà et al. (2017) use a historical macro-financial database covering 17 advanced economies over the last 150 years to show that the leverage level of the economy has become an important factor in explaining business cycle moments, making the role of financial variables crucial in understanding aggregate economic dynamics. Adrian et al. (2019) study US data to find that negative GDP growth is positively correlated with a deterioration in financial conditions. Caldara and Herbst (2019) employ a structural vector autoregressive model and discover that large effects of monetary policy shocks in the US during the Great Moderation period are explained by a strong systematic response of monetary policy to financial conditions. Gilchrist and Zakrajšek (2012) focus their research on the relationship between corporate bond credit spreads and economic activity, building the "GZ credit spread", a reliable measure of the strength of financial frictions concerning the non-financial corporate sector in the US, and finding a correlation with substantial contractions in economic

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[1] See Piketty (2017) for a review of the history of inequality, especially in advanced economies.

[2] For instance, Ahn et al. (2017) point out that the composition of micro-data incorporated in a Dynamic Stochastic General Equilibrium (DSGE) model could have significant effects on macro-aggregate fluctuations, and vice versa.

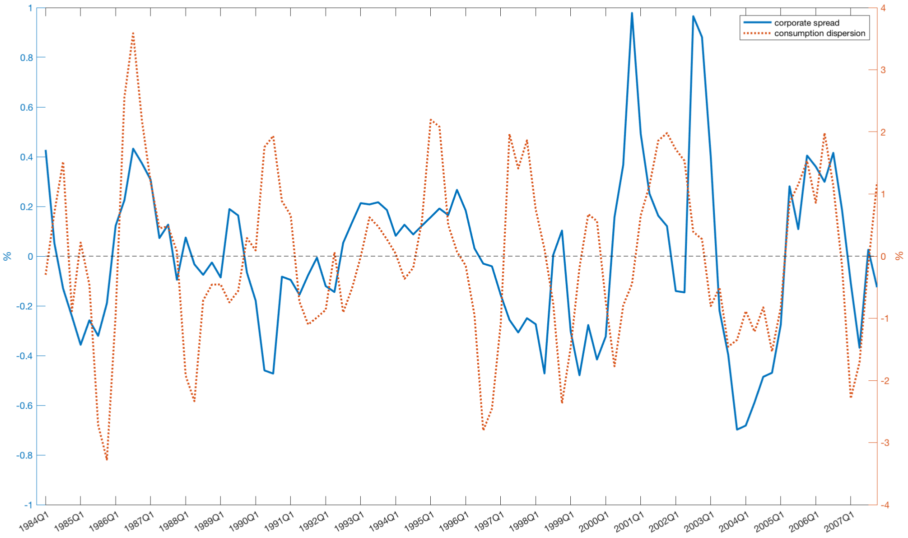

Figure 1: Corporate spread and consumption dispersion

The blue solid line shows the evolution of the GZ spread over time. The red dotted line displays the ratio of consumption at the 50th percentile to that at the 10th percentile of the consumption distribution. Both series have been detrended with a 8th-degree polynomial trend. The 50/10 ratio has also been logged, de-sesonalized with a quarterly dummy and smoothed with a centered three-quarter moving average.

Source: Gilchrist and Zakrajšek (2012) for the GZ spread. U.S. Bureau of Labor Statistics for consumption data.

activity. In terms of theoretical contribution, the so-called "financial accelerator" was first introduced by Bernanke et al. (1996), and is based on a mechanism that amplifies initial shocks due to changes in financial conditions for non-financial companies.

However, the dynamics related to the effects of corporate financial frictions on monetary transmission to household wealth and consumption distributions have not been fully addressed, either theoretically or empirically. The rise of inequality, either at wealth or consumption level, has been one of the main topics of discussion in the last years in the US and in most advanced economies. To this extent, findings of a notable role of the financial accelerator in this process could be helpful understand such a complex phenomenon. The aim of this study is to fill this gap by providing empirical evidence and a theoretical framework to understand the underlying dynamics.

To grasp intuition on a possible positive correlation between financial frictions and inequality measures in the data, let us consider Figure 1, which shows detrended series for the GZ spread and for a measure of consumption inequality, the ratio of the 50th percentile to that at the 10th percentile of the consumption distribution.[3] The reference period is the so-called "Great Moderation", from the mid-1980s until 2007. These two measures appear to have a certain correlation, since consumption inequality responds with a lag to fluctuations in the spread until the beginning of the new millennium. After the burst of the Dot Com bubble, these co-movements appear to be even more contemporaneous.

From a theoretical point of view, the intuition comes from the influential paper by

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[3] See Appendix A for details about the 50/10 consumption ratio.

Kaplan et al. (2018). One of their main findings is that, when households are heterogeneous, most of the monetary policy transmission on households' consumption does not pass through direct effects (e.g., intertemporal substitution), but rather through indirect effects, such as labor dynamics, fiscal policy, and changes in asset prices.[4] More specifically, in their baseline model, labor income fluctuations are the most important component, accounting for more than half of the percentage change in aggregate consumption, leaving a marginal role for direct effects. Considering this result, I expect the presence of financial frictions in the production sector to be highly significant for wealth and consumption distribution shifts after a change in monetary policy, due to the existence of a share of households with zero or little wealth who rely mostly on their labor income for saving and consumption smoothing. Simultaneously, households with a high level of liquidity should also be affected, likely with the opposite effect.

My empirical contribution consists of a Structural Vector Auto-Regressive (SVAR) model with exogenous identification, including a monetary policy shock, financial frictions, and consumption inequality measures, along with other macroeconomic variables. The purpose of this exercise is twofold. First, it determines how these variables behave in the data after monetary policy innovation. Second, and most importantly, it assesses whether financial frictions have a significant influence on the pass-through of monetary policy to household consumption dispersion. In addition, I estimate the relationship between financial frictions and corporate firms' leverage level, defined as the value of firms' capital over equity, which is crucial for the financial accelerator mechanism used in the theoretical model. The results indicate a contraction of the economy, a strengthening of financial frictions, and an increase in consumption inequality. Financial frictions appear to be a statistically significant cause of an increase in consumption dispersion after the central bank increases the interest rate. Finally, monetary shocks generate a co-movement between financial frictions and leverage, consistent with the theoretical literature.

For the theoretical contribution, a HANK model capable of explaining the empirical findings is built. This model features asset market incompleteness, idiosyncratic income risk, sticky prices, and a *financial accelerator* on the production side, as in Bernanke et al. (1999). The "acceleration" effect arises due to friction in the way entrepreneurs obtain funds for the production of goods. Since an asymmetric information problem is introduced between lenders (financial intermediaries) and borrowers (entrepreneurs), lenders must pay auditing costs to check the actual production and to verify whether borrowers can repay their debt. This implies the existence of an "external finance premium", which is defined as the difference between the cost of funds raised externally (debt) and the

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[4] Table 1 in Kaplan et al. (2018) displays how in standard Representative Agent New Keynesian (RANK) models, direct effects account for almost 100% of the monetary transmission. This percentage could drop up to 50% in a Two Agents New Keynesian (TANK) model, indicating that heterogeneity among households actually matters. Nonetheless, in TANK models, direct effects are still the most important.

opportunity cost of funds internal to the firm (net worth or equity).[5] This premium is linked to entrepreneurs' leverage: the more exposed the entrepreneurs, the higher the premium. Whereas lenders are risk-averse and borrowers are risk-neutral, audit costs are ultimately rebated to entrepreneurs themselves. Therefore, a contraction of economic activity that causes an increase in entrepreneurs' leverage will, in turn, result in higher auditing costs and a higher external finance premium. Entrepreneurs' net worth suffers a further depression due to these higher costs. Ceteris paribus, with lower equity to be used for production, entrepreneurs have to resort to more external funding, increasing their leverage and, consequently, incurring in a higher external finance premium, generating the financial acceleration in the economy. In short, higher leverage increases the cost of external funding, and vice versa, higher cost of external funding negatively affects entrepreneurs' net worth, increasing their leverage. Including this mechanism in a model with household heterogeneity helps to assess the impact of this acceleration on wealth and consumption distribution.

The main finding is that the financial accelerator is also an accelerator of inequalities. The monetary contraction leads to a higher level of the Gini index for wealth and consumption when there are active financial frictions. This phenomenon occurs because households respond differently in terms of saving and consumption behaviors along their wealth distributions. Households experiencing the highest shifts are those closer to the borrowing constraint, which is in line with recent findings in the HANK literature, which aim to break the permanent income hypothesis. These agents are largely (if not fully) dependent on their current income for consumption, and they are unable to smooth it due to the lack of savings.[6] The further decline in production due to the financial accelerator has a significant impact on labor and wages and therefore has a greater impact on households relying more on labor income than on income from profits or savings. On the other hand, rich households benefit from the interest rate rise, accumulate more wealth and increase their consumption. Because the financial accelerator enhances these movements at the two tails of the distribution, the model generates even greater global inequality of wealth and consumption under active financial frictions.

My research lies in the rapidly growing literature on household heterogeneity within a New Keynesian framework. TANK models constitute a parsimonious yet powerful way to introduce household heterogeneity, with interesting results in monetary and fiscal policy evaluations (e.g., Galí et al., 2007; Bilbiie, 2008). Moreover, Debortoli and Galí (2017) showed how TANK models can reasonably approximate the predictions of a HANK model regarding the effects of an aggregate shock on aggregate variables. Nevertheless, they also point out that TANK models are not suitable for addressing other questions, such as the change in households' wealth distribution. Therefore, in such cases, we must

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[5] Throughout the paper, net worth and equity are intended as synonym.

[6] As I explain in Section 3, I assume that households cannot borrow resources to smooth consumption.

resort to fully-fledged HANK models (e.g., Kaplan et al., 2018; Bayer et al., 2019; Auclert et al., 2021; Luetticke, 2021). Aside from the incredible contribution provided in creating algorithms that allow working with enormous amounts of grid points and, hence, with a great variety of households, a common goal is usually to match empirical micro data as accurately as possible. Differently, the aim of this study is to use a simpler model, taking advantage of such methodologies, to study the dynamics generated from the peculiar structure of the production sector in the economy.

My contribution is, obviously, also related to the financial frictions literature, in particular to the branch studying the financial accelerator generated by the existence of an "External Finance Premium" for firms (e.g., Carlstrom and Fuerst, 1997; Bernanke et al., 1999; Christiano et al., 2014; Carlstrom et al., 2016). In their seminal paper, Bernanke et al. (1999) articulate why the Modigliani and Miller (1958) assumption of financial structure irrelevance for real economic outcomes could be too limiting in certain cases, especially when frictions in financial markets are not small. The two main justifications the authors provide are that (i) even relatively small changes in entrepreneurial wealth could deliver important cyclical fluctuations (a line of thinking that goes back to Fisher, 1933) and (ii) empirical studies have appointed growing importance to credit market frictions, thereby increasing the need to fill the gap present in the theoretical literature at the time. My idea is to verify whether this acceleration mechanism takes place and has significant results also on inequality measures, a path that could not be explored by Bernanke et al. (1999) because they assumed a representative household in their model. Adding heterogeneity among households allows to understand not only how shocks affect the aggregate variables of the business cycle, but also the implications at idiosyncratic levels.

To the best of my knowledge, to date, only a few studies consider financial frictions in a HANK environment, such as Guerrieri and Lorenzoni (2017), Nakajima and Ríos-Rull (2019) and Fernández-Villaverde et al. (2023). Nonetheless, none of these studies seem to focus on the consequences of inequality arising from conventional monetary policy. The paper by Lee et al. (2020) is probably the closest to my research. However, the substantial difference with my study is in the type of friction in place and, hence, in the dynamics that are meant to be comprehended. They build on the works of Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) to analyze the effects of frictions on banks' balance sheets, the presence of which directly affects households' chances to borrow resources from financial intermediaries (higher borrowing rates) and, consequently, to smooth consumption. On the other hand, my study focuses more on *direct* frictions on production firms that have *indirect* effects on households, mainly through changes in labor income. Since a consistent share of households relies entirely (or for a good part) only on labor income for their consumption, it becomes important to study how inequalities are shaped not only when the banking sector is not running smoothly, but also when firms' financing becomes more costly because of their financial structure.

In addition, I contribute to expanding the empirical literature concerning the effects of monetary shocks in the economy, accounting for financial frictions. Gertler and Karadi (2015) use shocks identified using high-frequency surprises around policy announcements as external instruments to obtain a consistent impulse response for corporate credit spreads. Caldara and Herbst (2019) employ a similar methodology to prove that a strong systematic response of monetary policy to financial conditions is crucial to account for the large effects of monetary policy during the Great Moderation. Although Coibion et al. (2017) show that contractionary monetary policy has an increasing effect on consumption dispersion measures, to the best of my knowledge, no study has investigated whether financial frictions on non-financial firms enhance monetary transmission to consumption inequality dynamics.[7]

The remainder of this chapter is organized as follows. Section 2 describe the empirical analysis conducted and its results. Section 3 outlines the model. Section 4 explains the calibration strategy. Section 5 displays quantitative results. Section 6 gives summary conclusions.

2 Empirical analysis

This section provides empirical evidence of the effects of a contractionary monetary policy shock on household consumption dispersion, taking into account corporate financial frictions. While I study two different types of inequalities (wealth and consumption) in the HANK model, conducting an empirical wealth analysis is less feasible. The Survey of Consumer Finances, the most reliable source of household wealth statistics in the United States, is a triennial survey. Therefore, I consider only consumption inequality in this analysis, given that time series of household consumption in the US can be found with quarterly frequency.

2.1 Methodology and data

To this end, a Structural Vector Auto-Regression with external instrument identification (i.e., a proxy-SVAR) is employed. As pointed out by Gertler and Karadi (2015), adopting the classic Cholesky identification in a SVAR that includes both financial and real variables could generate results inconsistent with economic theory. The proxy-SVAR presented in this section contains both types of variables. I choose the 3-Month Treasury Bill rate (TB3MS) as the policy rate.[8] Exogenous monetary policy surprises are identi-

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[7] Lee et al. (2020) provide also empirical evidence for their model. However, as already explained, they focus on consumer credit spreads and not corporate spreads.

[8] Using other variables, such as the federal funds effective rate (FEDFUNDS) or the one-year government bond rate (GS1), does not significantly change the SVAR results.

fied as in Romer and Romer (2004). The effects of increasing interest rate on financial frictions, output, occupation, and consumption dispersion are then evaluated. I use the Excess Bond Premium (EBP) built by Gilchrist and Zakrajšek (2012) as a proxy for the magnitude of financial frictions in the corporate non-financial sector. I then use the natural logarithm of industrial production (INDPRO) and the percentage level of unemployment (UNRATE) as measures of industrial output and employment, a choice in line with Caldara and Herbst (2019). To evaluate consumption dispersion, I use two measures commonly employed in the literature: the ratio between the 50th and 10th percentiles of consumption distribution and the Gini index. Data on consumption dispersion are constructed using the Consumer Expenditure Survey (CEX), a database built by the US Bureau of Labor Statistics;[9] more information about the CEX database are provided in Appendix A. Romer and Romer (2004) innovations are collected by the series updated by Coibion et al. (2017). All other data, except the EBP, are obtained from the St. Louis FRED.

I choose to use quarterly data for the period 1984Q1–2007Q4. Two main reasons dictate this choice. First, in the theoretical model displayed in the next section, one period represents a quarter and the model is calibrated on the Great Moderation time-span, since the focus is on conventional monetary policy. Second, the CEX has been collected continuously since 1984 and on a quarterly basis. In addition, it would be difficult to carry out an analysis well beyond 2007, since the quarterly EBP series developed by Gilchrist and Zakrajšek (2012) covers the period up to 2010Q3.

2.2 Empirical results

Impulse response functions (IRFs) for the proxy-SVAR are shown in Figure 2.[10] I display results for two SVARs where the consumption dispersion measure is the only endogenous variable changing: 50/10 consumption ratio in the left column and the Gini index in the right column. As suggested by the Bayesian Information Criterion (BIC), the SVARs are estimated using two lags of each endogenous variable.[11] I show the mean values, 68%, and 90% confidence intervals after 2000 bootstraps.[12]

These results appear to be consistent with the existing literature. Values for F-statistics in first-stage regressions suggest a good instrument validity, according to the

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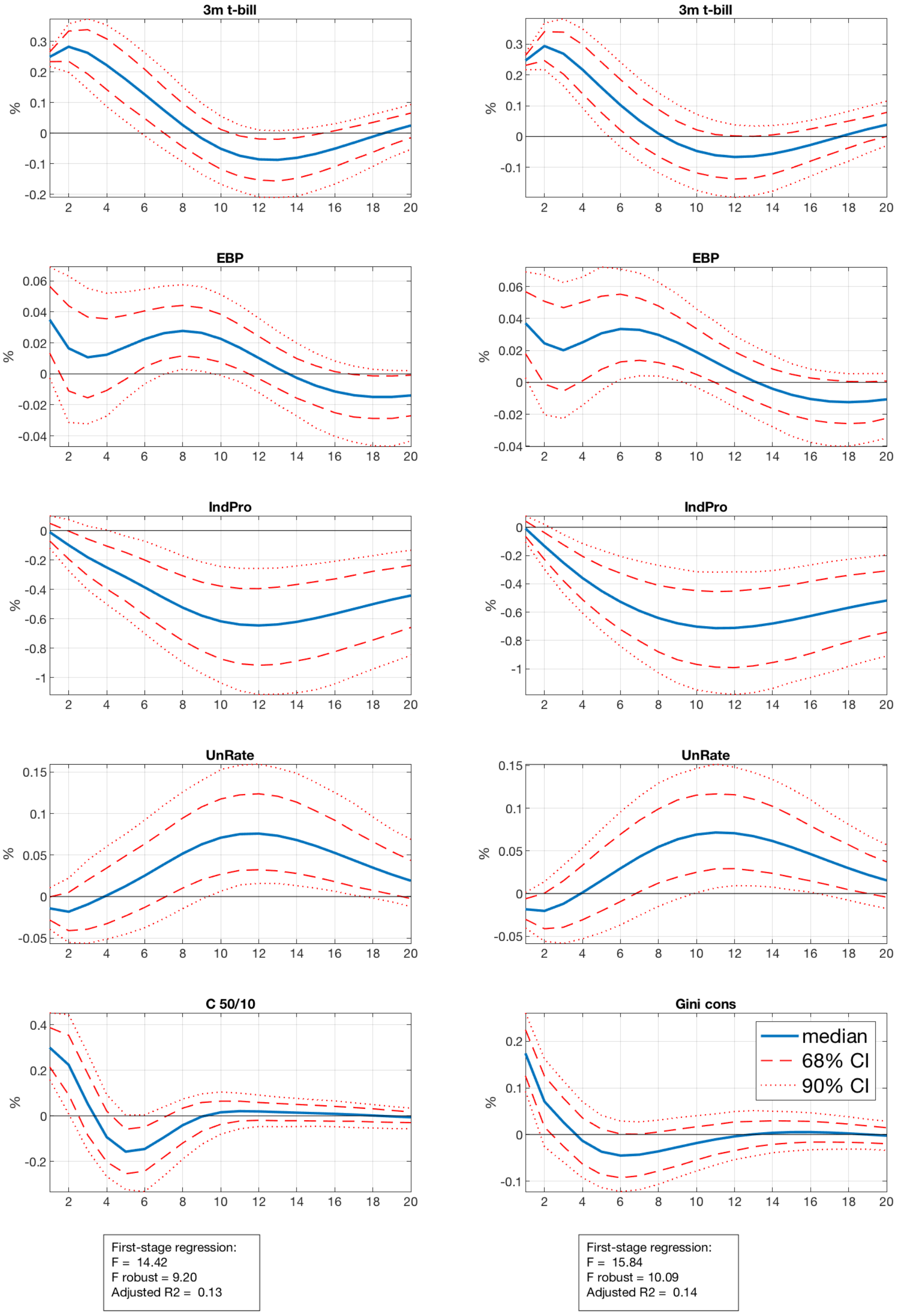
[9] `https://www.bls.gov/cex/`

[10] To obtain IRFs, I employ the VAR toolbox for Matlab developed by Ambrogio Cesa-Bianchi (`https://sites.google.com/site/ambropo/MatlabCodes`)

[11] Given the short sample employed in this SVAR (96 observations for each variable), the BIC seems to be the right criterion to consider because it places a higher weight on the sample size. On the other hand, the Akaike Information Criterion (AIC) suggests higher lag values, which would result in statistically insignificant IRFs. In fact, running the same SVAR with up to four lags does not substantially change the shape of the IRFs, but it generally increases the width of the confidence intervals.

[12] Following Gertler and Karadi (2015) and Mertens and Ravn (2013), I use wild bootstrap, which generates valid confidence intervals under heteroscedasticity and strong instrument assumptions.



First-stage regression:
F = 14.42
F robust = 9.20
Adjusted R2 = 0.13

First-stage regression:
F = 15.84
F robust = 10.09
Adjusted R2 = 0.14

Figure 2: Impulse responses to monetary policy shock

Estimated responses to a standard deviation shock of monetary policy using an external instrument for shock identification. Bootstrapped median and confidence intervals are obtained after 2000 wild bootstrap.

threshold recommended by Stock et al. (2002) when only one instrument is employed. As in Gertler and Karadi (2015), a one standard deviation surprise monetary tightening induces a rise in the interest rate of approximately 0.25% and significantly increases the EBP, thus strengthening financial frictions. I also find a contraction in economic activity that is very similar to that shown in Caldara and Herbst (2019). Even though the two studies present substantial differences,[13] fluctuations in unemployment and industrial production are very similar both in magnitude and shape. Finally, an increase in the interest rate by the central bank enlarges consumption dispersion among households, a result in line with findings by Coibion et al. (2017). It should be noted that in the case of the 50/10 consumption ratio, the IRF undershoots after one year. However, it is never negatively significant at the 90% confidence interval. The Gini index for household consumption displays a similar behavior, although negative values are never statistically significant, not even for the 68% confidence interval.

These outcomes show how the theoretical model should behave, at least qualitatively, after the central bank increases the interest rate. However, they do not say much about how financial frictions affect consumption inequality. I employ two different methodologies to clarify this aspect. First, a two-variable SVAR with Cholesky identification is used, where the second variable, consumption dispersion, is assumed to have no contemporaneous effects on the first variable, EBP, using two lags of each endogenous variable.[14] This exercise does not consider the monetary policy contraction, but it aims to assess whether higher financial frictions have a significant effect on consumption inequality in the data, regardless of what causes an increase in the EBP. Again, in Figure 3, I consider two SVARs, one for the 50/10 consumption ratio and one for the Gini index, showing mean values and confidence intervals after 2000 bootstraps. The results show a positive relationship between an increase in financial frictions and a rise in consumption inequality, although it is less statistically significant when we consider the 50/10 consumption ratio. However, both consumption inequality measures have mostly positive mean values with a hump-shaped response. This latter feature is consistent with the descriptive statistics in Figure 1, where consumption dispersion seems to have a lagged response to corporate spread fluctuations.

Second, I resort again to the proxy-SVAR employed above, but I now "shut off" the effects of the EBP on other variables. To do so, I follow the methodology proposed by Lettau et al. (2002).[15] Let us consider the structural form of the VAR in Figure 2:

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[13] Caldara and Herbst (2019) adopt a Bayesian VAR, whereas I employ a frequentist VAR. In addition, the exogenous instrument and the policy rate are also different in their baseline model.

[14] For these two SVARs, according to the inequality measure considered, the BIC suggests a different number of lags: In the case of the 50/10 ratio, the BIC still recommends the use of two lags, whereas in the case of the Gini index, it recommends six lags. However, adopting a higher lag value does not qualitatively change the results.

[15] An approach following a similar logic, although different in the application, can be found in Mumtaz and Theodoridis (2020)

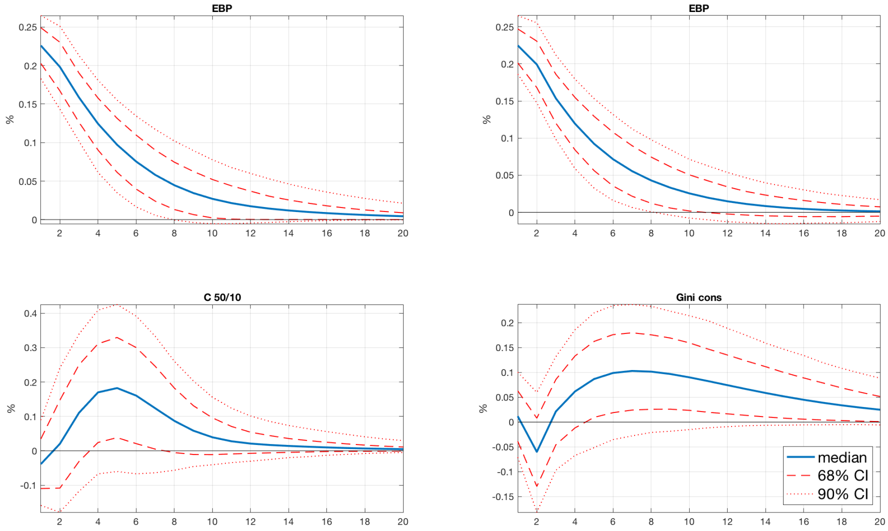

Figure 3: Impulse responses to a EBP shock

Estimated responses to a standard deviation shock of EPB using Cholesky identification. Bootstrapped median and confidence intervals are obtained after 2000 residual bootstrap.

$$B_0 x_t = a + B_1 x_{t-1} + B_2 x_{t-2} + w_t, \tag{1}$$

where x_t is the vector of endogenous variables, a is the deterministic trend containing a constant, w_t is the vector of mutually uncorrelated structural shocks, and B_i with $i = 0, ..., 2$ are matrices of structural model coefficients. To shut off the EBP effect on other variables, I set to zero the second column in B_1 and B_2 (since the EBP is ordered second in the vector of variables), except for the second element in the column. Thus, I cancel the effect that lagged values of EBP have on all endogenous variables except EBP itself. In Figure 4 I show consumption dispersion IRFs for (1) in the unrestricted (blue solid line) and counterfactual (green line with asterisks) models, that is, when the effects of EBP on other endogenous variables are present or shut off, respectively. I also show the confidence interval for the unrestricted scenario, computed after 2000 wild bootstraps. In the unrestricted model, consumption inequality is consistently higher for most of the initial five years, indicating that the EBP tends to increase the dispersion of consumption. At certain intervals, the counterfactual scenario shows lower levels of consumption inequality than the baseline scenario's 68% confidence interval. Interestingly, this pattern seems to have a more pronounced effect on the Gini index compared to the 50/10 consumption ratio, despite their relatively similar trends.

2.3 Financial frictions and leverage

Leverage plays a fundamental role in the financial accelerator dynamic, as discussed in the next section. According to the mechanism developed by Bernanke et al. (1999), financial

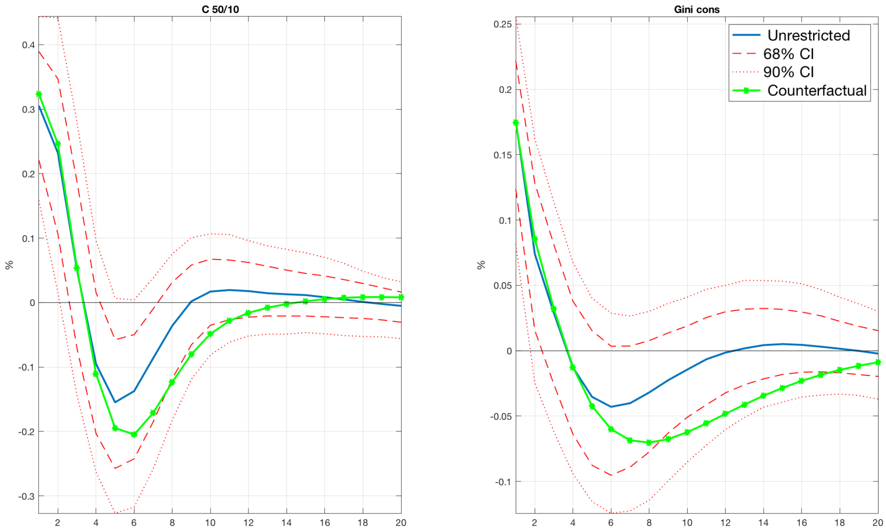

Figure 4: Impulse response of consumption dispersion to a monetary shock
Estimated responses to a standard deviation shock of monetary policy using an external instrument for shock identification. The counterfactual response is obtained after "shutting off" the financial friction channel.

frictions and leverage are strongly related, with one component positively affecting the other and vice versa. From an empirical point of view, the two variables should experience co-movement after a shock to the economy. To determine if this is also the case in the data, I employ a smaller proxy-SVAR, using the same monetary external instrument and featuring only three endogenous variables: the 3-Month Treasury Bill rate, the EBP, and the natural logarithm of non-financial corporate leverage. In the theoretical model, leverage is defined as firms' capital over equity. To be consistent with this definition, I compute the non-financial corporate leverage as the ratio of total assets of nonfinancial corporate business (TABSNNCB) to equity, which in turn is calculated as the difference between total assets and total liabilities (TLBSNNCB).[16] As before, I show the mean values, 68% and 90% confidence intervals after 2000 bootstraps, with two lags for each endogenous variable. The results are displayed in Figure 5. EBP and leverage have relatively similar responses in shape, but with some differences: the leverage response appears to be a little stronger at its peak and generally more persistent. However, both responses show a statistically significant hump-shaped increase, pointing to an empirical validity of the co-movement needed for the financial accelerator framework.

In the next section, I build a HANK model featuring financial frictions on productive firms to explain most of these empirical results and make estimates of changes in the wealth distribution.

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[16] Data for non-financial corporate assets and liabilities are obtained from the St. Louis FRED.

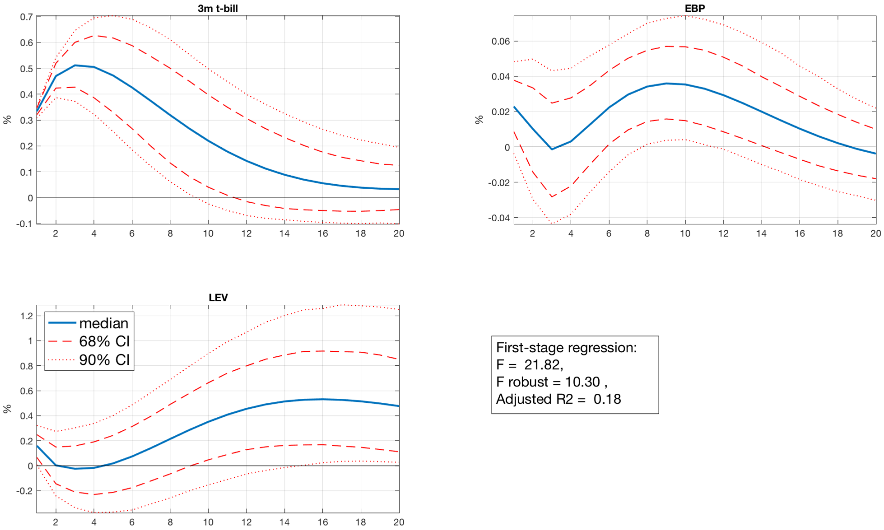

Figure 5: Impulse responses to monetary policy shock
Estimated responses to a standard deviation shock of monetary policy using an external instrument for shock identification. Bootstrapped median and confidence intervals are obtained after 2000 wild bootstrap.

3 The model

The theoretical model comprises households, financial intermediaries, a production sector, a central bank, and the government. Households consume, earn income (either from labor or profit, depending on the household type), and save in a liquid asset, which yields an interest rate. Financial intermediaries obtain deposits from households and lend them to the production sector, which, in turn, is responsible for the production of goods and capital. The central bank is in charge of monetary policy and sets the nominal interest rate, whereas the government acts as fiscal authority and chooses how to finance government spending. Time is discrete and infinite. The behavior of each agent is explained in detail below.[17]

3.1 Households

There is a continuum of ex ante identical households of measure one indexed by $i \in [0, 1]$. They are infinitely lived, have time-separable preferences with time-discount factor β and their utility function u is affected positively by consumption, c_{it}, and negatively by labor, l_{it}, with $l_{it} \in [0, 1]$ being hours worked as a fraction of the time endowment, normalized to 1. The utility function u is strictly increasing and strictly concave in consumption and strictly decreasing and strictly convex in labor. Household i value function is the following:

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[17] The model structure follows closely the 1-asset HANK version proposed in Luetticke (2021), with the exception of the introduction of financial frictions.

$$V = E_0 \max_{\{c_{it}, l_{it}\}} \sum_{t=0}^{\infty} \beta^t u(c_{it}, l_{it}) \ , \tag{2}$$

where I assume households have separable preferences with a Constant Relative Risk Aversion (CRRA) form:

$$u(c, l) = \frac{c^{1-\xi}}{1-\xi} - \psi \frac{l^{1+1/\nu}}{1+1/\nu} \ . \tag{3}$$

There are two types of household: workers and rentiers. Workers supply labor, l_{it}, in the production sector and have positive idiosyncratic labor productivity, $h_{it} > 0$. Because the global wage level, W_t, is the same for everyone, their income is given by $W_t h_{it} l_{it}$. Rentiers have zero labor productivity, $h_{it} = 0$, but collect a proportional share of total profits generated from the production sector, Π_t. Idiosyncratic labor productivity h_{it} follows an exogenous Markov chain according to the following first-order autoregressive process and a fixed probability of transition between the worker and the rentier state:

$$h_{it} = \begin{cases} exp(\rho_h log(h_{it-1}) + \epsilon_{it}^h) & \text{with probability } 1-\zeta \text{ if } h_{it-1} \neq 0 \\ h_t^H & \text{with probability } \iota \text{ if } h_{it-1} = 0 \\ 0 & \text{else} \end{cases} \tag{4}$$

where $\epsilon_{it}^h \sim N(0, \sigma_h)$ and h_t^H is the highest possible productivity realization for workers. The parameter $\zeta \in (0,1)$ is the probability that a worker becomes a rentier, while $\iota \in (0,1)$ is the probability that a rentier becomes a worker. As stated above, workers who become rentiers leave the labor market ($h_{it} = 0$), whereas rentiers that become workers are endowed with productivity h_t^H.[18] Workers and rentiers pay the same level of taxation, τ, on their income.

The asset market is incomplete: there are no Arrow-Debreu state-contingent securities, households self-insure themselves only through savings in a non-state contingent risk-free liquid asset, a_{it}, and they cannot get indebted on that, that is, an *ad hoc* borrowing constraint exists ($a_{it} \geq 0$). Thus, households cannot borrow from financial intermediaries to smooth their consumption. The household's budget constraint is:

$$c_{it} + a_{it+1} = \left(\frac{R_t}{\pi_t}\right) a_{it} + (1-\tau)(W_t h_{it} l_{it} + \mathbf{I}_{h_{it}=0} \Pi_t) \ , \tag{5}$$

where $\mathbf{I}_{h_{it}=0}$ takes the value of 1 if the household is a rentier and 0 otherwise. On the right-hand side, we have households' expenditure, that is, consumption, c_{it} and 1-year-maturity savings, a_{it+1}. The left-hand side corresponds to households' total earnings: work/rent income net of taxes, $(1-\tau)(W_t h_{it} l_{it} + \mathbf{I}_{h_{it}=0} \Pi_t)$, and the gross real interest rate on previous savings, $(R_t/\pi_t) a_{it}$, where π_t is the gross inflation rate.

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[18] Appendix B contains details on the transition matrix for household productivity.

Liquid assets held by households are a mix of deposits, D_t, and government bonds, B_t, so that we have the following relation:

$$A_t = D_t + B_t \ , \tag{6}$$

where $A_t = \int a_{it} di$. Deposits and bonds are perfect substitutes, which means that they carry the same real interest rate, $\frac{R_t}{\pi_t}$, and that households are indifferent to the composition of A_t.[19]

3.2 Financial intermediaries

Financial intermediaries collect deposits from households and promise returns equal to the real risk-free interest rate, R/π, where π is the inflation level in the economy. For ease of display, I assume that the production sector is run by entrepreneurs, who are a mass-zero group of managers who are entitled to all the profits generated in the production sector and rebate them to rentier households. Financial intermediaries and entrepreneurs are responsible for the financial frictions considered in this model. Following Bernanke et al. (1999), I assume a continuum of entrepreneurs, indexed by j. Entrepreneur j acquires capital, K_j, from capital producers at the end of period t that is used at time $t+1$. To buy capital for production, entrepreneurs rely on two type of financing: internal financing, that is, equity, N_j, and external financing, D_j.

Entrepreneur j balance sheet at period $t+1$ is:

$$q_t K_{jt+1} = N_{jt+1} + D_{jt+1} \ , \tag{7}$$

where q is the price of capital at the time of the purchase.

One prerequisite for the functioning of this financial accelerator is that entrepreneurs are not indifferent to the composition of their balance sheet; that is, external financing is more expensive than internal financing. To introduce this feature, a Costly State Verification (CSV) problem à la Townsend (1979) exists, in which lenders (i.e., financial intermediaries) must pay a fixed auditing cost to observe the realized returns of borrowers (i.e., entrepreneurs). A relatively higher demand for debt increases auditing costs, resulting in a lower level of aggregate capital obtained for production.

Entrepreneurs repay investment banks with a portion of their realized returns on capital. In this framework, entrepreneurs are risk-neutral, while households are risk-averse. This implies a loan contract in which entrepreneurs absorb any aggregate risk on the realization of their profits. I also assume the existence of an idiosyncratic shock to entrepreneur j, ω_j,[20] on the gross return on aggregate capital, R^K. The idiosyncratic

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[19] I assume that each household has the same portfolio composition of liquid assets, which is equal to their aggregate level.

[20] As noted by Christiano et al. (2014), ω could be thought of as the idiosyncratic risk in actual

shock ω has a log normal distribution of mean $E(\omega) = 1$ that is i.i.d. across time and across entrepreneurs, with a continuous and once differentiable c.d.f., $F(\omega)$.[21]

The optimal contract for financial intermediaries is:

$$\bar{\omega}_{jt+1} R^K_{t+1} q_t K_{jt+1} = Z_{jt+1} D_{jt+1} \ , \tag{8}$$

where Z_j is the gross non-default loan rate and $\bar{\omega}_j$ is the threshold value for entrepreneur j such that, for $\omega_{jt+1} \geq \bar{\omega}_{jt+1}$, entrepreneur j repays $Z_{jt+1}D_{jt+1}$ to financial intermediaries and retains $\omega_{jt+1} R^K_{t+1} q_t K_{jt+1} - Z_{jt+1} D_{jt+1}$. In the case of $\omega_{jt+1} < \bar{\omega}_{jt+1}$, instead, she cannot repay and defaults on her debt, obtaining nothing. Since entrepreneurs' future realizations of capital returns are only known by entrepreneurs ex-post, financial intermediaries must pay a fixed auditing cost, μ, to recover what is left of entrepreneur j's activity after default, obtaining $(1-\mu)\omega_{jt+1} R^K_{t+1} q_t K_{jt+1}$.

Because of the optimal contract, financial intermediaries should receive an expected return equal to the opportunity cost of their funds. By assumption, they hold a perfectly safe portfolio (i.e., they are able to perfectly diversify the idiosyncratic risk involved in lending), and the opportunity cost for financial intermediaries is the real gross risk-free rate, R/π. It follows that the participation constraint for financial intermediaries that must be satisfied in each period $t+1$ is:

$$[1 - F(\bar{\omega}_{jt+1})] Z_{jt+1} D_{jt+1} + (1-\mu) \int_0^{\bar{\omega}_{jt+1}} \omega_j dF(\omega_j) R^K_{t+1} q_t K_{jt+1} \geq \frac{R_{t+1}}{\pi_{t+1}} D_{jt+1} \ , \tag{9}$$

where $F(\bar{\omega}^F_j)$ is entrepreneur j default probability. Since financial markets are in perfect competition, (9) must hold with equality. The first term on the left-hand side of (9) represents the revenues received by financial intermediaries from the fraction of entrepreneurs that do not default, whereas the second term is what financial intermediaries can collect from defaulting entrepreneurs after paying monitoring costs.

Following the notation proposed in Christiano et al. (2014), I combine (7), (8), and (9) to write the following relationship:

$$EFP_{jt+1} = f\left(\bar{\omega}_{jt+1}, LEV_{jt+1}\right) \ , \ \text{with} \ f'(LEV_{jt+1}) > 0 \ . \tag{10}$$

where EFP is the "External Finance Premium" that Bernanke et al. (1999) define as the ratio between the return on capital and the real risk-free rate, $R^K / (R/\pi)$, and $LEV = qK/N$ is entrepreneur's leverage. The EFP can be considered a measure of the cost of external funds for the entrepreneur and, therefore, as a proxy for the strength of financial

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business ventures: in the hands of some entrepreneurs, a given amount of raw capital is a great success, while in other cases may be not.

[21] Appendix C.1 provides analytical expressions for $F(\omega)$ and other functions used in the following equations.

frictions. The $(\bar{\omega}_{jt+1}, LEV_{jt+1})$ combinations that satisfy (10) define a menu of state $(t+1)$-contingent standard debt contracts offered to entrepreneur j, who chooses the contract that maximizes its objective.

In Appendix C.2, I illustrate the entrepreneur j's optimization problem, which provides three important outcomes. First, the EFP increases monotonically with LEV. This means that entrepreneurs with a higher level of leverage pay a higher EFP. Second, the threshold value for entrepreneur j's default, $\bar{\omega}_j$, is endogenously defined by the EFP. Third, the fact that $\bar{\omega}_j$ depends only on the aggregate variables (R,R^K and π) implies that every entrepreneur will choose the same firm structure, that is, $\bar{\omega}$ and LEV. Therefore, it is possible to drop the superscript j in the notation and consider a representative entrepreneur.

The other fundamental equation for the functioning of this financial accelerator is the law of motion for entrepreneurs' equity, which is expressed as follows:

$$N_{t+1} = \gamma \left[q_{t-1} R_t^K K_t - \frac{R_t}{\pi_t} D_t - \mu G(\bar{\omega}_t) q_{t-1} R_t^K K_t \right] . \tag{11}$$

Equation (11) states that entrepreneurs' equity after the production process at time t is equal to the gross return on capital net of the loan repayment and auditing costs (which are borne by entrepreneurs because they are risk-neutral). Parameter γ represents the share of surviving entrepreneurs who bring their equity to the production process from one period to the next. Conversely, the share of entrepreneurs $1-\gamma$ dies and consumes equity at time t (we can think of this as entrepreneurial consumption). As explained by Carlstrom et al. (2016), this assumption avoids excessive entrepreneurs' self-financing in the long run.

Note that in (11) I did not included entrepreneurial labor, as usual in the literature (e.g., Bernanke et al., 1999, Christiano et al., 2014). The assumption of entrepreneurial labor was introduced mainly to justify the initial amount of equity for new entrepreneurs that take the place of the dead ones. However, to keep the model as simple as possible, I follow Carlstrom et al. (2016), assuming that new entrepreneurs' initial equity comes from a lump-sum transfer from existing entrepreneurs. Even so, since the funding can be arbitrarily small and since only aggregate equity matters, this transfer can be neglected in equation (11).[22]

Alternatively, (11) can be written in a more compact form as:

$$N_{t+1} = \gamma \left[1 - \Gamma(\bar{\omega}_t)\right] R_t^K q_{t-1} K_t \ , \tag{12}$$

where $[1 - \Gamma(\bar{\omega}_t)]$ is the share of capital returns to which non-defaulting entrepreneurs

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[22] Bernanke et al. (1999) keep the share of income going to entrepreneurial labor at a very low level (on the order of 0.01), therefore neglecting this income sounds as a reasonable model simplification.

are entitled.[23] Equation (12), together with (10), explains the financial accelerator mechanism. Equation (10) states that an increase in entrepreneurs' leverage increases also the EFP. At the same time, (12) tells that an increase in the EFP increases $\bar{\omega}$ as well, negatively affecting entrepreneurs' equity level for the next period and, therefore, impacting the aggregate leverage.

3.3 Intermediate-goods producers

Intermediate-goods producers adopt a standard Cobb-Douglas production function with constant returns to scale, employing aggregate capital, K, supplied by entrepreneurs and labor, L, from workers:

$$Y_t = z_t L_t^{\alpha} K_t^{1-\alpha} \ , \tag{13}$$

where z represents the Total Factor Productivity (TFP).

TFP follows a first-order autoregressive process of type:

$$log(z_t) = \rho_z log(z_{t-1}) + \epsilon_t^z \ , \tag{14}$$

with ϵ_t^z following a normal distribution with mean 0 and variance σ^z.

Intermediate-good producers sell their production to resellers at a relative price MC_t. Therefore, their profit optimization is given by:

$$\Pi_t^{IG} = MC_t z_t L_t^{\alpha} K_t^{1-\alpha} - W_t L_t - r_t^K K_t \ . \tag{15}$$

Since they are in perfect competition, their profit optimization problem returns the wage paid per unit of labor and the rent paid per unit of capital:

$$W_t = \alpha MC_t z_t \left(\frac{K_t}{L_t}\right)^{(1-\alpha)} \ , \tag{16}$$

$$r_t^K = (1-\alpha)\, MC_t z_t \left(\frac{L_t}{K_t}\right)^{\alpha} \ . \tag{17}$$

3.4 Resellers

Resellers are agents assigned to differentiate intermediate goods and set prices. Following Bayer et al. (2019), I assume that price adjustment costs follow a Rotemberg (1982) setup and that resellers are directly run by entrepreneurs, preserving their characteristics.[24] The

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[23] See Appendix C.2

[24] Bayer et al. (2019) make the further assumption that price setting is delegated to a mass-zero group of households (managers) that are risk neutral and compensated by a share in profits. Since in my model the whole production sector is run by entrepreneurs that, by assumption, are risk neutral and entitled to all the profits generated in this sector, I do no need to make this further assumption.

demand for the differentiated good g is:

$$y_{gt} = \left(\frac{p_{gt}}{P_t}\right)^{-\eta} Y_t \ , \tag{18}$$

where $\eta > 1$ is the elasticity of substitution and p_g is the price at which good g is purchased.

Given (18) and the quadratic costs of price adjustment, resellers maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t Y_t \left\{ \left(\frac{p_{gt}}{P_t} - MC_t\right) \left(\frac{p_{gt}}{P_t}\right)^{-\eta} - \frac{\eta}{2\kappa} \left(log \frac{p_{gt}}{p_{gt-1}} \right)^2 \right\} \ , \tag{19}$$

with a time-constant discount factor.[25]

The New Keynesian Phillips Curve (NKPC) derived from the F.O.C. for price setting is as follows:

$$log(\pi_t) = \beta E_t \left[log(\pi_{t+1}) \frac{Y_{t+1}}{Y_t} \right] + \kappa \left(MC_t - \frac{\eta - 1}{\eta} \right) \ , \tag{20}$$

where π_t is defined as $\frac{P_t}{P_{t-1}}$.

3.5 Capital producers

After production at time t, entrepreneurs sell depreciated capital to capital producers at a price q_t. They refurbish depreciated capital at no cost,[26] and uses goods as investment inputs, I_t, to produce new capital, $\Delta K_{t+1} = K_{t+1} - K_t$, subject to quadratic adjustment costs. Finally, they resell the newly produced capital to entrepreneurs before entering the next period (therefore still at price q_t).

The law of motion for capital producers is:

$$I_t = \Delta K_{t+1} + \frac{\phi}{2} \left(\frac{\Delta K_{t+1}}{K_t} \right)^2 K_t + \delta K_t \ . \tag{21}$$

where δ is the depreciation rate for capital.

Then, capital producers maximize their profit, $q_t \Delta K_{t+1} - I_t$, w.r.t. newly produced capital, ΔK_{t+1}. This optimization problem delivers the optimal capital price:

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[25] As explained by Bayer et al. (2019), only the steady state value of the discount factor matters in the resellers' problem, due to the fact that I calibrate to a zero inflation steady state, the same value for the discount factor of managers and households and approximate the aggregate dynamics linearly. This assumption simplifies the notation, since fluctuations in stochastic discount factors are virtually irrelevant.

[26] The "no cost" assumption does not mean that δK is refurbished for free. Capital producers still need to buy the exact amount of I necessary to refurbish depreciated capital, but do not waste any further resources in this process. In fact, the law of motion for capital producers in the steady state (when $\Delta K = 0$) is $I = \delta K$.

$$q_t = 1 + \phi \frac{\Delta K_{t+1}}{K_t} \ . \tag{22}$$

This ensures that if the level of aggregate capital increases over time, so does its price.

It follows that entrepreneurs' return on capital does not depend only on goods production, but also on fluctuations of the capital price. Since entrepreneurs buy capital at the end of the period, they see that their capital at the beginning of the next period appreciated (depreciated) if q increases (decreases). The gross return on capital employed at time t can be written as:

$$R_t^K q_{t-1} K_t = r_t^K K_t + q_t K_t (1-\delta) \ , \tag{23}$$

where the first term on the right-hand side is the marginal productivity of capital derived in (17) and the second term represents the eventual capital gain (or loss) net of capital depreciation.

I can rearrange and finally derive the gross interest rate of capital as:

$$R_t^K = \frac{r_t^K + q_t(1-\delta)}{q_{t-1}} \ . \tag{24}$$

3.5.1 Final-goods producers

Final-goods producers are perfectly competitive, buy differentiated goods from resellers at a given price, and produce a single homogeneous final good used for consumption, government spending, and investment. The optimization problem of final-goods producers is:

$$\max_{\{Y_t, y_{gt} \in [0,1]\}} P_t Y_t - \int_0^1 p_{gt} y_{gt} dg \ , \tag{25}$$

subject to the following Constant Elasticity of Substitution (CES) function:

$$Y_t = \left(\int_0^1 (y_{gt})^{\left(\frac{\eta-1}{\eta}\right)} dg \right)^{\left(\frac{\eta}{\eta-1}\right)} \ . \tag{26}$$

From the zero-profit condition, the price index of the final good is:

$$P_t = \left(\int_0^1 (p_{gt})^{(1-\eta)} \right)^{\left(\frac{1}{1-\eta}\right)} \ . \tag{27}$$

3.6 Central bank

The central bank is responsible for the monetary policy. It sets the gross nominal risk-free interest rate, R, reacting to the deviation from steady state inflation, and engages interest rate smoothing. The Taylor-type rule employed by the central bank is as follows:

$$\frac{R_{t+1}}{\bar{R}} = \left(\frac{R_t}{\bar{R}}\right)^{\rho_R} \left(\frac{\pi_t}{\bar{\pi}}\right)^{(1-\rho_R)\rho_\pi} \epsilon_t^R \ , \tag{28}$$

where ϵ_t^R is the monetary policy shock defined as $log(\epsilon_t^R) \sim N(0, \sigma_R)$. The parameter $\rho_R \geq 0$ rules interest rate smoothing (if $\rho_R = 0$, the next-period interest rate depends only on inflation), whereas ρ_π captures the magnitude of the central bank's response to inflation fluctuations: the larger ρ_π, the stronger the central bank reaction (for the case limit $\rho_\pi \to \infty$, inflation is perfectly stabilized at its steady state level).

3.7 Government

The government acts as fiscal authority. It determines the level of public expenditure, G_t, tax revenues, T_t and issuance of new bonds, B_{t+1}. Its budget constraint is given by:

$$B_{t+1} = \left(\frac{R_t}{\pi_t}\right) B_t + G_t - T_t \ , \tag{29}$$

where T_t are taxes collected from both worker and rentier households:

$$T_t = \tau \left[\int W_t h_{it} l_{it} d\Theta_t(a, h) + \mathbf{I}_{h_{it}=0} \Pi_t \right] \ , \tag{30}$$

and $\Theta_t(a, h)$ is the joint distribution of liquid assets and productivity across households on date t.

Government bond issuance is regulated by the following rule:

$$\frac{B_{t+1}}{\bar{B}} = \left(\frac{B_t \frac{R_t}{\pi_t}}{\bar{B} \frac{\bar{R}}{\bar{\pi}}}\right)^{\rho_B} \ . \tag{31}$$

The parameter ρ_B captures how fast the government wants to balance its budget. When $\rho_B \to 0$, the government balances its budget by adjusting its spending. Instead, when $\rho_B \to 1$, the government is willing to roll over most of its outstanding debt.

3.8 Market clearing

The labor market clears when:

$$\int h \ l^*(a, h) \Theta_t(a, h) da dh = L_t \ , \tag{32}$$

where $l^*(a, h)$ is the optimal labor supply policy function of the household.

The liquid asset market clears when:

$$\int a^*(a, h) \Theta_t(a, h) da dh = A_t \ , \tag{33}$$

where $a^*(a, h)$ is the optimal saving policy function of the household.

The market for capital clears for (21) and (22).

Finally, good market clearing, which holds by Walras' law when other markets clear, is defined as:

$$Y_t = C_t + G_t + I_t + C_t^E + \mu G(\bar{\omega}_t) R_t^K q_{t-1} K_t \,, \tag{34}$$

where on the left-hand side we have total output. On the right-hand side, apart from household consumption, public expenditure and investments, we also find entrepreneurial consumption, C^E (due to dying entrepreneurs), and auditing costs.[27]

3.9 Numerical implementation

To solve the model, I follow the solution proposed in Bayer et al. (2019) and Luetticke (2021). As the joint distribution, Θ_t, is an infinite-dimensional object (and therefore not computable), it is discretized and represented by its histogram, a finite-dimensional object. I solve the household's policy function using the Endogenous Grid-point Method (EGM) developed by Carroll (2006), iterating over the first-order condition and approximating the idiosyncratic productivity process using a discrete Markov chain with three states using the Tauchen (1986) method. The log grid for liquid assets comprises of 100 points. I solve for aggregate dynamics by first-order perturbation around the steady state, as in Reiter (2009). The joint distribution is represented by a bi-dimensional matrix (capital K does not display heterogeneity) with a total of 300 grid points, maintaining a sufficiently low computational time.

4 Calibration

The model is calibrated on the US economy, and because the focus is on conventional monetary policy, business cycle moments are targeted on the Great Moderation (i.e., 1983-2007). Periods in the model represent quarters; consequently, the following values for the calibrated parameters are intended quarterly unless otherwise specified. Table 1 provides a list of calibrated parameters for the model, whereas Table 2 shows the model's effectiveness in replicating wealth distribution and business cycle moments.

4.1 Households

For the households' utility function, I assume the coefficient of relative risk aversion $\xi = 2$, which is consistent with the findings of Attanasio and Weber (1995) and already used by Auclert et al. (2021). I set the Frisch elasticity of labor supply $\nu = 1$, in line

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[27] Similarly to Kaplan et al. (2018), we can think of this last term as "financial services".

Table 1: Calibrated parameters

Parameter	Value	Description
β	0.987	Discount factor
ξ	2	Relative risk aversion
ν	1	Frisch elasticity of labor
ψ	5.5	Disutility of labor
$\underline{a}$	0	Borrowing constraint
ι	0.0625	Prob. of leaving entr. state
ζ	0.0005	Prob. become rentier
ρ_h	0.98	Persistence of idio. prod. shock
σ_h	0.06	SD if idio. prod. shock
α	0.7	Labor share of production
δ	0.2	Depreciation rate
η	20	Elasticity of substitution
κ	0.09	Price stickiness
ϕ	5	Adjustment cost of capital
μ	0.12	Auditing costs
σ_ω	0.27	SD of the id. shock on entr.
γ	0.985	Entr. surviving rate
ρ_z	0.95	TFP shock persistence
σ_z	0.00915	TFP shock SD
R	1.0063	Nominal int. rate
ρ^R	0.8	Int. rate smoothing
ρ^π	1.5	Reaction to inflation
σ_R	0.0025	Monetary shock SD
τ	0.3	tax rate
ρ_B	0.86	Auto-correlation of debt

Table 2: Wealth distribution and business cycle moments

Wealth distribution moments

Target	Model	Target
Gini wealth	0.78	0.78
top 10% wealth	0.71	0.67
zero-wealth HHs	0.16	0.20∼0.30

Business cycle moments

Target	Model	Target
SD of Y (%)	1.38	1.38
σ^I/σ^Y	4.5	4.5
SD of C (%)	0.47	0.98
Corr. of Y with Y	1	1
Corr. of I with Y	0.99	0.92
Corr. of C with Y	0.95	0.92

Real GDP, investment and consumption are in logs. All data for business cycle moment analysis are processed with a H-P filter with $\lambda = 1600$. The calibrated moments for wealth distribution is the Gini index for wealth. For business cycle moments, SD of Y and SD of I after a TFP shock.

with the results of Chetty et al. (2011). The parameter for the disutility of labor, ψ, is set to 5.5, to have an average value for hours worked equal to 1/2, as in Kaplan et al. (2018). The intertemporal discount factor, β, is equal to 0.987, so savings in deposits by households are sufficient to have a leverage for entrepreneurs of 2, the same value used by Bernanke et al. (1999) in their model, and a fair calibration given historical levels of corporate leverage. I decide on purpose to impose a non-borrowing condition for households, setting the borrowing limit for liquidity $\underline{a} = 0$, to highlight the transmission mechanism of monetary policy through financial frictions on the production sector rather than on the lending sector.[28]

The calibration of the productivity transition matrix, which determines how households move between the worker and rentier states, aims to provide a distribution of wealth consistent with empirical data. As in Luetticke (2021), I assume that the probability of becoming a rentier is the same for workers independent of their labor productivity, and once they become workers again, they start with the highest productivity realization. The probability of leaving the rentier state is $\iota = 0.0625$, following the findings of Guvenen et al. (2014) on the probability of dropping out of the top 1% income group in the US. The probability of moving from the worker to the rentier state is $\zeta = 0.0005$, a value calibrated to obtain a Gini coefficient for wealth of 78%, in line with empirical data from the Survey of Consumer Finances (Luetticke, 2021), implying a share of rentier households of approximately 0,8%. Regarding idiosyncratic income risk for labor productivity, I set autocorrelation $\rho_h = 0.98$ and standard deviation $\sigma_h = 0.06$, as estimated by Bayer et al. (2019).

4.1.1 Financial Intermediaries

The parameters concerning financial frictions on firms are in the ballpark of Bernanke et al. (1999) calibrations; therefore, the auditing cost is $\mu = 0.12$ and the standard deviation of the idiosyncratic shock on the entrepreneur's returns is $\sigma_\omega = 0.27$, which are calibrated to have $EFP = 1.005$ (and, therefore, a credit spread of 2% p.a.) when the corporate leverage is 2. The share of surviving entrepreneurs, γ, is calibrated such that, at steady state, the equity level in (12) is equal to the equity implied by (10).

4.1.2 Production Sector

The labor share of production (accounting for profits) and capital depreciation rate follow standard values in the literature and are set respectively to $\alpha = 0.7$ and $\delta = 2\%$. The mark-up is also standard, at 5%, which implies elasticity of substitution between goods

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[28] The lack of a negative ad hoc borrowing constraint denies a further instrument of parameterization, since in the literature this feature is often used to target the share of HtM or borrowing households. Nonetheless, the share of zero-wealth households generated by the model is still significant, approximately 16%.

varieties $\eta = 20$. The price stickiness parameter in the NKPC, $\kappa = 0.09$, is calibrated to generate a slope of the curve similar to the one that would arise in a model with sticky prices à la Calvo, with an average price duration of four quarters. The adjustment cost of the capital parameter is calibrated to $\phi = 5$ to match investment-to-output volatility $\sigma(I)/\sigma(Y) = 4.5$ after a TFP shock, in line with empirical data for the US elaborated by Bayer et al. (2019), in the model where the financial accelerator is in place. The persistence of the TFP shock is $\rho_z = 0.95$, while the standard deviation $\sigma_z = 0.00915$ is calibrated to match the standard deviation of the US output (after HP filtering) in the targeted time period.

4.2 Central Bank and Government

Inflation at the steady state is set to 0% per annum, and the nominal (therefore real) interest rate on bonds is 2.5%, a value in line with the real average federal funds rate for the Great Moderation period. I impose the same interest rate on all types of liquid savings (i.e., government bonds and deposits); otherwise, households would choose to invest only in one asset or the other. Regarding the Taylor rule adopted by the Central Bank, the parameter for interest rate smoothing is $\rho_R = 0.8$, according to the findings of Clarida et al. (2000), whereas the reaction to inflation fluctuations from the steady state is $\rho_\pi = 1.5$, which is a common value in the macroeconomic literature. For the magnitude of the monetary policy shock, I assume that the central bank raises the nominal interest rate by 25 b.p., a common value in the literature and consistent with the empirical results in Section 2.

The taxes set by the government are proportional to both labor income and profits, with a tax rate $\tau = 0.3$ that targets the ratio of government spending to GDP to a standard value in the New Keynesian literature, $G/Y = 20\%$. Since I am using a fiscal policy rule similar to the one adopted by Bayer et al. (2019), I also follow their estimation and set $\rho_B = 0.86$. This implies that the fiscal dynamic passes through government debt, with public spending adjusting to re-stabilize debt to its steady state level.

5 Results

To begin with, the fluctuations in aggregate variables are shown. This helps to assess the consistency of the results with respect to the findings of Bernanke et al. (1999). Subsequently, I examine the inequalities in the model, which are at the core of this research.

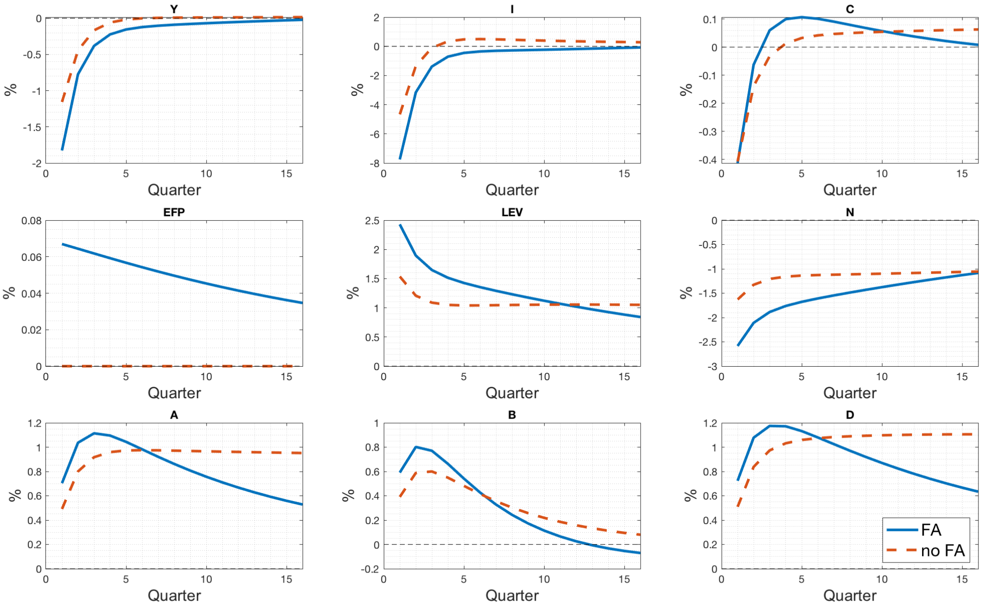

Figure 6: Impulse response to a monetary contraction for aggregate variables

Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off.

5.1 Aggregate fluctuations

During the first period, the economy experiences an unexpected increase in the nominal interest rate (one-time innovation). Figure 6 compares the response of several aggregate variables to this shock when financial frictions are active (blue solid line) or not (red dashed line), i.e., when the EFP can fluctuate or is fixed to its steady state value.

The effect of the financial accelerator on aggregate variables has also been confirmed for heterogeneous households. Results are fairly similar to Figure 3 in Bernanke et al. (1999), with output and investment responses under financial frictions exhibiting higher magnitude on impact and higher persistence over time,[29] although IRFs in the HANK model converge to the steady state (or even overshoot) more rapidly. Aggregate consumption fluctuations do not significantly differ between the two scenarios on impact, but this result is also consistent with the findings in Bernanke et al. (1999).[30]

To illustrate how the financial accelerator works, the IRFs for the EFP, leverage, firm equity, and household liquidity are also displayed.[31]. An increase in the nominal interest rate depresses economic activity, leading to a lower demand for capital and, consequently, lower investment and capital price. On the other hand, a higher interest rate

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[29] Since in Bernanke et al. (1999) there is a fall in the nominal interest rate, the two dynamics are mirrored.

[30] The authors do not show impulse responses for consumption in their paper. Nonetheless, using replication codes as the one present in the Macroeconomic Model Data Base (`https://www.macromodelbase.com`) allows us to see this dynamic.

[31] More IRFs for aggregate variables are shown in Appendix D

increases household liquidity, particularly liquidity directed to firms in the form of loans through financial intermediaries. As suggested by equation (11) and shown in the central panels of Figure 6, lower levels of capital and capital price and higher levels of firms' debt cause a decline in firms' equity and, therefore, a higher level of leverage.[32] Higher leverage implies higher firm financing costs, i.e., higher EFP, as pointed out by by eq. (10). Simultaneously, the entrepreneur's default threshold value, $\bar{\omega}$, also increases, which negatively affects the firm's equity level in the next period. With lower equity, firms need to resort to more external financing, but since the latter is more expensive as leverage and EFP increase, the level of capital that firms can afford is even lower, which means less investment and less goods production, generating the multiplier effect of the financial accelerator. The countercyclicality of leverage and EFP in the theoretical model is relevant for two reasons. First, it allows the replication of the financial accelerator mechanism developed by Bernanke et al. (1999). Second, it is consistent with the empirical evidence highlighted in Figure 5, in which a monetary contraction is followed by a co-movement of the corporate leverage and a proxy measure of financial frictions.

In addition, a comparison of the leverage and output behavior in the two scenarios (active or passive frictions) deserves a closer look. While output fluctuations are always enhanced by financial frictions for the entire horizon considered, this is not the case for leverage, where the leverage level with active frictions is relatively lower after three years. Although it may seem counter-intuitive, it is a common result in the theoretical literature,[33] and a possible explanation can be found in the power of the friction itself. In the "shut-off" version of the model, external funds are relatively cheaper because the EFP is fixed at its steady state level. Therefore, firms' deleveraging is slower in time, mainly because of the higher debt they contract with financial intermediaries, as shown in Figure 6. Nonetheless, active financial frictions can lead to a higher economic depression in terms of output and investment, even at relatively lower leverage levels in the economy.

5.2 Inequality among households: consumption

To check whether the model is consistent with the empirical findings shown in Section 2, I first analyze how consumption dispersion evolves. Figure 7 displays IRFs for the Gini index of consumption and the ratio of consumption for the median percentile to consumption of the 10th percentile, measures already employed in the empirical analysis. The model replicates two main empirical results: (i) a contractionary monetary policy shock causes a rise in consumption dispersion both in terms of the Gini index and the 50/10 consumption ratio, and (ii) financial frictions increase the effect of monetary policy on consumption inequality.

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[32] Recall that in this model leverage is defined as $\frac{qK}{N}$, or equivalently, $\frac{D+N}{N}$.

[33] A similar dynamic occurs in the original Bernanke et al. (1999) model.

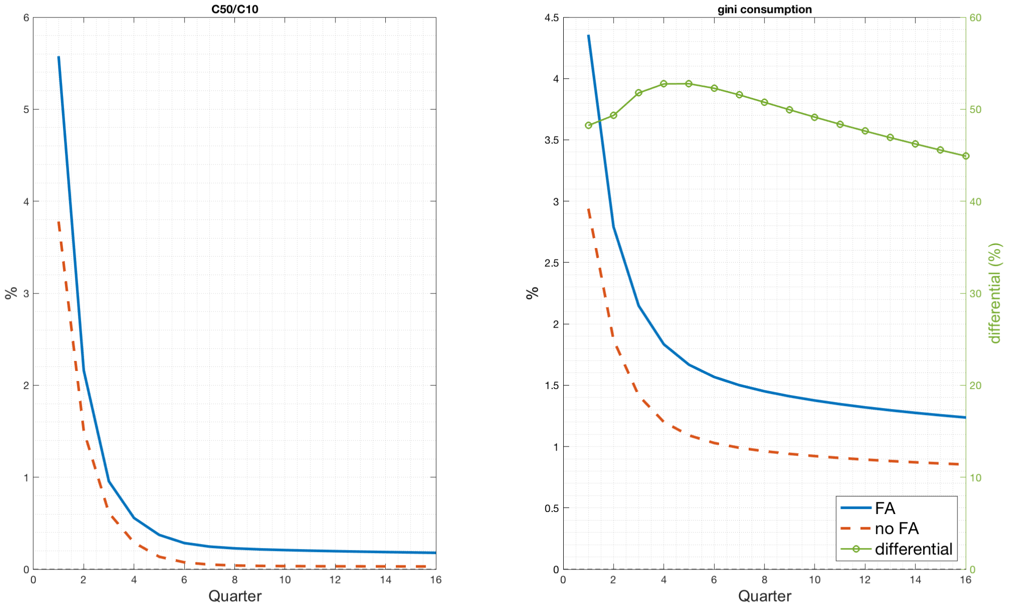

Figure 7: Impulse responses for the 50/10 consumption ratio and Gini index

Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation from red line to the blue line.

The 50/10 consumption ratio rapidly converges to the steady state, but does not exhibit undershooting behavior, as observed in Figure 2. However, the Gini coefficient rapidly decreases during the first year, but then starts to flatten, resulting in a lower but long-term increase in general consumption inequality. Although this outcome seems to be at odds with findings in Section 2, where IRFs for the Gini index rapidly converge to zero, it is a common result in the theoretical literature.[34]

The increasing effect of financial frictions on the magnitude and persistence of the IRFs in Figure 7 is evident. To better understand the effect of the financial accelerator on the Gini index, I plot a green line with circles that account for the percentage variation of the Gini index impulse response from the scenario with a muted financial accelerator to that where frictions are active. Acceleration of consumption inequality is actually hump-shaped and goes downward after one year. Therefore, the two curves representing consumption dispersion with and without financial frictions activity show some convergence in the medium term, even though the reversal to the steady state is much slower.

The Gini index is a powerful tool because it allows us to estimate the total inequality using a single number. However, it does not specify the distribution of the variable at stake (in this case consumption) among agents. Therefore, it is not possible to explain why inequality increases after the monetary contraction and why financial acceleration

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[34] As explained by Luetticke (2021), the persistence of the increase in the Gini index is motivated by a prolonged time of higher wealth inequality, as shown in Section 5.3.

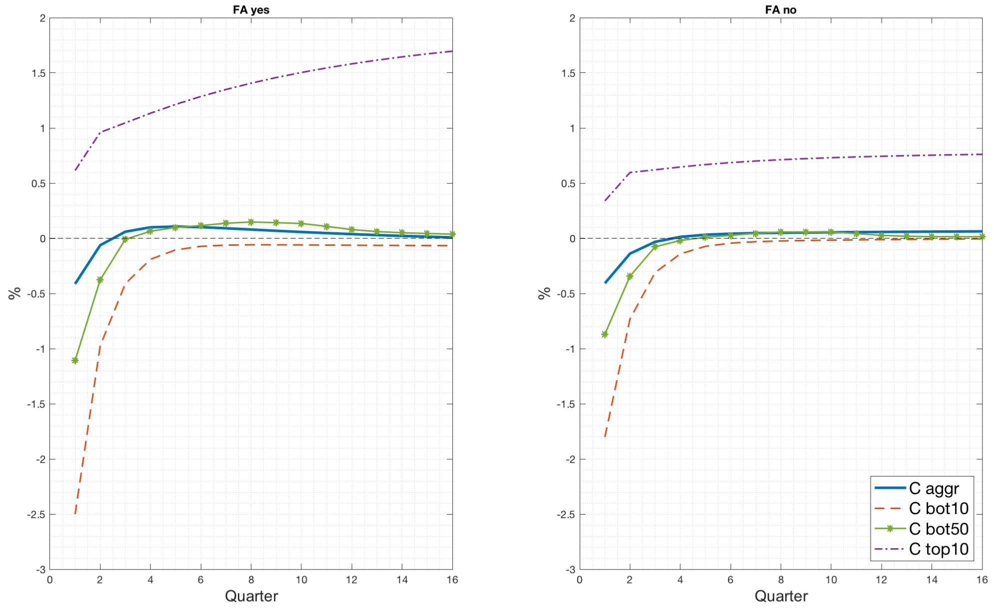

Figure 8: IRFs for consumption, aggregate and averages per wealth share
The blue solid line represents the aggregate consumption. The dashed lines represent the average consumption of a specific share of households.
Monetary shock $\epsilon^R = 0.0025$. On the left is the case with active financial frictions. On the right, financial frictions are shut off.

enhances this process. To clarify these points, in Figure 8, I decompose the aggregate impulse response for consumption to determine how it varies along the distribution. To study consumption behavior among poorer and richer agents, I track fluctuations in average consumption for the bottom 10% and 50%, and for the top 10% of households according to their wealth distribution.[35]

Figure 8 suggests two major considerations. First, monetary contraction results in lower average consumption for poorer households, confirming the literature findings. The average consumption in the bottom 10% of the distribution shows a significant contraction compared to aggregate consumption. As these households are perfectly constrained, the reduction in consumption is solely due to worsening labor conditions. Depression of consumption occurs up to the bottom half of the distribution. In this last case, however, consumption overshoots after around one year, since this share the population also includes households with a certain level of liquidity, who benefit from financial income. On the other hand, the average consumption at the top of the distribution increases steadily when the top 10% of the population is considered. Whereas in this model households can only save liquid assets, an increase in the interest rate would be very beneficial for rich households, who hold a significant amount of liquidity.[36] Even though richer households

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[35] Higher household share values include consumption of lower shares. This means that the average consumption of the bottom 50% also includes consumption of the bottom 10%

[36] A more comprehensive discussion about the implications of considering only liquidity for household savings can be found in Section 5.3.

have a lower marginal propensity to consume, their gains are significant enough to create a substantial increase in average consumption. However, the importance of the marginal propensity to consume can be appreciated by looking at fluctuations in consumption at the lowest decile: on impact, the percentage increase in average consumption at the top 10% is always less than a third of consumption at the bottom 10%, regardless of active or passive financial frictions.

Second, the financial accelerator does not drastically change the behavior of IRFs, but affects their magnitude. Although aggregate consumption is similar in both cases, fluctuations in average consumption per share of wealth increase significantly on impact in case of active financial acceleration. The higher decline in labour and wage levels due to active financial frictions is more significant for poor households, whereas wealthier households benefit from the relative increase in interest rate and profits.[37] This explains why the Gini index for consumption is higher when the financial accelerator is taken into account, even if consumption fluctuations appear similar at aggregate level.

A final remark on consumption inequality concerns the hump-shaped evolution of the percentage difference (green line with circles) between the two Gini coefficients in Figure 7. The average consumption per wealth share shown in Figure 8 helps us understand this behavior. On the left-hand panel, the average consumption fluctuation for the bottom 50% (green line with asterisks) overshoots earlier and stronger when compared with the muted financial accelerator case. In view of the fact that this share includes the bottom 10% (whose average consumption shows a relatively higher and more persistent depression), households around the middle percentile should be responsible for this overshoot. This dynamic is consistent with the fact that a part of households have a significant marginal propensity to consume, but are not wealth-constrained, and thus rely on both labor and financial income. Therefore, higher consumption in the middle of the distribution most likely contributes to pushing down the Gini index, causing a reversal of the trend for the green line with circles in the right panel of Figure 7.

5.3 Inequality among households: wealth

After observing that the results for consumption inequality are consistent with empirical evidence, I analyze how household wealth reacts to a monetary shock. Empirical evidence for these dynamics is more difficult to obtain because of the frequency of available data. Theoretical outcomes are therefore a good instrument for estimating wealth inequality. I begin with the Gini index for the wealth distribution. Figure 9 displays how the Gini index changes from its steady state value, with active or passive financial accelerator.

First, let us focus on the Gini index dynamic for active financial frictions. The impulse response shows a significant and long-lasting increase. It reaches its apex one year after

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[37] As I explain in Section 5.3, most rentiers belong to the top 10%.

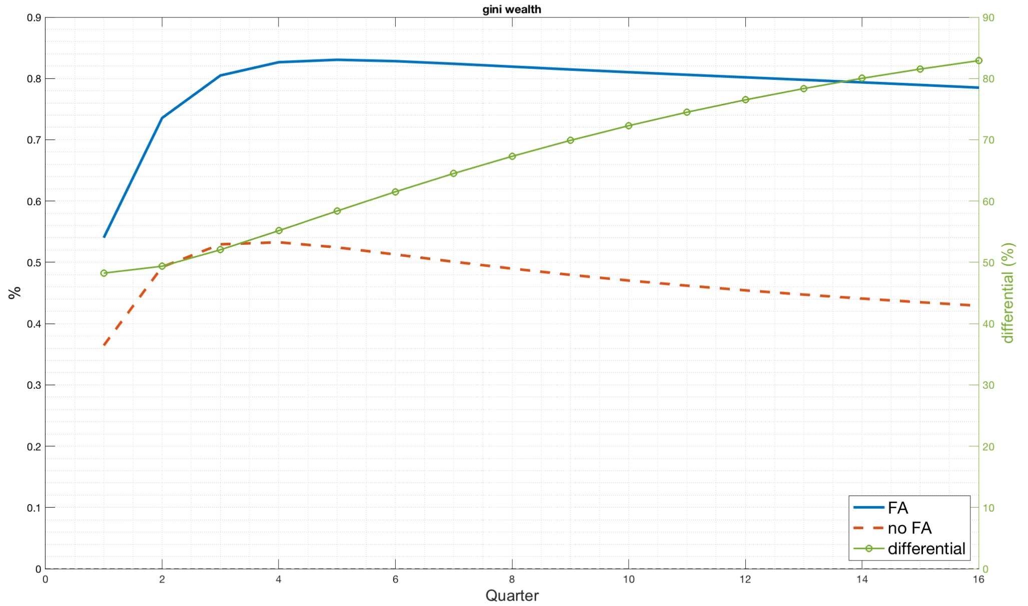

Figure 9: Impulse responses of the Gini index for wealth

Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation between the two IRFs.

the shock and then reverts very slowly. After five years, the increase from the steady state value is still greater than the on-impact value. This long-lasting effect has already been seen in Figure 7 and is shared with household liquidity dynamics. In fact, in this model, the only type of wealth that households can accumulate is liquid, since by construction, they can only save in deposits and government bonds.[38] Contractionary monetary policy has a long-term impact not only on the total amount of wealth in the economy, but also on its distribution.

Also when considering wealth, the financial accelerator is an inequality accelerator. The red dashed line represents the IRFs for the Gini index with silenced frictions, which show significantly lower magnitude and persistence. In order to clarify the difference between the two scenarios, I plot again a green line with circles that account for the percentage variation of the Gini index impulse response from the scenario with a muted financial accelerator to that where frictions are active. On impact, financial friction implies a fluctuation in wealth inequality that is approximately 50% greater. Although both curves (solid and dashed) start reverting to the steady state value after about one year, their rate of reversion is different. The shape of the line with circles shows how this difference actually grows over time, reaching above 80% after four years. Therefore, the

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[38] Although it is not an exercise I undertake in this study, considering multiple assets should not significantly change the shape of the Gini index. For instance, Luetticke (2021) considers a contractionary MP shock in a model where households hold liquid and illiquid assets, and the evolution of the Gini index for wealth (see Figure 1 in its Appendix) is similar to that in Figure 9.

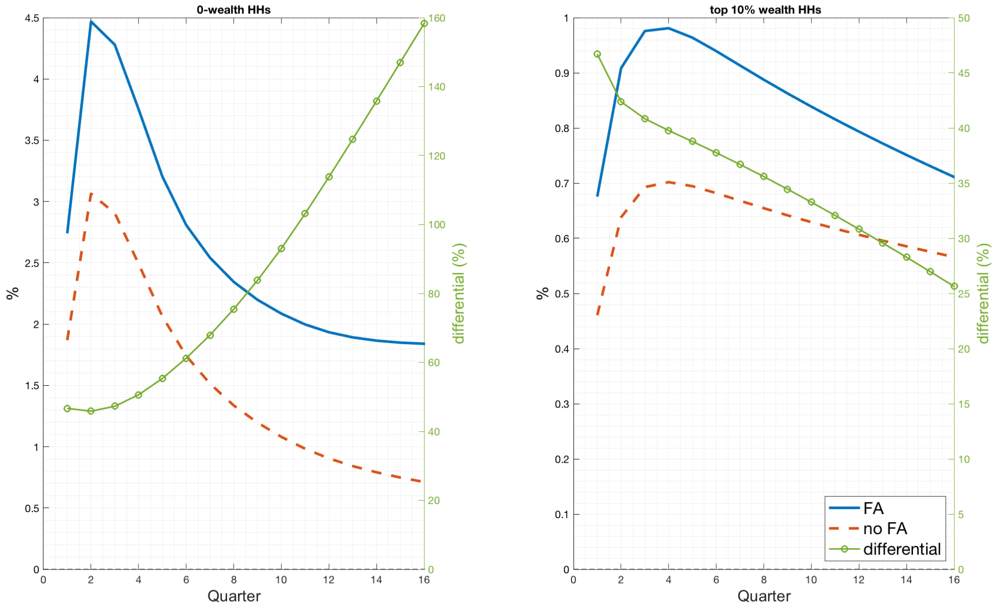

Figure 10: Impulse responses for households' share measures

The graph on the left-hand side represents the fluctuations in the share of households with zero wealth. The one on the right-hand side represents the fluctuations in the share of wealth held by the richer 10%. Monetary shock $\epsilon^R = 0.0025$. The blue line refers to an economy with a financial accelerator. The red line refers to the case where financial frictions are shut off. The green dotted line (with values on the right side of the figure) represent the percentage variation from red line to the blue line.

financial accelerator does not only increase inequality in wealth, but this increase is also constant, at least in the medium term. Interestingly, an increase in the magnitude of the monetary shock affects absolute values (the Gini index increases more with respect to its steady state values in both scenarios), but not relative values; that is, the shape and magnitude of the green line with circles are almost the same. Inequality acceleration has little to do with shock magnitude, but depends mostly on steady state dynamics such as leverage and initial wealth distribution. For instance, Figure E.1 in Appendix E shows how the same aggregate shock applied to a similar model that features higher firm leverage (2.5, instead of 2) generates significantly higher Gini index differentials between the case of active and inactive financial frictions.

As already explained in the previous section, the Gini index cannot say how the our variable of interest is distributed among agents. For wealth analysis, fluctuations of two measures representing behavior at the two tails of the wealth distribution are computed: the share of perfectly constrained households (i.e., with zero wealth) and the share of wealth held by the richest 10% of the population. The results are shown in Figure 10.

Once again, let us first focus only on the scenario with active financial frictions (blue solid line). Similar to the Gini index, the two measures increase with a hump-shaped response. This suggests that (i) there is an increase in the number of poorer households because more households are pushed to the constraint, (ii) rich households are becoming richer, and (iii) the increase in the Gini index is caused by substantial movements on both tails of the wealth distribution. However, the dynamics triggering increasing responses in the two measures considered are completely different.

Constrained households have zero wealth, so an increase in the interest rate has essentially no effect on their financial income. On the other hand, indirect effects highlighted by Kaplan et al. (2018), in particular fluctuations related to labor income, are responsible for the rise in the share of constrained households. The economic depression brought about by contractionary monetary policy reduces the quantity of labor needed in the economy and the wage level (as can be seen in Appendix D) and poor households rely only or mostly on labor income for consumption and saving. Therefore, in addition to households already at the constraint, a share of households that was not perfectly constrained before the aggregate shock is pushed to the very bottom of the distribution.

To analyze what happens at the top of the distribution, it is important to remember that, according to model's assumptions, households can only accumulate wealth in liquid assets. Government bonds and deposits have a fixed price (normalized to one), unlike capital; therefore, they are not affected by price fluctuations. This assumption neglects the fact that, in empirical data, a significant share of rich households' savings comprises illiquid assets, which usually bear a higher interest rate but are subject to price changes. The choice of a single liquid asset for household saving in the model has two main justifications. First, it does not add any further complications to the model structure, keeping it as simple as possible. Second, it provides continuity with the RANK model developed by Bernanke et al. (1999). It follows that IRFs for richer households' wealth could suffer from upward bias because they do not consider the negative effects of capital price fluctuations. However, this should not affect the validity of the results, since empirical evidence shows that rich households react to an increase in the interest rate by increasing the share of liquidity in their portfolio.[39]

Households in the top 10% of the model are therefore highly affected by the direct effects of monetary policy, because they experience a significant increase in financial income and are less affected by labor dynamics. A further push toward wealth accumulation in the top decile comes from an increase in firms' profits. Although the share of rentiers (the only ones collecting profits) is quite small (approximately 0.8% of the total population), the vast majority of them belong to the top 10%.

Similarly to what happens for the Gini index, the financial accelerator increases the magnitude of impulse responses for these two measures of wealth fluctuation. The red dashed lines in Figure 10, in fact, always lie below the blue solid ones over the first four years, and the percentage differential on impact is very similar, between 45% and 50%. The striking difference in the dynamics at the two ends is the medium-term evolution of the differential (i.e., the green line with circles). At the bottom of the distribution,

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[39] Luetticke (2021) shows with empirical estimates that wealthy households react to a contractionary monetary policy increasing their holdings of liquid wealth and portfolio liquidity.

the effect of the financial accelerator continues to increase, whereas at the top 10%, the differential line starts decreasing immediately. Active financial frictions have a negative impact on constrained households as they lead to a further reduction in the quantity of labour and, in particular, a permanent reduction in wages. In Appendix D it can be seen that the financial accelerator further depresses the quantity of labor required for goods production, although it overshoots with respect to the counterfactual scenario after approximately three years. On the other hand, IRFs for the wage level are always lower for active financial frictions and at a very distant horizon. This latter dynamic is therefore probably the main reason for the constant increase in the differential line for constrained household wealth.

To understand why the differential of IRFs for wealth held by the richest 10% converges already in the short–medium term, we should look again at how aggregate household deposits evolve. As already explained above, firm financing is relatively cheaper when financial frictions are shut off. As a result, firms can take up relatively higher amounts of funds from households as the on-impact effects wane. It should also be noted that in this model, the household top decile holds 71% of the total wealth. The vast majority of firms'debt is likely to come from wealthy households' deposits. For this reason, we see a faster reversion to the steady state in the case of active financial frictions when considering fluctuations in the wealth held by the top decile. Fluctuations in the real interest rate obviously play an important role as well. The IRFs in Appendix D show that in the case of active financial frictions, the real interest rate is indeed higher for the first three quarters, but then undershoots with respect to the scenario in which frictions are shut off. This helps to explain why the differential line for the top10% wealth decreases even more rapidly after about one year.

5.4 Inequality between households: skilled-unskilled workers and rentiers

Households in this model are heterogeneous according to their wealth level and their taxed-income source. Consequently, an interesting analysis can be conducted on how inequality is shaped between household types, that is, workers (who collect income through labor) and rentiers(whose income is made of firms' profits). Workers can be further divided into two categories: those with low and high productivity. As already expressed in eq. (5), labor income for workers before taxes is defined as $W_t h_{it} l_{it}$. Since the wage level, W_t, is not idiosyncratic and is equal for everyone, if two workers with different productivity, h_{it}, were to provide the same quantity of labor, l_{it}, the high-productivity worker would obtain a higher salary. Therefore, with an abuse of notation, I sort households into three types: unskilled (low-productivity workers), skilled (high-productivity workers), and rentiers (profit collectors). I show how wealth inequality evolves between

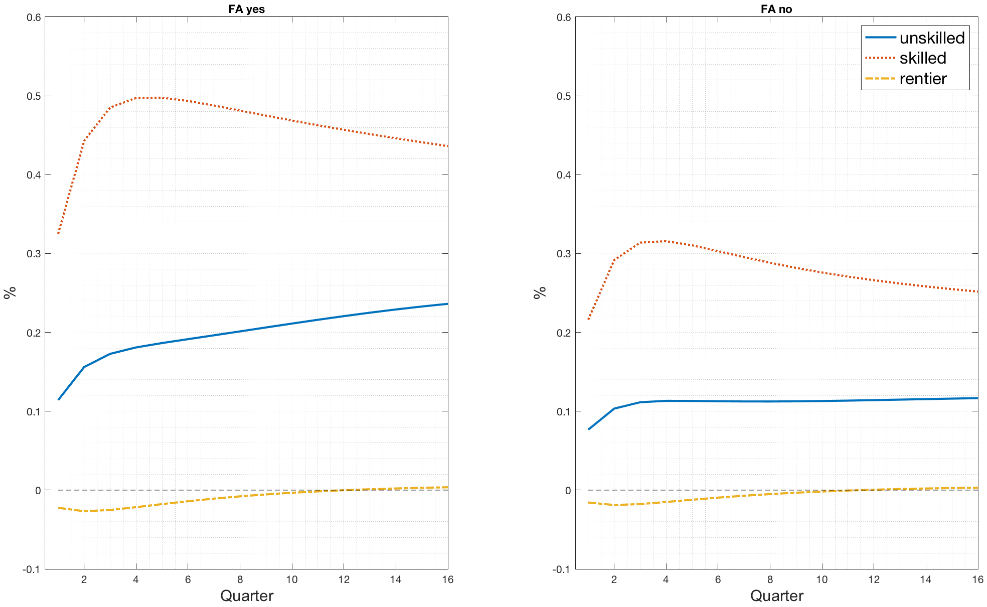

Figure 11: Gini index for wealth inequality according to households type

these households and how the financial accelerator affects these dynamics. To do so, I use the wealth Gini index forz every household type. The results are presented in Figure 11. The financial accelerator not only increases the magnitude of the Gini index fluctuations but, in some cases, also changes the shape of the curves over time. For instance, while unskilled workers' Gini index variation seems to stabilize after one year when financial frictions are shut off, it continues to increase in the other scenario. Variations in the Gini index for rentiers seem to be exactly the same in the two cases, with the difference that they are enhanced in the presence of financial frictions.

Aside from financial accelerator effects, Figure 11 provides an interesting outcome: wealth inequality does not always increase. In fact, wealth inequality decreases among rentiers. The reason for this difference in the behavior of the Gini IRF is likely twofold. First, workers collect labor and financial income. Given that they are affected by both dynamics, it seems plausible that the shape of the evolution of their inequality mimics the shape of the global Gini index. On the other hand, rentiers always benefit from an increase in the interest rate, since both financial income and profits rise. Therefore, rentiers at the bottom of the wealth distribution are also better off.

Second, these trends could be caused not only by households moving along the distribution but also by wealth movements between household types. To see this, Figure 12 shows how relative wealth changes after the contractionary monetary shock among workers and rentiers.[40] Fluctuations in the two scenarios have essentially the same shape, but

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[40] As "relative wealth" I mean the percentage of wealth in the hands of a certain household type over the whole wealth. Intuitively, if the relative wealth of a household category decreases, it does not necessarily mean that they have less wealth in absolute terms. In fact, as household savings increase

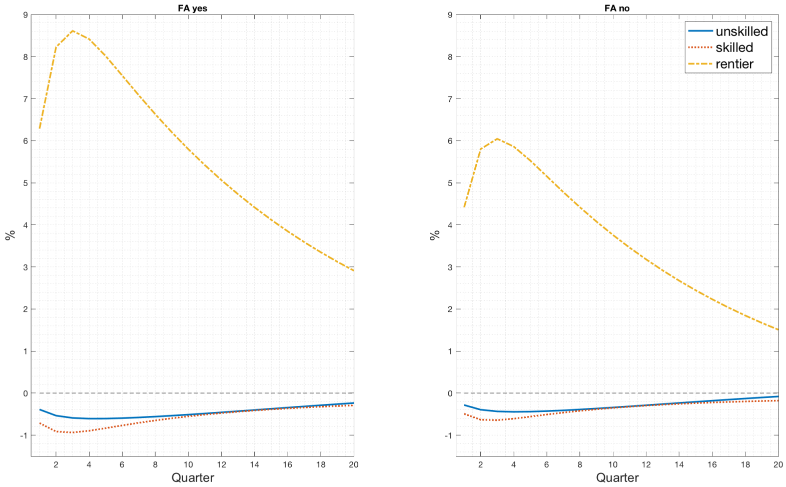

Figure 12: Relative wealth changes per households type

differ in magnitude. The relative wealth of rentiers increases with a peak of over 3% in the case of financial frictions, whereas the relative wealth of workers decreases, albeit to a lesser extent. The workers who experienced the highest fluctuations are skilled workers who lose more relative wealth than unskilled workers. These results suggest that, aside from changes in household wealth distribution, the variations in the Gini index per household type could also be caused by wealth movements between groups, with the relative gains of rentiers more evenly distributed among them.

6 Concluding remarks

Empirical and theoretical evidence points to a relevant role of the financial accelerator in the monetary transmission, and this seems also to be true for consumption and wealth inequality dynamics.

Adopting a proxy-SVAR with externally identified monetary shocks, I show that a contractionary monetary policy has an increasing effect on consumption dispersion, and financial frictions have a multiplier effect that is empirically significant.

Introducing financial frictions in the flavor of Bernanke et al. (1999) in a full-fledged HANK model, I am able to replicate relevant empirical results, showing that the financial accelerator not only causes a higher depression in aggregate variables such as output and investment after a monetary policy shock, but also an increase in inequality measures concerning wealth and consumption, coming to the conclusion that the financial accelerator is also an “inequality accelerator”.

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after a rise in the nominal interest rate, the opposite is more likely. However, a decrease in relative wealth means a decrease in the weight of a household type’s wealth compared with total wealth in the economy. This can be thought as a “relative drain” of wealth from certain household categories at the expense of others.

This acceleration is mostly due to movements at the two tails of the wealth distribution, with constrained households playing a crucial role. Since they cannot rely on savings or borrowing to smooth consumption, they rely solely on their income, which largely comes from labor. Frictions on the production side of the economy, such as those studied in this paper, depress labor income, pushing more people into the borrowing constraint and increasing wealth and consumption inequality. On the other hand, households in the top decile benefit from an increase in the interest rate, and their wealth and consumption increase. Nonetheless, to better understand the behavior of this latter share of households, an extension of the model that allows households to save also in illiquid assets is desirable. I will leave this as a possible venue for future research.

In addition, financial frictions not only enhance wealth changes among households but also between household types (workers and rentiers). In terms of relative wealth shares in the hands of a certain group, rentiers become relatively richer, and workers become relatively poorer after an increase in the interest rate. Wealth inequality in the economy is not only a matter of how households move along the wealth distribution but also of how wealth is redistributed between household types.

Although central bankers do not formally care about redistribution trends, their concern about this topic has increased over the last decade. From a technical perspective, the blooming literature on HANK models proves that wealth distribution has important effects on the transmission of monetary policies. Acknowledging that the financing structure of non-financial firms has important implications for the wealth and consumption redistribution of monetary policy shocks could be something to consider for future policy-making.

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Appendix

A CEX consumption data

To build the consumption dispersion measures used in Figure 1 and Section 2, I use consumption expenditure data from the Consumer Expenditure Survey (CEX). The advantage of this dataset is that it contains consumption expenses on a quarterly basis continuously since 1984Q1. Because households in the dataset are representative of a portion of the US population (a weight is assigned to each of them), it is possible to build consumption distributions and consumption inequality measures. I use data from the FMLI interview file to compute households' total consumption: the total expenditure in a quarter (TOTEXPPQ) net of life and personal insurance (LIFINSPQ), cash contributions (CASHCOPQ), retirement, pensions and social security (RETPENPQ). As in Lee et al. (2020), I adopt a definition of consumption that includes durables, non-durables, and housing services, restricting the sample to households aged 20–60 years, working at least 10 hours a week, with a partner, and families with 10 members or less. As suggested by the US Bureau of Labor Statistics, the weight used to obtain a representation of the entire population in the US is the variable FINLWT21. The consumption ratio between the median and 10th percentiles is logged. Both consumption dispersion measures used, 50/10 ratio and Gini index, are smoothed with a centered three-quarter moving average and de-sesonalized with a quarterly dummy.

B Idiosyncratic productivity process and the joint distribution

Households can be workers, with productivity $h > 0$, or rentiers, with $h = 0$, which means that they do not earn labor income but only profit income. Furthermore, I assume that there are only two possible productivity realizations for workers: high productivity, h^H, and low productivity, h^L. This assumption, in addition to simplifying the computations, is useful for developing the analysis in Section 5.4 between skilled and unskilled workers. The Markov process generates the following transition matrix:

$$\begin{array}{cc} & h_{t+1} \\ & \begin{array}{ccc} h^L & h^H & 0 \end{array} \\ h_t \begin{array}{c} h^L \\ h^H \\ 0 \end{array} & \begin{bmatrix} p_{LL}(1-\zeta) & p_{LH}(1-\zeta) & \zeta \\ p_{HL}(1-\zeta) & p_{HH}(1-\zeta) & \zeta \\ 0 & \iota & 1-\iota \end{bmatrix} \end{array}$$

with probabilities, p, determined using the Tauchen method. In other studies using this household distribution framework, such as Luetticke (2021),rentiers who become workers are endowed with the median productivity level ($h = 1$). However, in this model, there are no states with median productivity levels.[41] Therefore, I assume that new workers are endowed with the highest productivity possible, h^H.

At the steady state, a joint distribution of households exists according to their wealth level, a, and their productivity, h. This joint distribution can be represented by the bi-dimensional matrix as follows:

$$\text{prod. } h \qquad \begin{array}{c|cccc|} h_m & H_{m,1} & H_{m,2} & \cdots & H_{m,n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ h_2 & H_{2,1} & H_{2,2} & \cdots & H_{2,n} \\ h_1 & H_{1,1} & H_{1,2} & \cdots & H_{1,n} \\ \hline & a_1 & a_2 & \cdots & a_n \end{array}$$

$$\text{wealth } a$$

where $H_{1,1}$ is the share of households with the lowest level of wealth and labor productivity (except for the last state $h_m = 0$, since in this model they are rentiers), and $\int H da dh = 1$. As the vector indicating possible household wealth levels is composed of 100 entries, this joint distribution matrix comprises 300 grid points ($a_n = 100$ and $h_m = 3$).

C Entrepreneurs optimal contract

C.1 Idiosyncratic shock on return on capital

I assume that the Idiosyncratic shock ω is distributed log-normally. i.e. $\omega \in [0, +\infty)$.[42] Using results from Appendix A.2 in Bernanke et al. (1999) I can write $F(\omega)$, $\Gamma(\omega)$ and $G(\omega)$ in the analytical expressions that I use in my code to solve the model:

$$F(\omega) = \Phi\left[\left(log(\bar{\omega}) + \frac{1}{2}\sigma_\omega^2\right)/\sigma_\omega\right] , \tag{A1}$$

$$\Gamma(\omega) = \Phi\left[\left(log(\bar{\omega}) - \frac{1}{2}\sigma_\omega^2\right)/\sigma_\omega\right] + \bar{\omega}\left\{1 - \Phi\left[\left(log(\bar{\omega}) + \frac{1}{2}\sigma_\omega^2\right)/\sigma_\omega\right]\right\} , \tag{A2}$$

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[41] Following the calibration of the baseline model, I obtain that $h^L = 0.786$ and $h^H = 1.272$

[42] Note that other kinds of distribution with values greater or equal to 0 could be used as well. Here I choose to adapt the same distribution as in Bernanke et al. (1999) to give a sense of continuity between the two studies.

$$G(\omega) = \Phi\left[\left(log(\bar{\omega}) + \frac{1}{2}\sigma_\omega^2\right)/\sigma_\omega - \sigma_\omega\right] \ . \tag{A3}$$

With $\Phi(\cdot)$ being the normal cumulative distribution function and σ_ω the standard deviation of the idiosyncratic shock on entrepreneurs' return on capital.

C.2 Financial intermediaries' participation constraint and entrepreneur j's optimization problem

After substituting (8) and (7) into (9), I obtain:

$$[1-F(\bar{\omega}_{jt+1})]\bar{\omega}_{jt+1}R^K_{t+1}q_tK_{jt+1}+(1-\mu)\int_0^{\bar{\omega}_{jt+1}} \omega_j dF(\omega_j)R^K_{t+1}q_tK_{jt+1} = \frac{R_{t+1}}{\pi_{t+1}}(q_tK_{jt+1}-N_{jt+1}) \ . \tag{A4}$$

Divide everything by $R^R_{t+1}q_tK_{jt+1}$:

$$\frac{R^K_{t+1}}{\frac{R_{t+1}}{\pi_{t+1}}}\left([1-F(\bar{\omega}_{jt+1})]\bar{\omega}_{jt+1} + (1-\mu)\int_0^{\bar{\omega}_{jt+1}} \omega_j dF(\omega_j)\right) = \left(1 - \frac{N_{jt+1}}{q_tK_{jt+1}}\right) \ . \tag{A5}$$

Following the notation used in Bernanke et al. (1999) and Christiano et al. (2014):

$$\Gamma(\bar{\omega}_j) \equiv \int_0^{\bar{\omega}_j} \omega_j dF(\omega_j) + \bar{\omega}_j \int_{\bar{\omega}_j}^{\infty} dF(\omega_j) \ , \qquad \mu G(\bar{\omega}_j) \equiv \mu \int_0^{\bar{\omega}_j} \omega_j dF(\omega_j) \ , \tag{A6}$$

where $\Gamma(\bar{\omega}_j)$ is the expected gross share of profits going to the lender and $\mu G(\bar{\omega}_j)$ is the expected monitoring cost paid by the lender. $\Gamma(\bar{\omega}_j)$ can be rewritten as:

$$\Gamma(\bar{\omega}_j) = G(\bar{\omega}_j) + \bar{\omega}_j\left[1 - F(\bar{\omega}_j)\right] \ . \tag{A7}$$

I can now use (A6) and (A7) in (A5) and rearrange to finally obtain:

$$\frac{R^K_{t+1}}{\left(\frac{R_{t+1}}{\pi_{t+1}}\right)} = \frac{1}{\Gamma(\bar{\omega}_{jt+1}) - \mu G(\bar{\omega}_{jt+1})}\left(1 - \frac{N_{jt+1}}{q_tK_{jt+1}}\right) \ , \tag{A8}$$

where $\Gamma(\bar{\omega}_{jt+1}) - \mu G(\bar{\omega}_{jt+1})$ is the share of entrepreneur j's profits going to the lender (as loan repayment), net of auditing costs.

Equation (A8) is the complete version of (10), which explain the function underlying $f\left(\bar{\omega}_{jt+1}, LEV_{jt+1}\right)$. For a higher level of entrepreneur leverage, the EFP increases, raising the return on capital. However, it also increases the probability of an entrepreneur's default, thereby increasing the net share of profit demanded by financial intermediaries as loan repayment, resulting in higher financing costs for entrepreneurs. To see in detail how this mechanism works, I show the entrepreneur j's optimization problem below.

According to the optimal contract set by financial intermediaries, entrepreneur j's expected return can be expressed as:

$$E_t \left\{ \int_{\bar{\omega}_{jt+1}}^{\infty} \omega_j dF(\omega_j) R^K_{t+1} q_t K_{jt+1} - (1 - F(\bar{\omega}_j)) R^K_{t+1} q_t K_{jt+1} \right\} \, , \tag{A9}$$

with expectations taken with respect to the realization of R^K_{t+1}. The first term of (A9) represents the entrepreneur's profit when she does not default on debt, while the second term is the amount of profits that she uses to repay the lender. Following the notation used above, and considering that the entrepreneur's return is subject to the participation constraint (9), I write entrepreneur j's optimal contracting problem as:

$$\begin{aligned} &\max_{\{K_{jt+1}, \bar{\omega}_{jt+1}\}} E_t \left\{ [1 - \Gamma(\bar{\omega}_{jt+1})] R^K_{t+1} q_t K_{jt+1} \right\} \, , \\ &s.t. \quad \frac{R_{t+1}}{\pi_{t+1}} (q_t K_{jt+1} - N_{jt+1}) = [\Gamma(\bar{\omega}_{jt+1}) - \mu G(\bar{\omega}_{jt+1})] R^K_{t+1} q_t K_{jt+1} \, . \end{aligned} \tag{A10}$$

Deriving F.O.C. I obtain:

$$w.r.t. \;\; \omega_{jt+1} : \quad -\Gamma'(\bar{\omega}_{jt+1}) + \lambda_{jt+1} [\Gamma'(\bar{\omega}_{jt+1}) - \mu G'(\bar{\omega}_{jt+1})] = 0 \, , \tag{A11}$$

$$w.r.t. \;\; K_{jt+1} : \quad E_t \left\{ [1 - \Gamma(\bar{\omega}_{jt+1})] R^K_{t+1} - \lambda_{jt+1} \left[\frac{R_{t+1}}{\pi_{t+1}} - \left(\Gamma(\bar{\omega}_{jt+1}) - \mu G(\bar{\omega}_{jt+1}) R^K_{t+1} \right) \right] \right\} = 0 \, , \tag{A12}$$

$$w.r.t. \;\; \lambda_{jt+1} : \quad E_t \left\{ \frac{R_{t+1}}{\pi_{t+1}} (q_t K_{jt+1} - N_{jt+1}) - [\Gamma(\bar{\omega}_{jt+1}) - \mu G(\bar{\omega}_{jt+1})] R^K_{t+1} q_t K_{jt+1} \right\} = 0 \, , \tag{A13}$$

where λ_j is the Lagrangian multiplier for entrepreneur j's problem. By rearranging (A11), it is possible to express λ_{jt+1} as a function of only $\bar{\omega}_{jt+1}$. Furthermore, rearranging (A12):

$$E_t \left\{ \frac{R^K_{t+1}}{\frac{R_{t+1}}{\pi_{t+1}}} \right\} = \frac{\lambda_{jt+1}}{[1 - \Gamma(\bar{\omega}_{jt+1}) + \lambda_{jt+1} (\Gamma(\bar{\omega}_{jt+1}) - \mu G(\bar{\omega}_{jt+1}))]} \, . \tag{A14}$$

It can be proven that there is a monotonically increasing relationship between the

EFP and $\bar{\omega}_j$. According to (A8), we can extend this relationship between the EFP and the leverage level of j, assessing that a higher entrepreneur's leverage implies a higher EFP.[43]

Furthermore, it is clear from (A14) that $\bar{\omega}_j$ is determined only by aggregate variables. Thus, any entrepreneur chooses the same threshold $\bar{\omega}$ for the idiosyncratic shock on capital returns, below which they default, and the same leverage level.[44] This result allows to consider only the aggregate variables in the production sector part of the model, since every entrepreneur has the same firm structure.

D Impulse responses of MP contractionary shock

Figure D.1 show several aggregate variables impulse responses for the monetary policy shock considered in the main text. This integrate IRFs present in Figure 6 in the main text.

E Gini indices for higher leverage at steady state

Figure E.1 shows fluctuations of the Gini indices for wealth and consumption in a model with a higher initial level of firm leverage. I show results for the case where the latter is targeted to be equal to 2.5 (instead of 2, as in the baseline model). To reach this level of leverage while maintaining the general calibration, I slightly decrease the discount factor β, increase the labor disutility parameter ψ to 6.5, change the household probability to become a rentier, $\zeta = 0.00056$, and the parameter governing the adjustment cost of capital, $\phi = 10$.

F Robustness to risk aversion

For the baseline model, I used a parameter for households' risk aversion $\xi = 2$, which is already used in other HANK models in the literature. However, other models used different values; for instance, Bayer et al. (2019) and Luetticke (2021) assume $\xi = 4$. I recalibrated the model with this parameter to obtain relevant moments as in the baseline version. This implies a discount factor $\beta = 0.986$, labor disutility parameter $\psi = 11$, household probability of becoming a rentier $\zeta = 0.00072$ and the parameter governing the adjustment cost of capital $\phi = 7$. Figure F.1 and Figure F.2 show fluctuations for aggregate variables and Gini indices, respectively.

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[43] See Appendix A.1 in Bernanke et al. (1999) for proofs.

[44] According to (A8), leverage is a function of the EFP (composed of only aggregate variables) and $\bar{\omega}_j$. If $\bar{\omega}_j$ depends only on aggregate variables (since it is a function of the EFP, according to (A14)), then the same can be said for the leverage.

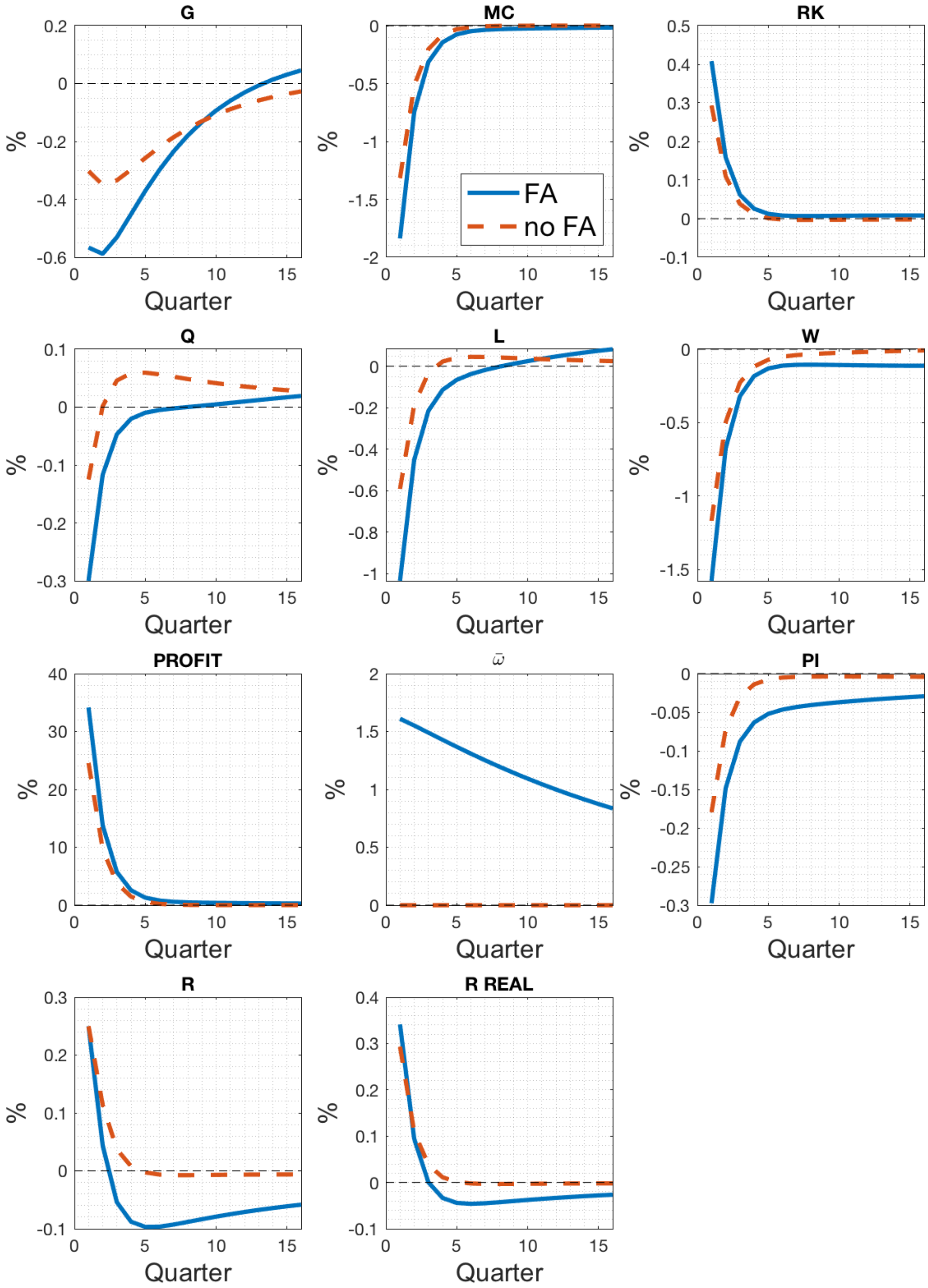

Figure D.1: Aggregate fluctuations consequent to an increase of the nominal interest rate. Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off.

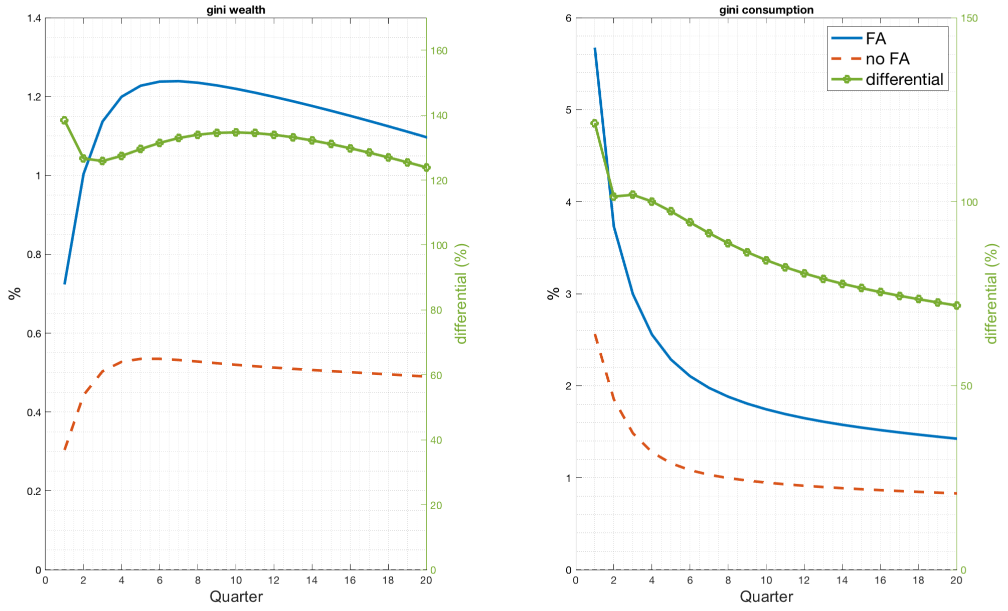

Figure E.1: IRFs for Gini indices, LEV = 2.5

The graph on the left-hand side represents fluctuations in the Gini index for wealth, while the one on the right-hand side for consumption. Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation from the solid line to the dashed line.

G Robustness to investment cost

The baseline model features quadratic investment costs (the central term on the right-hand side of Eq. (21)) where the parameter ϕ is calibrated to match an investment volatility of 4.5. I display in Figure G.1 and Figure G.2 aggregate and Gini index fluctuations for the case limit where there is no investment cost, that is, $\phi = 0$. This means that the capital price q is fixed over time, and entrepreneurs do not make any profit from capital gains or creation of new capital ΔK. This extreme calibration also confirms the financial accelerator: the output, investment, consumption, and Gini indices are all greater when financial frictions are active. However, it is worth noting that some aggregate variables display completely different behaviors. For instance, the quantity of aggregate labor L increases after a MP contractionary shock. Interestingly, aggregate consumption fluctuations do not overshoot in the short-run with this parameterization.

H Robustness to fiscal policy

Since I employ a HANK model, the Ricardian equivalence does not hold, and fiscal policies could have significant effects on monetary transmission. In the baseline model, I assume that the government adjusts its spending to bring debt to steady state values. In line with the empirical data, as in Bayer et al. (2019) and Luetticke (2021), I set the

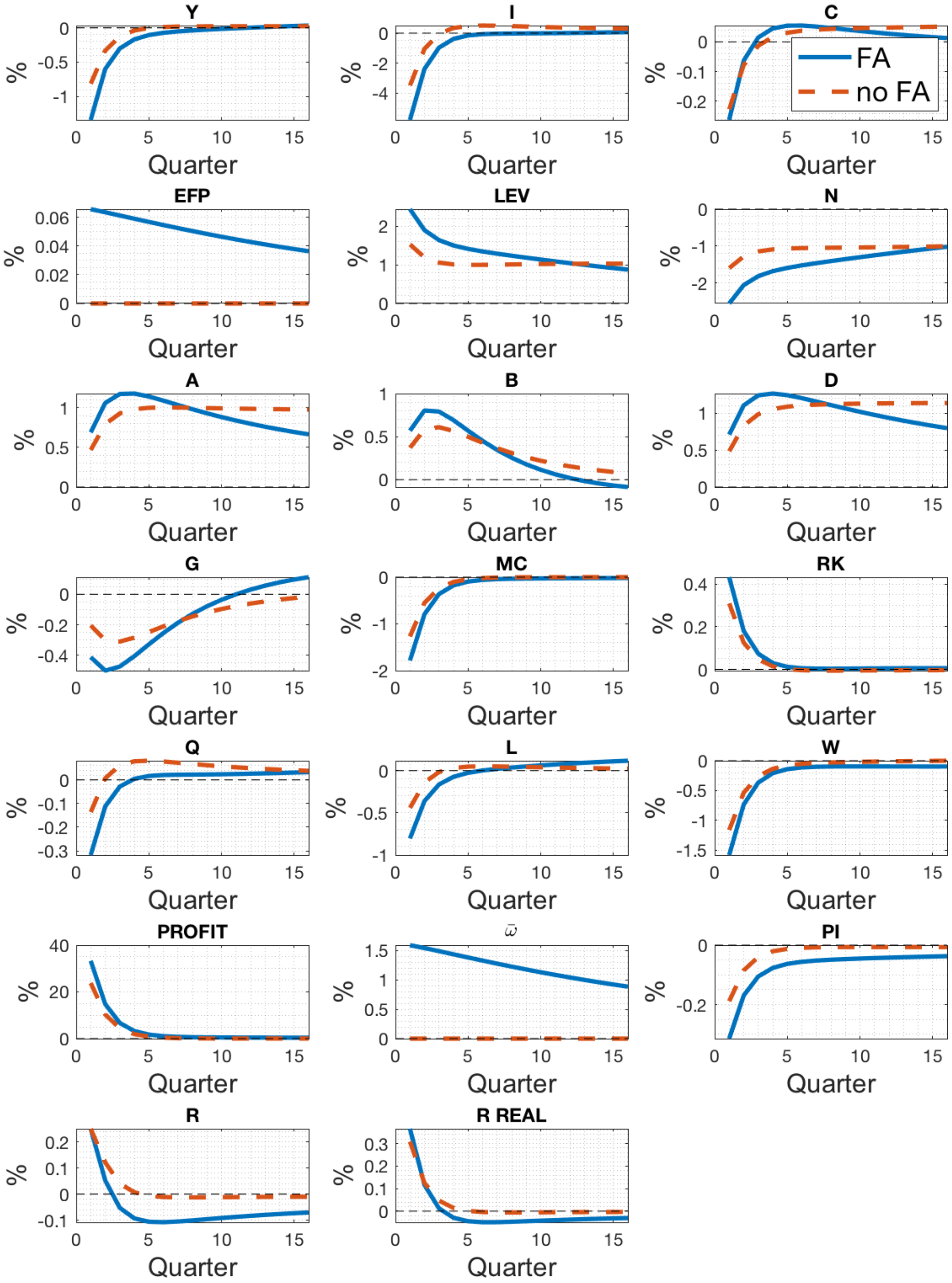

Figure F.1: IRFs for aggregate variables, $\xi = 4$

Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off.

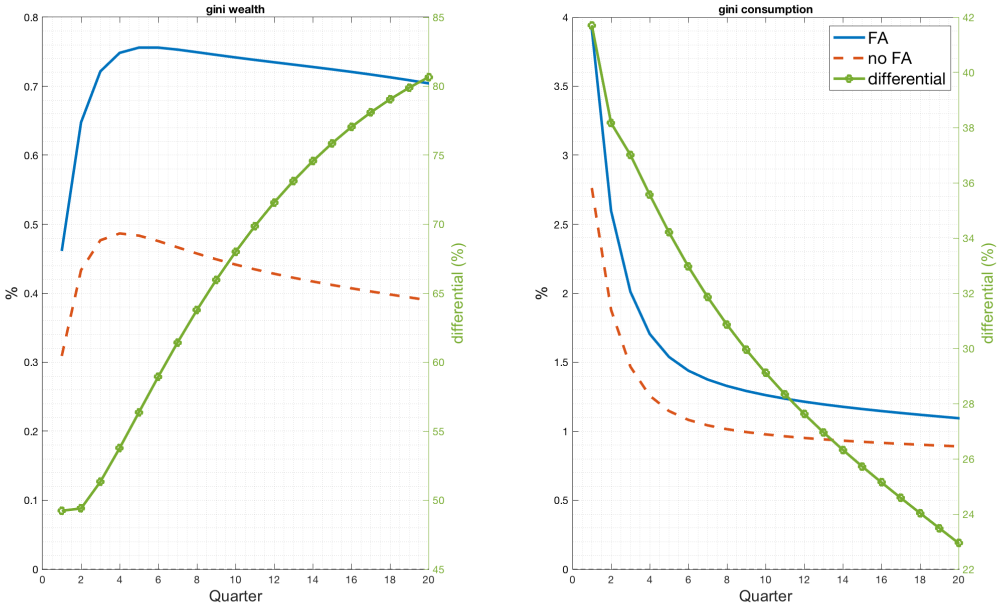

Figure F.2: IRFs for Gini indices, $\xi = 4$

The graph on the left-hand side represents fluctuations in the Gini index for wealth, while the one on the right-hand side for consumption. Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation from the solid line to the dashed line.

debt autocorrelation $\rho_B = 0.86$, meaning that the government is willing to roll over most of this debt, sustaining a higher level of public expenditure. I now consider the case in which the government wants to revert immediately to its steady state level of debt after a MP contractionary shock, setting $\rho_B = 0$. The results are shown in Figure H.1 and Figure H.2. The government achieves debt control by cutting even more expenditure, inducing a higher economic depression in terms of output and consumption, and increasing inequalities even more when compared to the baseline specification of the model.

The government could also choose to maintain spending at its steady state level and adjust taxation through the tax parameter τ. The results are shown in Figure H.3 and Figure H.4. While Output and investment do not display significant differences compared to the baseline calibration, consumption falls more, and the respective Gini index is higher. Taxes increase to balance the government budget constraint; however, taxation is proportional and not progressive. Therefore, poorer households (who rely more on labor income for consumption and have a higher marginal propensity to consume) are more affected by this tax rise. In this model, financial income is not taxed; therefore, wealthier households suffer less from an increase in tax rate.

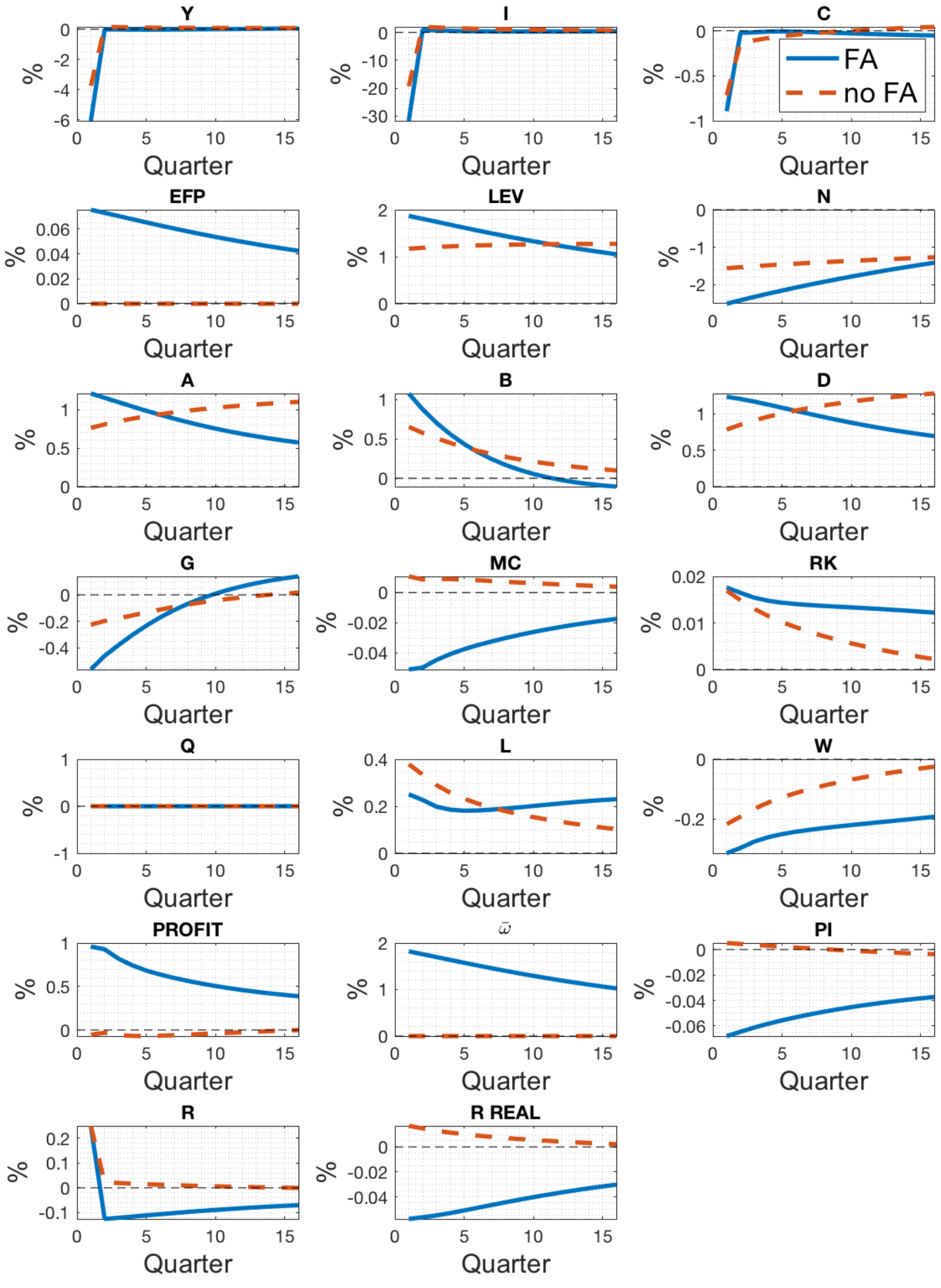

Figure G.1: IRFs for aggregate variables, $\phi = 0$

Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off.

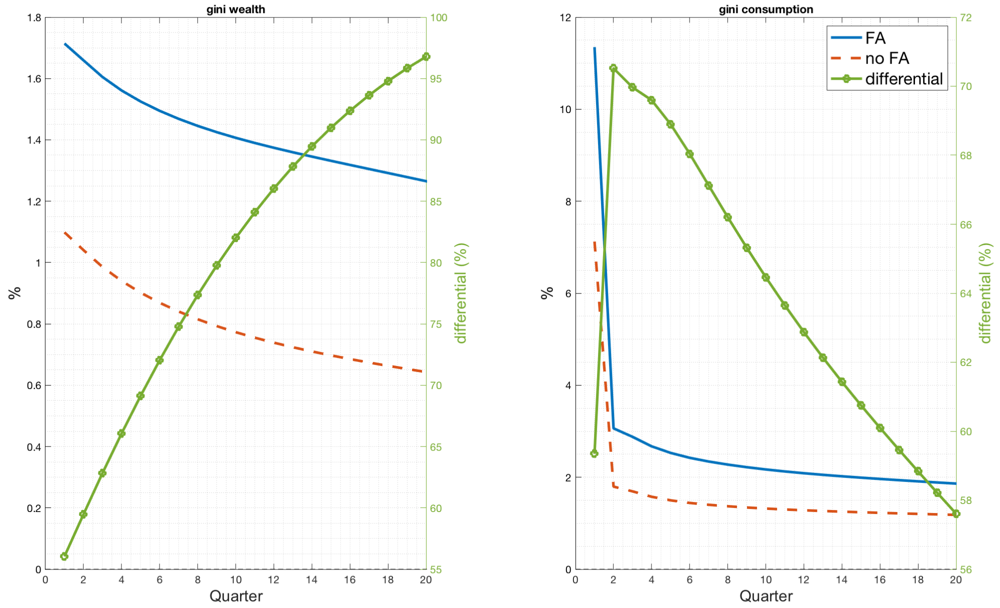

Figure G.2: IRFs for Gini indices, $\phi = 0$

The graph on the left-hand side represents fluctuations in the Gini index for wealth, while the one on the right-hand side for consumption. Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation from the solid line to the dashed line.

I Impulse responses of a TFP shock

In this section, I show aggregate and inequality fluctuations when a positive TFP shock occurs, instead of a contractionary MP shock. The shock to z_t follows an AR(1) process with persistence $\rho_z = 0.95$ and SD $\sigma_z = 0.00915$. The SD is calibrated such that the autocorrelation of output is in line with values from US data. Figure I.1 shows aggregate variable fluctuations, while Figure I.2 shows fluctuations of the Gini indices for wealth and consumption. Interestingly, adopting a HANK model seems to solve the "financial accelerator dampening" of the TFP shock that occurs in Bernanke et al. (1999). In their results, the TFP shock confirms the financial accelerator only if persistence is set to $\rho_z = 1$ such that the shock never reverts to zero over time. For a more standard value of the TFP shock persistence, such as $\rho_z = 0.95$, the model presented in Bernanke et al. (1999) shows a "financial deceleration". On the other hand, as shown in Figure I.1, output, investment, and consumption also increase (albeit slightly) when persistence is less than 1.

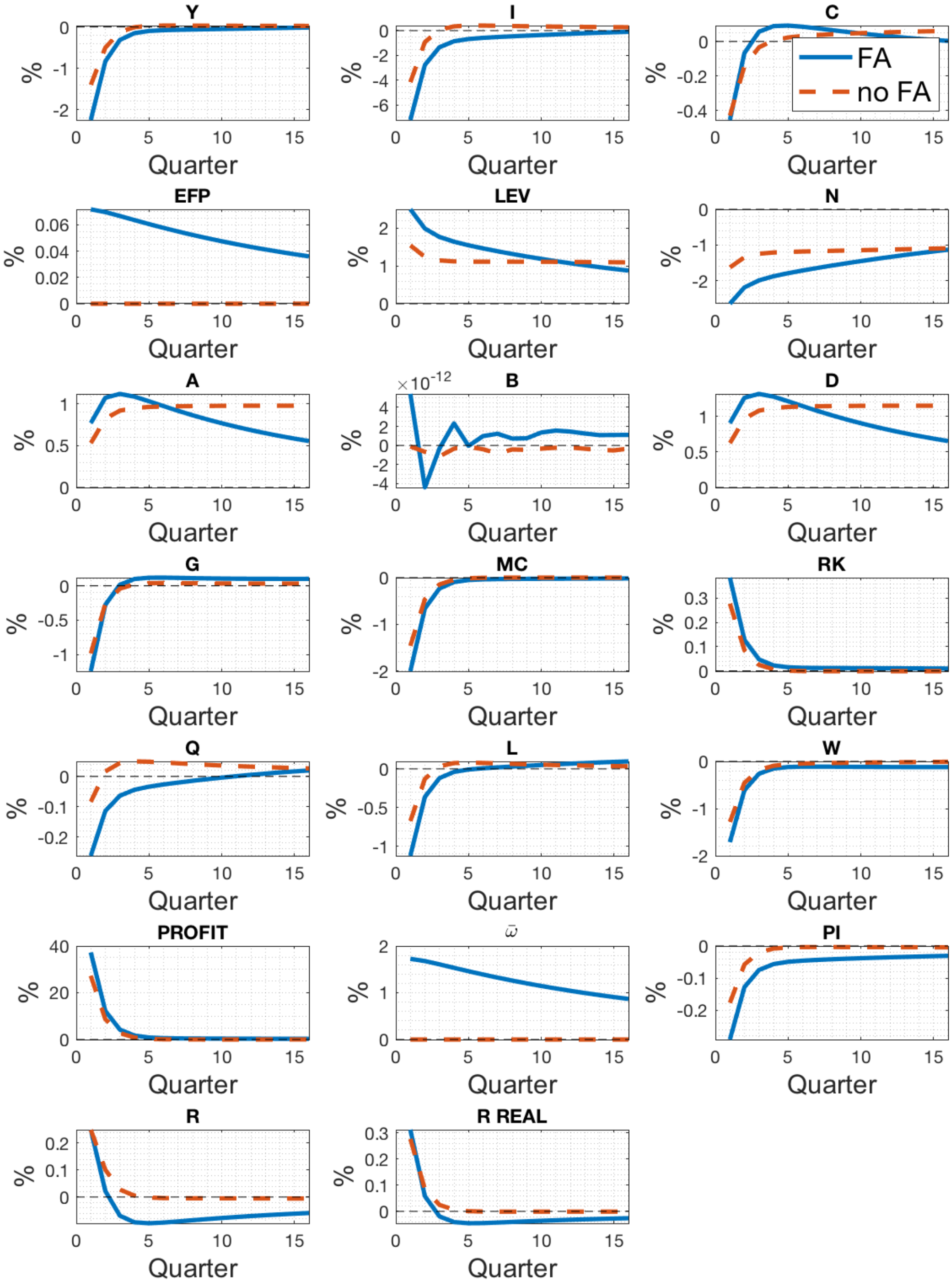

Figure H.1: IRFs for aggregate variables, $\rho_B = 0$

Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off.

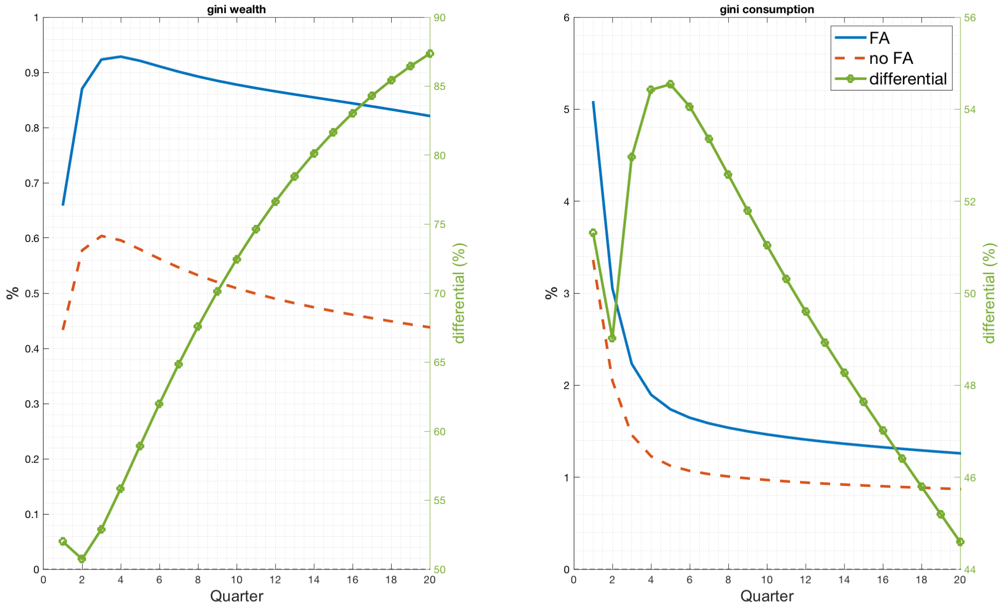

Figure H.2: IRFs for Gini indices, $\rho_B = 0$

The graph on the left-hand side represents fluctuations in the Gini index for wealth, while the one on the right-hand side for consumption. Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation from the solid line to the dashed line.

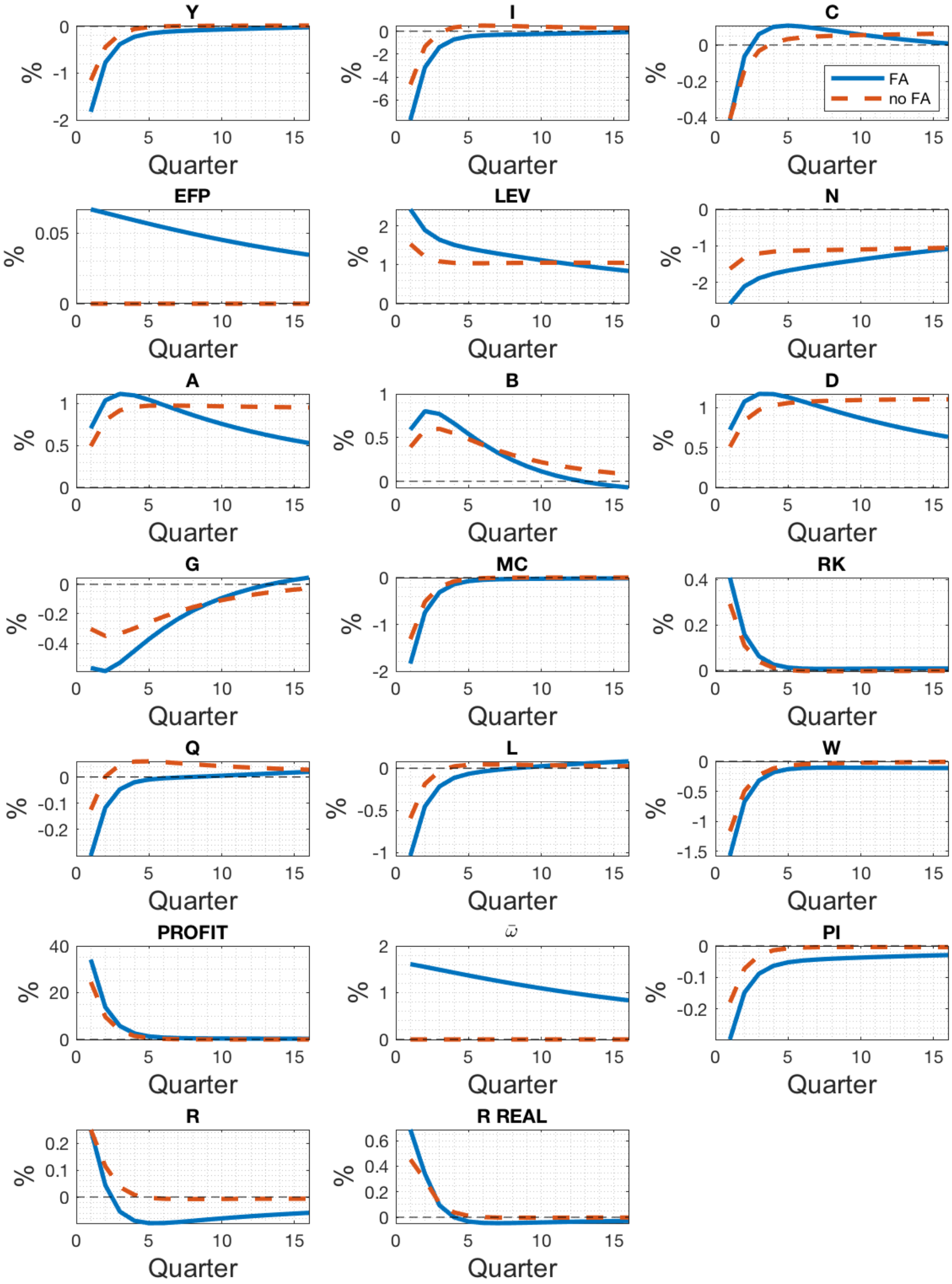

Figure H.3: IRFs for aggregate variables, τ adjustment

Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off.

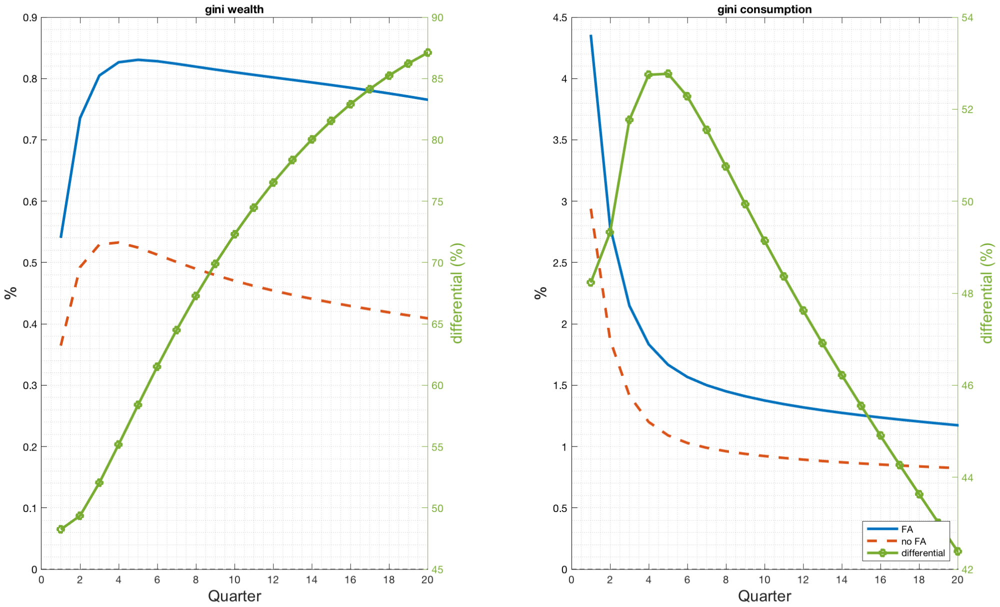

Figure H.4: IRFs for Gini indices, τ adjustment

The graph on the left-hand side represents fluctuations in the Gini index for wealth, while the one on the right-hand side for consumption. Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation from the solid line to the dashed line.

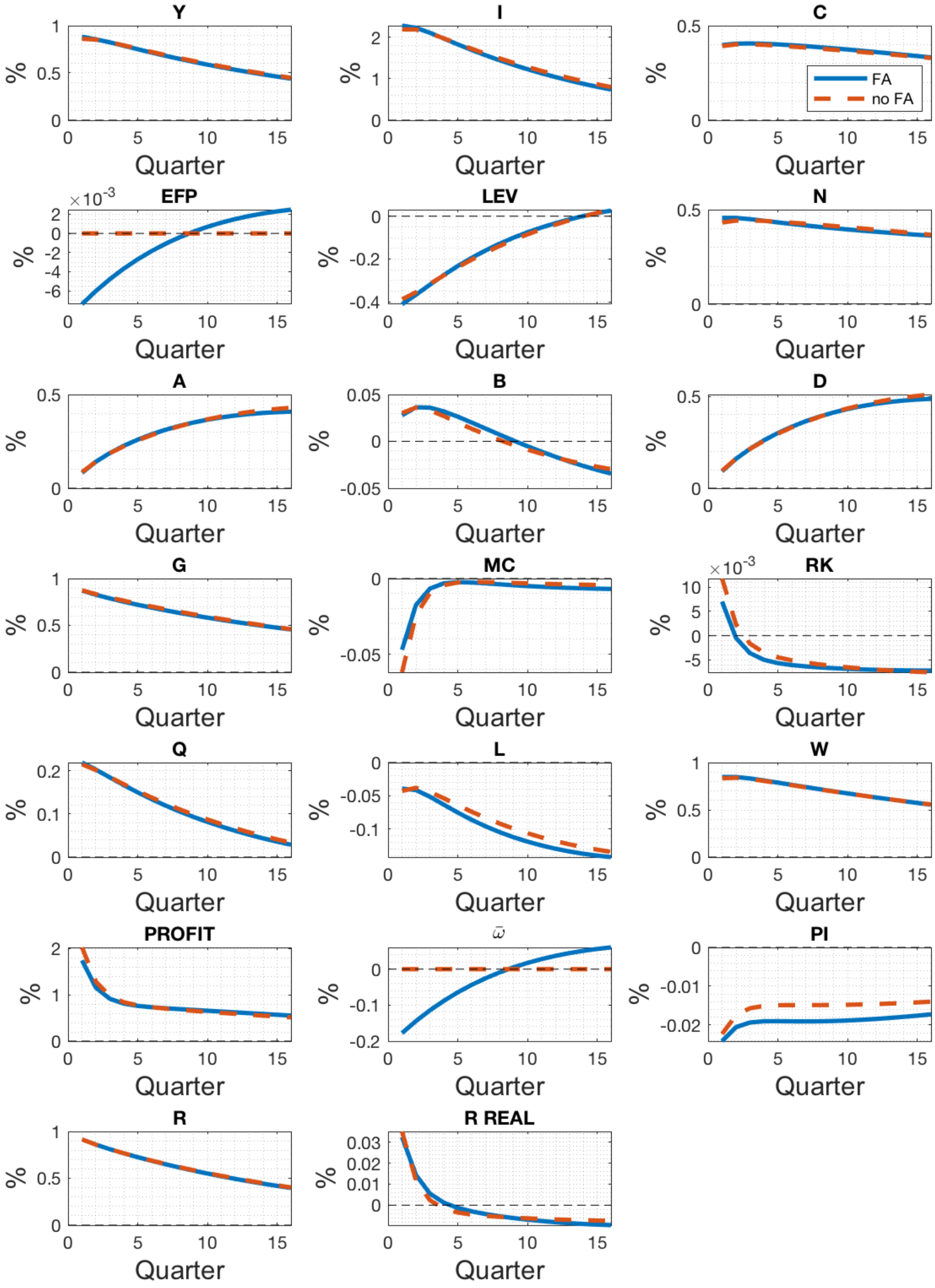

Figure I.1: IRFs for aggregate variables to positive TFP shock

TFP shock $\sigma_z = 0.00915$ with $\rho_z = 0.95$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off.

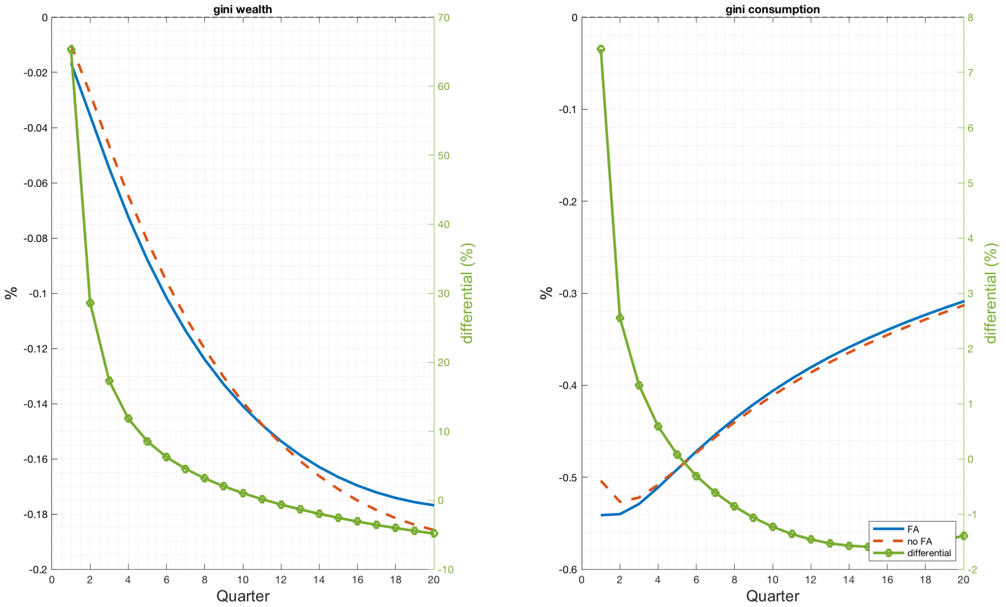

Figure I.2: IRFs for Gini indices to positive TFP shock

The graph on the left-hand side represents fluctuations in the Gini index for wealth, while the one on the right-hand side for consumption. Monetary shock $\epsilon^R = 0.0025$. The blue solid line refers to an economy with a financial accelerator. The red dashed line refers to the case where financial frictions are shut off. The green line with circles (with values on the right side of the figure) represent the percentage variation from the solid line to the dashed line.