Juan-Francisco Albert and Nerea Gómez-Fernández

Monetary policy and the redistribution of net worth in the US

Discussion paper [or working paper, etc.]

Monetary Policy and the redistribution of net worth in the US

Juan-Francisco Albert[2]

Juan.F.Albert@uv.es

Nerea Gómez-Fernández[2]

N.Gomez-Fernandez@lse.ac.uk

Abstract

The view that expansionary monetary policy can exacerbate both income and wealth inequality by increasing asset prices has become increasingly popular. The aim of this paper is to study the distributive effects of monetary policy on wealth inequality. In the first part of this research, we develop a simple framework based on accounting identity to examine the redistributive repercussions of changes in monetary policy on net worth through different channels. Based on this framework, in the second part of the paper, we show empirical evidence concerning the effects of monetary policy on wealth inequality in the US. To derive this, we combined macro and micro data, and proceeded in two steps. Firstly, we estimated a Proxy structural vector autoregression (SVAR) model, combining high-frequency identification used as external instruments with a classic SVAR, to measure the response of the real and financial variables that could affect wealth inequality after an expansive monetary policy shock. Considering this information, we then used the microdata of the Survey of Consumer Finance (US, 2016) and simulated changes to the value of a household's assets and liabilities, as well as the inflation rate, produced by an expansive mone-

[1]Department of Applied Economics, Universitat de València. Juan-Francisco Albert conducted this research while he was a visiting researcher at the London School of Economic and Political Sciences (Cañada Blanch Centre).

[2]Centre for Quality and Change Management, Universitat Politècnica de València. Nerea Gómez-Fernández conducted this research while she was a visiting researcher at the London School of Economic and Political Sciences (Cañada Blanch Centre).

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tary policy. We considered three different time horizons and the whole of the distribution, measured by the Gini coefficients, and the simulation results suggest that wealth inequality increases after an expansive monetary policy shock. Additionally, focusing on the net worth by deciles, we found a relevant result. The expansive monetary policy shock substantially increases the net worth of the richest and the poorest households, while the middle class tends to benefit the least. Monetary policy on stock prices is the most important driver of the significant increases in net wealth among the richest households, while its effect on debt is most significant among the poorest.
Keywords: Monetary Policy, wealth inequality, Proxy VAR, household survey

1. Introduction

The unconventional monetary policy measures introduced by the major central banks in advanced economies since the Great Recession, alongside the increase in income and wealth inequality since the 1970s, concern policy makers and academics. After the unconventional monetary policy measures applied by central banks, the view that expansionary monetary policy can exacerbate both income and wealth inequality by increasing asset prices has become increasingly popular. However, there are few studies about the possible drivers of inequality induced by changes in monetary policy, specifically regarding wealth inequality.

Focusing on the United States (US), this paper seeks to document and quantify the distributional consequences on household wealth associated with changes in monetary policy. To do so we develop a simple framework as well as combine macro and micro empirical analysis in order to investigate how monetary policy in the US affects the distribution of wealth across individual households. For that purpose, we first develop a simple framework to explore the distributional implications of monetary policy measures. Specifically, we develop a formulation proposed by Meade (1964) which offers a simple framework for analysing wealth distribution based on the accounting identity. Using this framework, our model identifies various channels through which monetary policy may have a distributional impact on wealth distribution. Although most of these channels have direct or indirect consequences in income inequality as well, this paper is only interested in studying the distributional consequences of monetary policy on wealth. Hence, we restrict our analysis to this purpose. However, since there is a clear relationship between income inequality and wealth inequality, we identify the dynamic of this relationship across the household to obtain a complete picture of how monetary policy affects wealth inequality.

For the empirical part of our paper we proceed in two steps. First, we estimate the aggregate effects of monetary policy on a set of relevant financial and macroeconomic variables. For this purpose, we estimate a proxy VAR model developed by Gertler and Karadi (2015) which combines high-frequency identification (HFI) as external instruments with a classic SVAR (Stock and Watson (2012) Mertens and Ravn (2013)). Since we are interested in estimating the response of financial variables after a monetary policy shock, the proxy VAR provides us with good estimates. As Ramey (2016) point outs: "The usual Cholesky ordering with the federal funds rate ordered last imposes the restriction that no variables ordered earlier respond to the funds rate shocks within the period. This is clearly an untenable assumption for financial market rates." Therefore, the main advantage of the Proxy VAR is that it does not need to resort to Cholesky orderings and it makes it suitable to estimate the response of financial variables. Additionally, the Proxy VAR approach is able to capture the "forward guidance measures" (agent forecasts about the future path of interest rates) which have become increasingly important since the Great Recession. Finally, the results of this identification method avoid the so-called "price puzzle" resulting from other identification strategies (Sterk and Tenreyro (2018)). Due to these reasons, our identification strategy following Gertler and Karadi (2015), allows us to estimate properly all macroeconomic and financial aggregate responses of a monetary policy shock which can influence wealth inequality according to the theoretical framework. Using this methodology we find that a monetary policy shock increases stock prices, housing prices and bond prices, as well as increases the price level and reduces the interest rate according to the standard theory. However, the magnitude of the responses differs among these variables.

In a second step, using micro data from the Survey of Consumer Finances (SCF), which provides detailed information about balance sheets of households in the US, we simulate the effects of the possible drivers of wealth inequality based on our results from the aggregate analysis. This simulation focuses on the impact of changes in interest rates and asset prices on wealth inequality, abstracting from active portfolio shifts by households and computed according with our theoretical framework. Subsequently, we compute the changes in the Gini coefficients for the net wealth distribution due to changes in the variables affected by the monetary policy shock. We also compute the gains of net worth by deciles of net worth. We follow the approach of Domanski et al. (2016) and Adam and Tzamourani (2016) but widen the analysis variables and use the responses we obtained following a monetary policy shock.

Focusing on the effects of monetary policy on wealth inequality is vital for improving the knowledge about distributive implications, but also for a better understanding of the transmission mechanism of monetary policy to consumption, as well as the effectiveness of monetary policy itself. For instance, Auclert (2017) and Kaplan et al. (2018) study the role of heterogeneity in the transmission mechanism of monetary policy considering agents with different marginal propensities to consume using Heterogeneous Agents New Keynesian (HANK). Similarly, Sterk and Tenreyro (2018) focus on the redistribution channel for the transmission of monetary policy using a tractable quantitative model. All of these works emphasize the idea that representative agent formulation is abstracted from distributional effects and they highlight the importance of new channels for the transmission of monetary policy focusing on wealth redistribution.

Our results show that expansive monetary policy increases wealth inequality, considering the whole distribution. Nevertheless, in an analysis by deciles of net worth, we show that an expansive monetary policy substantially benefits both the richest and poorest households, with the middle class benefiting less. This result is explained by the unequal concentration of financial assets and liabilities across households and the heterogeneous impact of monetary policy on financial and real variables.

The remainder of the paper is structured as follows. In section 2, we develop our simple framework based on the accounting identity. Section 3 presents and discusses the macro empirical facts which are used in subsequent simulations. In section 4, we explain the methodology used in our micro simulations, as well as present and discuss our results. Finally, section 5 offers concluding remarks.

2. Simple framework

In this section we develop the simple framework introduced by Meade (1964) and Davies and Shorrocks (2000) for analysing wealth distribution based on the accounting identity. We consider two households' net worth, a small one W_1 and a large one W_2, being w_i the growth rate of W_i. It is easy to see that if $w_1 > w_2$, then the ratio of $\frac{W_1}{W_2}$ will be nearly equal to unity and relative inequality will be declining.

Developing the model of Meade (1964), the growth rates of wealth for each household (w_i) could be expressed as:

$$w_i = s_i(\frac{Ei}{Wi} + r_i^W \frac{Wi}{Wi} + \frac{Ii}{Wi} + \frac{\tau_i}{Wi}) \tag{1}$$

where s_i is the average rate of saving and the first term of the equation $s_i \frac{Ei}{Wi}$ represents the rate of accumulation of net worth for incomes coming from labour,being E_i the earned incomes or wages of each household's net of taxes and transfers . The second term of the equation $s_i(r_i^W \frac{Wi}{Wi})$ represents the rate of accumulation of net worth for each household i from revaluation of existing wealth, being r_i^W the average net nominal return of the net worth for each household. The third term $s_i \frac{Ii}{Wi}$ represents the rate of accumulation of net worth for incomes coming from inheritances , being Ii gifts and bequests received by each household i net of taxes and transfers. Finally, the term $s_i \frac{\tau_i}{Wi}$ represents the rate of accumulation of net worth for incomes coming from the government, being τ_i a lump-sum transfer made by the government for each household.

Notice that we can decompose the net wealth of each household based on the composition of their assets portfolio and liabilities:

$$W_i = St_i + H_i + B_i - L_i \tag{2}$$

$$A_i = St_i + H_i + B_i \tag{3}$$

$$W_i = A_i - L_i \quad (4)$$

being St_i, H_i, B_i, L_i the stocks, housing, bonds and liabilities, respectively, that each household i owns. A_i represents the total assets of the households and W_i the net worth for each household i. The concept of wealth used in this paper is marketable wealth. Therefore, we exclude social security wealth or pension wealth, as well as consumer durables. For simplicity, we define net worth in Equation (2) as the sum of stocks, housing and bonds minus the household debt, since these three assets are more likely to be affected by changes in monetary policy as the portfolio channel predicts (Domanski et al. (2016) or Adam and Tzamourani (2016)). If we assume that the return of the assets differs between them, then:

$$r_i^W = r_i^{St} + r_i^h + r_i^b - i_i^l \quad (5)$$

where r_i^{St} is the nominal return of the stocks, r_i^h is the nominal return of the housing, r_i^b is the nominal return of the bonds and i_i^l is the average interest rate that each household has to pay for its liabilities. Therefore, considering this heterogeneity of the returns in the equation (1), we get:

$$w_i = s_i(\frac{Ei}{Wi} + (r_i^{St}\frac{STi}{Wi} + r_i^h\frac{Hi}{Wi} + r_i^b\frac{Bi}{Wi} - i_i\frac{Li}{Wi}) + \frac{Ii}{Wi} + \frac{\tau_i}{Wi}) \quad (6)$$

where $r_i^{St}\frac{STi}{Wi} + r_i^h\frac{Hi}{Wi} + r_i^b\frac{Bi}{Wi} - i_i^l\frac{Li}{Wi}$ represents the rate of accumulation of net worth from revaluation of existing wealth considering this heterogeneity between assets and liabilities.

Finally, we can represent the average net wealth of household i at time t in real terms in the following way:

$$\frac{W_{it}}{\pi_t} = \frac{(1 + w_{it})W_{it-1}}{\pi_t} \quad (7)$$

where π_t is the inflation rate.

2.1. Monetary policy and wealth inequality

According with the equation (6) and (7) and with the channels that the previous literature has recently explored (see the seminal work by Coibion et al. (2017)), monetary policy could affect wealth distribution in different ways.

1. *The earnings heterogeneity channel*: since monetary expansions tend to increase labour earnings, the distribution of these gains is likely to be unequal. Blanchard (1995) argues that monetary contractions have "ladder effects" and tend to harm in greater measure unskilled workers who used to be in the bottom part of the distribution. This divergence between labour earnings is empirically supported by Carpenter and Rodgers (2004), Heathcote et al. (2010) or Mumtaz and Theophilopoulou (2017) among others.

Focusing on the equation (6) and assuming that the saving rate is equal between two households $(s_1 = s_2)$, we see that if $\triangle E_1 > \triangle E_2$ caused by an expansionary monetary policy shock, then we get $\triangle w_1 > \triangle w_2$ and $\triangle W_1 > \triangle W_2$, getting evident distributive wealth effects.

2. *The fiscal channel of monetary policy*: since monetary policy through changes in interest rates and inflation affects government revenues, government deficit and government debt (Dahan (1998)), it may affect the decisions of fiscal policy leading distributive effects (Albert et al, 2018). However, we should consider that these possible distributive effects are not direct and dependent on the fiscal decisions made by policy makers.

Focusing on the equation (6) and assuming again $(s_1 = s_2)$, if $\triangle\ \tau_1 > \triangle\ \tau_2$ is caused by an expansive monetary policy shock, then we get $\triangle w_1 > \triangle w_2$ and $\triangle W_1 > \triangle W_2$, leading changes in wealth distribution. For instance, this could happen if an expansive monetary policy shock leads to a reduction in the servicing interest of the debt and policy makers decide to create a financial aid program for supporting households which are located in the lower part of the wealth distribution using this additional income.

3. *The Portfolio channel*: The conventional and unconventional monetary

policy measures recently introduced in the US have been related to strong movements in a number of important market prices. This is well documented by event studies which have provided the strongest evidence about the effect of monetary policy on financial asset prices as stocks and bonds (see Gürkaynak et al. (2005), Bernanke et al. (2005) or Rogers et al. (2014), among others). Bernanke and Kuttner (2005) explain how expansionary monetary policy news could affect stock prices through 3 channels: (1) increasing future dividends expectations, (2) the reduction in the discount rate, (3) news that affects the risk premium of stocks. Therefore, considering the effect of monetary policy on financial markets, some authors point out that monetary policy could increase income and wealth inequality because asset price increases tend to benefit the top part of the net wealth distribution, where stock ownership is more prevalent (Saiki and Frost (2014) Albert et al.) . However, other authors consider that this effect is mitigated when we take into account housing price increases caused by the same expansive monetary policy shock since especially middle class and the bottom part of the net wealth distribution on average own a higher proportion of their wealth in housing (Domanski et al. (2016), Adam and Tzamourani (2016) or Doepke and Schneider (2006)). This compensatory effect through housing prices increases is *the housing channel*. Additionally, a reduction in the policy rate decreases interest payments for households with outstanding debts as long as their loans are at a variable interest rate or they are able to refinance their debts, this is *the debt channel*. Hence, these households could benefit more after an expansive monetary policy shock in terms of income as well as in terms of wealth, as long as they save a part of this "unexpected income".

Focusing on the equation (6) and assuming again ($s_1 = s_2$), we can study the portfolio channel paying attention to the next term $r_i^{St}\frac{STi}{Wi} + r_i^h\frac{Hi}{Wi} + r_i^b\frac{Bi}{Wi} - i_i^l\frac{Li}{Wi}$ which represents the rate of accumulation of net worth for each household i from revaluation of existing wealth considering this heterogeneity in their portfolio. Therefore, if monetary policy affects in a heterogeneous way the return of each different asset $r_i^{St}, r_i^h, r_i^b, i_i^l$, the nominal growth in the net wealth of each household i will differ depending on the asset and liability composition of each household. For instance, if as a consequence of an expansive monetary policy shock $r_i^{St} > r_i^h$ capital gains of stocks increase more than capital gains of housing, this will benefit more households that hold a higher proportion of stocks in their net wealth ($\frac{STi}{Wi} > \frac{Hi}{Wi}$). In a similar way, if the expansive monetary policy shock reduces i_i^l, it will benefit more households who own more outstanding debt over their net wealth.

Finally, we have the inflation effect or *the Fischer effect*. This channel focuses on how unexpected inflation movements will affect the real value of all nominal assets and liabilities held by households (Fisher (1933), Auclert (2017)). This channel has been empirically explored by Doepke and Schneider (2006) in the US and by Adam and Zhu (2015) in the Eurozone. They show that indebted households tend to benefit from an unexpected hike in the inflation rate, while savers are harmed. Considering equation (7), we can see this inflation effect in wealth. If $\pi_t > 0$, will reduce the real net worth for all households i if $W_i > 0$, while it will increase the real value of net worth for all i households if $W_i < 0$.

Therefore, according to our simple model and the transmission channels of monetary policy there are several channels through which monetary policy could have distributive wealth effects. Of course, monetary policy could also have different effects on s_i between households. For instance, an expansive monetary policy shock could increase the marginal propensity to consume those households who benefit more from an accommodative monetary policy (Tobin (1982) and Auclert (2017)). It will involve differences on the saving rates and on the net worth accumulation rate among households according to equation (6). However, since it is a subtler channel of wealth distribution. In our empirical exploration we focus on the most direct channels that could lead to wealth distributive effects. These channels are: portfolio channel, housing channel, debt channel and the fisher effect. We follow a similar strategy than Domanski et al. (2016) Adam and Tzamourani (2016) and Doepke and Schneider (2006). Therefore, in our empirical estimations we will assume that wealth distribution is not affected by the earning heterogeneity channel and the fiscal channel. These two channels are important if we are interested in analysing only income distribution but could affect wealth distribution in an indirect way according with our model. Therefore, the empirical analysis focuses on the direct channels of monetary policy on wealth distribution but without forgetting that there are other subtler forms through monetary policy that could affect wealth inequality.

3. Macro empirical evidence

In this section we show the empirical evidence on the effects of monetary policy shocks on the financial and macroeconomic variables which could affect wealth distribution as we point out in our simple framework.

To do so we estimate a Proxy structural VAR following Gertler and Karadi (2015). The key of this strategy is the use of an instrumental variable which is correlated with the monetary policy shock, but not with the other macroeconomic shocks. Therefore, the basic idea of this approach is to identify the surprise component due to a monetary policy announcement. This identification strategy relies in the plausible assumption that in the short window around monetary policy announcements (normally thirty minutes), it is very likely that the most important shock hitting the economy is the monetary policy shock. This is specifically, the change in the three-month ahead futures rate during a 30-minute window around announcements by the Federal Open Market Committee (FOMC) is used as instrument. These data are taken from Gertler and Karadi (2015). Next, these shocks are used as external instruments in the VAR using the methodology developed by Stock and Watson (2012) and Mertens and Ravn (2013) (More details in Appendix 1).

FollowingGertler and Karadi (2015) we propose a similar baseline composed by: the Federal Fund rate (FF) as policy indicator, the log of consumer price index (CPI), the log of industrial production (IP), and excess bond premium (EBP) which is a control variable that captures the variation in the average price of bearing US corporate credit risk developed by Gilchrist and Zakrajšek (2012). Then, we employ different specifications for the endogenous variables. We use the baseline variables plus one additional variable that is our variable of interest and can capture movements on wealth distribution according to our simple model. These are the log stock price index (SP 500), the log of consume price index of housing prices, the log of Barclays US Aggregate Bond Price Index, which is weighted according to the market size of each bond type, and the log of Moody's AAA index Corporate Bond, which is used as an indicator of the debt interest rate. All these are collected by Datastream [3]. As we point out in the introduction, this identification strategy is a suitable strategy to estimate the response of financial variables, as well as the price level, because it assumes that monetary policy shocks may have contemporaneous effects on financial variables, unlike the classical Cholesky identification. Thus, we avoid the "price puzzle" and we get more consistent results with the standard theory. These are novel findings, in themselves, which motivate the study of the distributional effects of monetary policy (Sterk and Tenreyro (2018)).

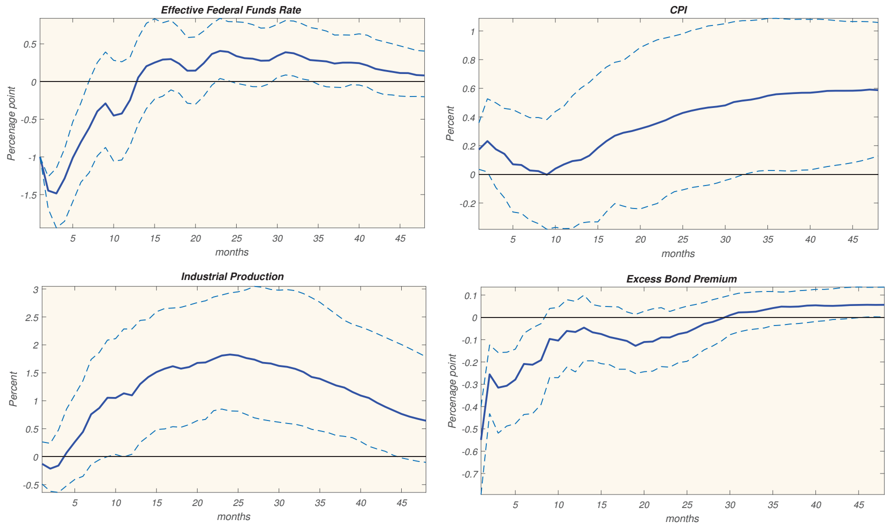
We use data in monthly frequency starting from July 1979, (when Paul Volcker became Chairman of the Federal Reserve) to July 2012. The reduced form of the VAR is estimated with a lag order of twelve as is usual in monthly VARs. Figure 1 displays the IRFs of the baseline model with 95 percent confidence bands. We show how a 100 basis point decrease in the federal funds rate leads to an increase of the consumer price index that is statistically significant since the month 30. As Gertler and Karadi (2015) and Sterk and Tenreyro (2018) we find a persistently increase in consumer price index by about 0.5 per cent. Thus, our results do not exhibit a price puzzle [4].This result is important for us since unexpected inflation leads to wealth distributive effects as we show in our theoretical model. On the other hand, the baseline model reports an increase of industrial production of about 2 percent similar to the one found by Ramey (2016)) and Paul et al. (2017). Expansive monetary policy leads to a statisti-

[3] We use other financial indicators for the interest variables finding similar responses- i.e. Dow Jones Index for stock prices, SP/Case-Shiller national home price index for home prices, treasury bond prices with different maturity for bond prices and the federal ten-year Treasury Bill as indicators of the interest rate

[4] Bernanke and Kuttner (2005) and Castelnuovo and Surico (2010) show other VAR approaches that avoid the price puzzle

cally significant effect on industrial production from month 7 onward. Finally, the response of the excess bond premium shows a decrease of roughly 50 basis points and this effect remains statistically significant up to eleven periods after the monetary policy shock.

Figure 1: Responses to an Expansionary Monetary Policy Shock in the Baseline model



The estimated IRFs of the interest financial and economic variables are depicted in Figure 2. The monetary expansion of a 100 basis point decrease in the federal funds rate leads to a strong increase of the stock prices, which reach almost 14 per cent in the month 7 after the shock, being statistically significant during all the period considered. Regarding home prices and bond prices, we find a slight increase in both, but not statistically significant in the case of home prices up to month 43. Finally, the interest rate index shows a large and significant decline. All of these results on financial and economic variables are consistent with conventional monetary theory and with the channel explained in the previous section. Furthermore, these results are in line with those obtained by event studies (Gürkaynak et al. (2005) Rogers et al. (2014) or Rosa (2012)), VAR approaches (Paul et al. (2017)) in the US and by Peersman and Smets (2001) in the Eurozone, given the sign of our shock.

The specific effects of the monetary shock on our interest variables in different time horizons are detailed in table 1. We use this information to simulate changes in wealth distribution in three different time horizons. In the next section, we explore how the effects of monetary policy on these variables could have distributive effects considering the portfolio composition of households.

Figure 2: Responses to an Expansionary Monetary Policy Shock in the interest variables

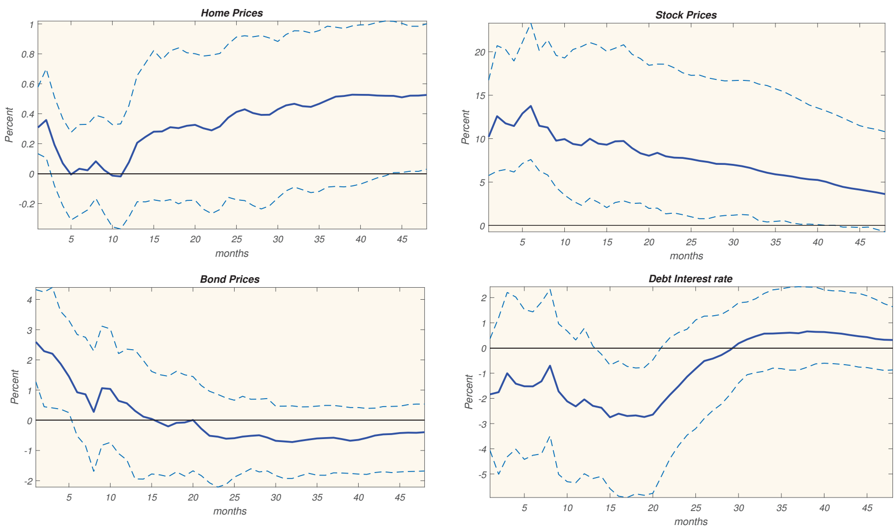


Table 1: Response of an monetary policy shock

Time	Stock Prices	Home Prices	Bond Prices	Interest Rate	Inflation Rate
6	13.76%	0.03%	0.93%	-1.52%	0.07%
12	9.23%	0.07%	0.56%	-2.04%	0.1%
30	6.98%	0.43%	0	0	0.48%

Percentage variation response of an exogenous 100 basis point shock reduction in the federal funds rate. For responses in 30 months following the shock of bond prices and interest rate we set the percentage variation to zero

4. Micro empirical evidence

In this section we simulate the impact of the changes in interest rates, asset prices, and inflation rate obtained in the IRFs of the previous section and detailed in table 1, on wealth inequality. To do so, we follow the approach of Adam and Zhu (2015) for the Eurozone and Domanski et al. (2016) for several advanced economies using microdata from the Survey of Consumer Finances, but expanding the analysis measuring the effects of asset prices, interest rate, and inflation rate following our formal model introduced in section 2. Furthermore, we do not apply a random change in these variables, instead we use the results obtained from our macro empirical analysis to simulate the wealth distribution effects.

4.1. Methodology and data

For the micro simulation part of this paper we use the portfolio information available from the most recent Survey of Consumer Finances (SCF 2016) to compute household net worth. The SCF is a triennial cross-sectional survey sponsored by the United States Federal Reserve Board in cooperation with the U.S. Treasury Department. It includes information on U.S. families' balance sheets, pensions, income, and demographic characteristics. The selection technique of the sample attempts to select families from all economic strata and ensures the representativeness of the study (see Kennickell (2005)). In 2016, the most recent study, a total of 6.500 families participated in the interviews.

Our research focuses on the following five variables: stocks, bonds, housing, debt, and net worth. The definition of these variables is presented as follows: we construct total stocks as the sum of directly held stocks, stock mutual funds, and businesses' (with either an active or non-active interest) non-financial assets. Total bonds are calculated as the sum of directly held bonds, savings bonds, tax-free bond mutual funds, government bond mutual funds, and other bond mutual funds. We define housing wealth as the sum of primary residence, other residential property (e.g., vacation homes), and net equity in non-residential real estate. Total debt is defined as the sum of debt secured by primary residence, debt secured by other residential property, other lines of credit, credit card balances after last payment, instalment loans, and other debts (e.g., loans against pensions or life insurance, margin loans). Finally, we define households' net worth as the difference between all household assets (total financial and non-financial assets) minus all debt. In appendix 2, we provide a short analysis of the net worth distribution as well as the composition of household net worth according to this survey. However, in initially approaching the data, we consider first that the net worth is highly concentrated (Gini coefficient of 0.86) and financial assets are highly concentrated in the top of the distribution, and secondly that debt over net worth is more concentrated in the bottom of the distribution.

Considering the previously defined variables, we then follow equation 6 of our framework to get the average net nominal return of net worth for each household. With this purpose, we first obtain the ratios representing the weight of stocks, bonds, housing and debt in household total net worth. After that, we multiply the resulting ratios by the considered price increases in the different simulation scenarios.

For instance, in our first simulation scenario a 10% increase in stock prices, bond prices, home prices, and a 10% reduction in interest rate are considered. The remaining three scenarios consider the percentage increases from our results in the macro empirical evidence on the effects of monetary policy shocks on the financial and macroeconomic variables evaluated (see table 1). Finally, following equation 7 of our framework, we divide the inflation responses of table 1 to scale the new household net worth. By doing so, we obtain in absolute terms distributive changes where if π_t >0, it will reduce the real net worth for all households i W_i >0, while it will benefit the real value of net worth for all i households W_i <0 By conducting this analysis, we are implicitly assuming that households do not adjust their portfolios in response to monetary policy. As Domanski et al. (2016) asserts, this assumption can be justified by thinking of our simulation as a partial equilibrium exercise. However, we can assume this since it is supported by the empirical evidence on considerable inertia in household portfolios, Wolff (2016) Ameriks and Zeldes or Lenza and Slacalek (2018)

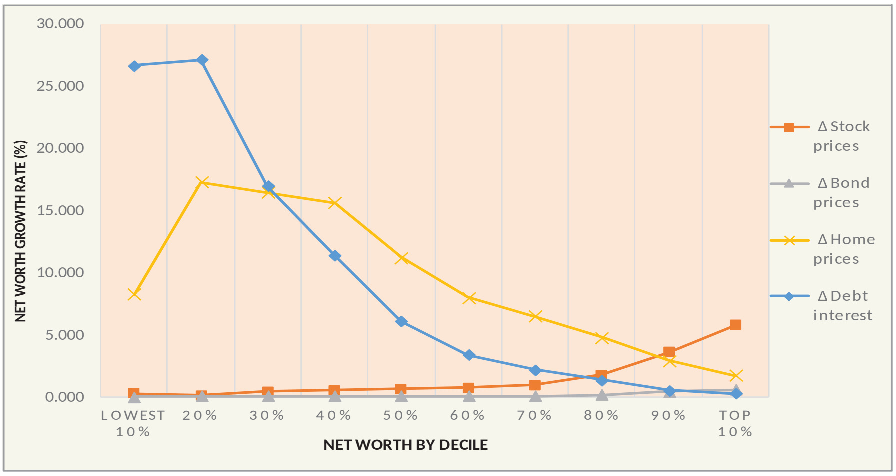
On the other hand, we have to consider, as we explained before, that in this simulation we only consider the direct effects of monetary policy on wealth inequality through the portfolio channel, housing channel, debt channel and fisher effect, but we do not consider other forms of subtler wealth distribution including changes in wages, fiscal policy or saving rates. Besides, due to the lack of data we cannot consider accrued pension rights. Even though these funds are a source of future wealth to families, they are not in their direct control and cannot be marketed Wolff (2016).

4.2. Analysis of deciles of net worth distribution

Figures 3-6 depict the distribution of net growth rate in each of the scenarios considered. We show the distribution of these gains across household percentiles ranked by net wealth. The distribution is ordered from left to right, with the lowest 10 percent being the "the poorest households", located in the left extreme and the top 10 percent being "the richest households", located in the extreme right.

Figure 3 focuses on the simulation scenario of a 10 percent variation following the exercise carried out by Adam and Tzamourani (2016) for the Eurozone, but including the change produced by debt interest rate. Figure 3 shows that the change in bond prices is similar across the different deciles of households. However, the rest of the variables exhibit important variations. Focusing on the stock price increase, we can see that it increases the net worth of the households in the top of the distribution more. This is because stocks are highly concentrated among the richest households. The situation differs noticeably when we consider home prices and debt interest. The decrease of the debt interest by 10 % greatly benefits the poorest households increasing the net worth of the lowest 20 % by 27 %. This variation decreases as we move through the deciles of households and can be explained because of the composition of debt, since the lowest deciles maintain more debt over their net wealth (see Annex 2). Finally, the effect of an increase in home prices has a hump shape. This result is explained because among the poorest households there are fewer homeowners, and among the richest households, housing represents a small proportion of their net wealth, with stocks and bonds holdings being more important. Therefore, those who benefit more from an increase in home prices are those in the middle class, especially the bottom middle class households. This situation differs to the Euro Area as a whole (see Adam and Tzamourani (2016)) due to the fact that in the US there are more homeowners in the bottom middle part of the distribution and thus an increase in home prices tends to reduce wealth inequality.

Figure 3: Net Worth growth rate in simulation scenario (△ 10 %)



Figures 4-6 display the distribution of the net worth growth rate after an expansive monetary policy shock of an 100 basis point decrease in the federal funds rate in three different time horizons: short run (6 months), medium run (12 months) and long run (30 months), according to the results obtained in the last section. The picture for short and medium run is quite similar (figures 4 and 5). The expansive monetary policy shock notably increases the net worth of the richest households through stock price increases and also markedly increases the net worth of the lowest households through the effect in the interest rate of the debt. Unsurprisingly, the effect of the changes in home prices and bond prices is quite modest due to the small impact of the monetary shock on them. Therefore, we can see that there are two great winners of the expansive monetary shock, the poorest and richest households, whereas the benefit of the middle class is so weak.

Figure 4: Net Worth growth rate 6 months after the shock

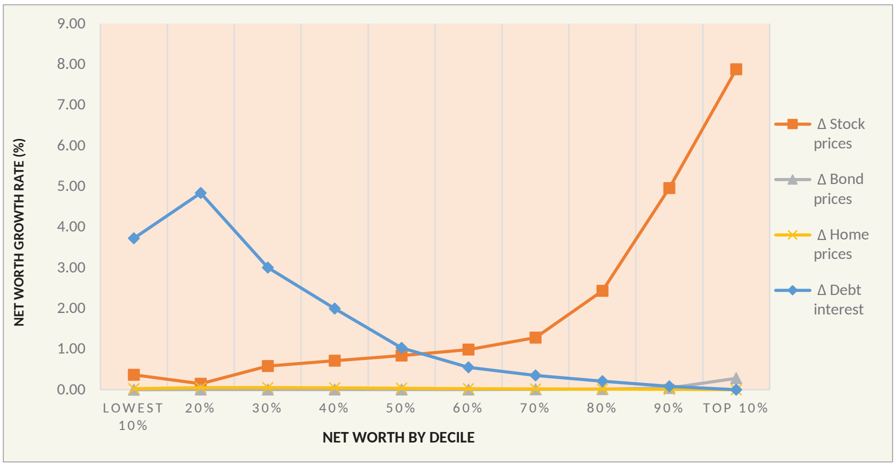
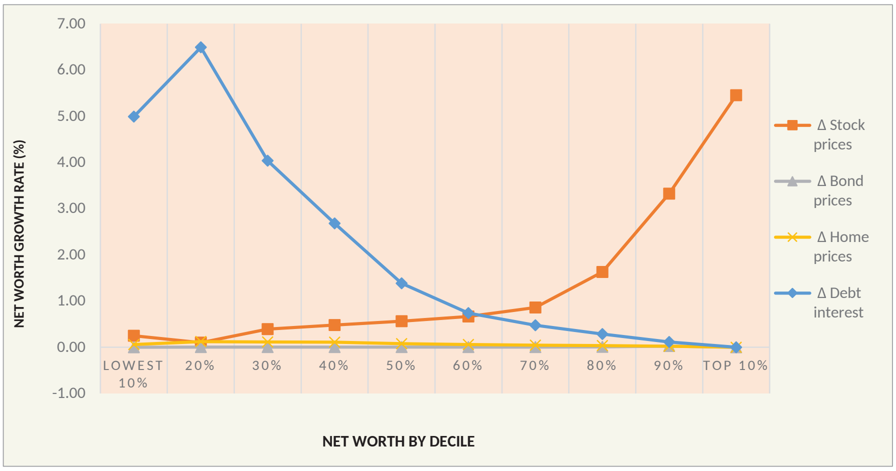


Figure 5: Net Worth growth rate 1 year after the shock



This picture changes when we focus on the long run, since the effect of monetary policy on the debt interest rate dissipates faster over time than the effect on stock prices (figure 6). Hence, we find that an expansive monetary policy shock increases the net wealth of the households in the top of the distribution more. Therefore, the effect of monetary policy on stock prices is the most important driver of net wealth inequality in the long run.

Figure 6: Net Worth growth rate 30 months after the shock

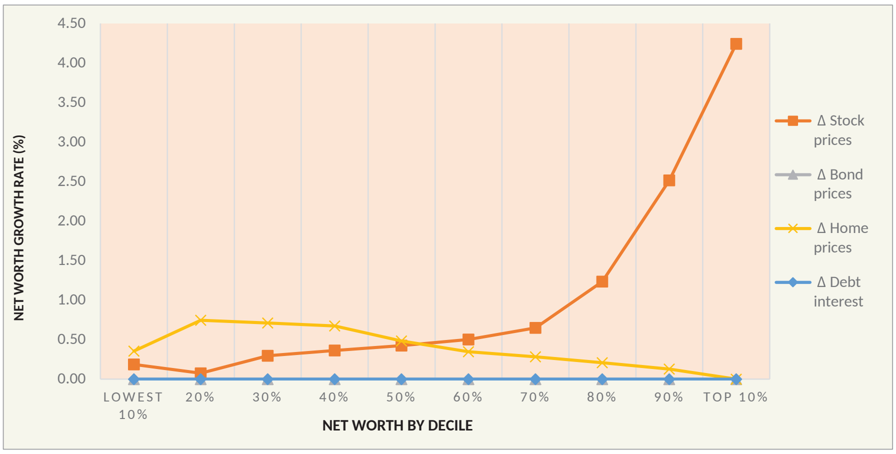
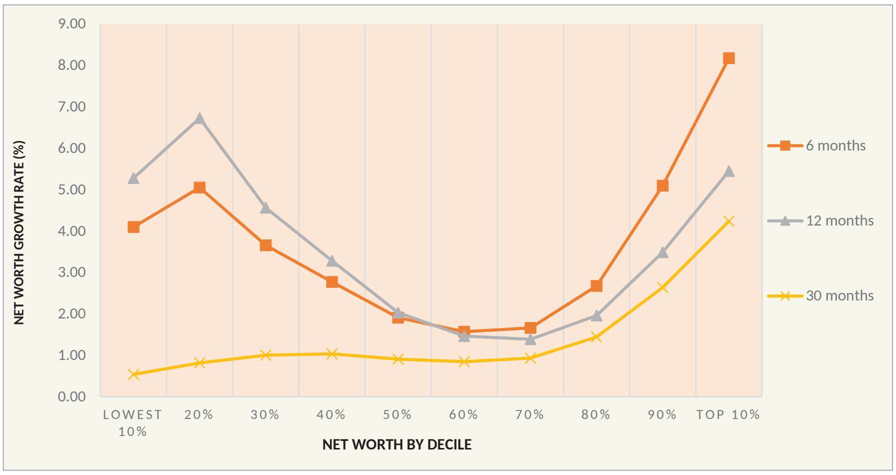


Figure 7 depicts the aggregate net worth growth rate by deciles of net worth for the 3 time horizons specified. This figure shows very relevant finding. An expansive monetary policy shock benefits the poorest and richest households in the short and medium run (increments of their net worth greater than 5%). The middle class is notably the least benefited, especially the upper middle class whose net worth barely increases at around 2 %. If we focus on the effects of monetary policy on the long run, the figure also displays an interesting result. For a time horizon of 30 months, the households in the top of the distribution experience a significant increase in net worth (around 4%), but the households in the bottom part only show a small increase (around a 0.5% for households in the first decile). These results clearly indicate that, whereas in the long run, an expansive monetary policy tends to increase net wealth inequality, in the short and medium run the impact is not so clear since the most benefited are in the two tails of the net wealth distribution.

Figure 7: Net Worth growth rate in all scenarios



4.3. Simulations of Gini coefficients

In table 2, we report the Gini coefficients since we are interested in using a measure that effectively summarizes the whole distribution, rather than just focusing on one location in the distribution.

To do so, we measure the change in net wealth inequality before and after an expansive monetary policy and we report in table 2 the Gini coefficients for the net wealth distribution. Table 2 reports the coefficients prior to any net wealth gain realization and after changes in stock prices, bond prices, home prices and debt interest rate respectively for the 4 scenarios that we consider, including the simulation of 10 %.

Our results show that in our simulation scenario - all assets prices increasing by a 10 % and the debt interest rate decreasing also by a 10%- the Gini coefficient records a rise after an increase in stock and bond prices. However, this rise is more than compensated when we consider the effect of changes of the housing prices and the interest rate, leading to a final decrease in the Gini coefficient of a 1.20%.

Nevertheless, when we consider the effect of monetary policy for the three time horizons, we find that the increase in the Gini coefficient driven through stock prices is not compensated by changes in home prices and interest rates increasing net wealth inequality. This is more than evident in the short run (6 months after shocks) and long run (30 months after shock), because the effect of monetary policy on stock prices and the rest of the variables reaches the widest differences. Hence, according to our simulations for the Gini coefficient, we find that the direct effects of expansive monetary policy increase wealth inequality considering the portfolio channel, housing channel, and debt channel.

On the other hand, in order to quantify the effect of inflation on wealth inequality according to equation 7 of our framework -this is the fisher effect- we cannot use relative measures of inequality such as relative Gini coefficient or percentiles shares. Additionally, whilst there is a wide consensus in the analysis of income or consumption, measuring net wealth inequality is a challenge, fundamentally because of the presence of negative net worth Jenkins and Jantti (2005). These features make some traditional measures of relative inequality inadequate and new measures of wealth inequality welcome. One of the most popular is the absolute Gini coefficient.

Therefore, to test our results and compute the fisher effect of monetary policy on wealth distribution, we follow Cowell and Van Kerm (2015) and we compute the absolute Gini coefficient. Table 3 reports the results in each scenario. We find that when the change in inflation rate is high, as in the case of the simulation scenario or 12 months after the monetary policy shock, the effect on absolute wealth inequality is relevant. This is the absolute Gini index decrease. However, the results are in line with those obtained when using relative inequality measures. In the simulation model when all the variables analysed change in the same proportion, we observe a reduction in net wealth inequality of -1.67% in absolute terms. Nevertheless, when we focus on the changes produced by the monetary shock, the effect of the asset price rise prevails over the rest of the variables leading to an increase in wealth inequality. Therefore, also considering the fisher effect on wealth distribution, our results show that an expansive monetary policy shock tends to increase net wealth inequality in both the short and long run.

Table 2: Gini coefficients for the net wealth distribution.

Scenarios	Prior	△ Stock	D.Gini (%)	△ Bond	D. Gini (%)	△ Home	D.Gini (%)	△ Int.	D.Gini (%)
Sim.10%	0.8606	0.8630	0.2742	0.8633	0.3149	0.8565	-0.4776	0.8503	-1.1968
6 m	0.8606	0.8641	0.4020	0.8641	0.4055	0.8641	0.4032	0.8630	0.2812
12 m	0.8606	0.8627	0.2475	0.8628	0.2498	0.8627	0.2440	0.8613	0.0779
30 m	0.8606	0.8621	0.1696	0.8621	0.1696	0.8618	0.1336	0.8618	0.1336

Table 3: Absolute Gini coefficients for the net wealth distribution.

Scenarios	Prior	△ Stock	D.Gini (%)	△ Bond	D. Gini (%)	△ Home	D.Gini (%)	△ Int.	D.Gini (%)	△ π	D.Gini (%)
Sim.10%	600000	630000	5.00	630000	5.00	650000	8.33	650000	8.33	590000	-1.67
6 m	600000	630000	5.00	640000	6.67	640000	6.67	640000	6.67	640000	6.67
12 m	600000	620000	3.33	620000	3.33	620000	3.33	630000	5.00	620000	3.33
30 m	600000	620000	3.33	620000	3.33	620000	3.33	620000	3.33	620000	3.33

5. Conclusions

In this paper, we have examined the redistribution implications of monetary policy on wealth inequality. First, we have developed a simple framework to examine the redistributive repercussions of changes in monetary policy on net worth. Then, we have used macro data and a VAR approach to estimate the response of real and financial variables to a monetary policy rate reduction, which could affect wealth distribution. A first conclusion from our research is that changes in monetary policy lead to no homogeneous responses on financial and real variables. We find that an expansive monetary policy shock increases to a greater extent stock prices than home and bond prices. Additionally, we find a significant reduction in the debt interest rate and a slight rise in the inflation rate. All these responses have fairly different distributional implications in the US.

Subsequently, we explore the evolution of household wealth inequality in the US by simulating changes in the value of household assets and liabilities, as well as in the inflation rate, according to our previous macroeconomic analysis. The simulation results suggest that wealth inequality increases after an expansive monetary policy shock considering three different time horizons. We find that increases of the stock and bond prices significantly increase net worth inequality, while increases of the housing prices and reductions of the debt interest rate reduction significantly reduce net wealth inequality without offsetting the first effect. Similarly, inflation rate increases tend to reduce absolute net wealth inequality, but they do not offset the rise produced by the stock price increases. Focusing on the net worth by deciles, our results suggest that an expansive monetary policy shock substantially increases the net worth of the richest and the poorest households ranked by net worth, while the middle class tends to benefit less. This result is explained by the fact that the effects of monetary policy on stock prices and debt are the most important drivers of increases on net wealth inequality, being two financial assets concentrated among the richest and poorest households respectively.

Nevertheless, important warnings apply when interpreting these results. First, our simulations focus only on the direct effects of monetary policy on the distribution of net wealth, leaving aside other subtler channels of distributional effects, such as changes in fiscal policy, wages or savings rates. Second, the value of future Social Security benefits that households can receive upon retirement is not included in our study due to a series of conceptual challenges. Finally, changes in capital gains do not necessarily imply improvements in welfare (e.g. prime residences).

While recent studies have documented the relationship between monetary policy and income inequality, there are few studies that explore the nexus between monetary policy and wealth inequality. This research aims to fill this gap. Understanding the effects of monetary policy on wealth inequality is not only valuable for broadening knowledge about distributive implications, but also for a better understanding of the transmission mechanism of monetary policy to consumption and the effectiveness of monetary policy itself.

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Appendix A. Proxy VAR

To analyzed and quantify the dynamic responses of real and financial macroeconomic variables we propose a proxy VAR which combine High Frequency Identification of shocks with a VAR approach following Gertler and Karadi (2015). Specifically, the shocks obtained using HFI are used as external instruments for the monetary policy indicator.

Let Y_t be the vector of real and financial variables which include the following variables in the baseline : Federal Fund rate (FF), consumer price index (CPI), industrial production (IP) and excess bond premium (EBP) plus one additional variable for the rest of our specifications, the structural form of the VAR is represented as

$$AY_t = C + \sum_{j=1}^{p} B_j Y_{t-j} + \varepsilon_t \tag{A.1}$$

where A is a nxn matrix which represent the contemporaneous relation between the endogenous variables and n denotes the length of the endogenous variables, Y_t is a nx1 vector of contemporaneous economic and financial variables, C is a nx1 vector of constant terms, B_j is a nxn matrix that captures the coefficients associated with each lagged variable and ε_t is a nx1 vector denoting the structural error terms.

The estimation of the reduced-form equation of the structural model (A.1) can be described as follows:

$$Y_t = B + \sum_{j=1}^{p} \Phi_j Y_{t-j} + u_t \tag{A.2}$$

where $B = A^{-1}C$; $\Phi_j = A^{-1}B_j$ and $u_t = A^{-1}\varepsilon_t$.

The nx1 vector u_t represents the reduced form residuals with $Var(u_t) = \Sigma$, u_t follows a normal distribution with mean 0 and variance Σ, i.e., $u_t \sim N(0, \Sigma)$.

The reduced form of the VAR was estimated with a lag order of 12 in all the specifications as it is usual in a monthly VAR. The period analyzed was from July 1979 to February 2018.

We use external instrument methodology as identification strategy developed by Stock and Watson (2012) and Mertens and Ravn (2013). Being our policy indicator the federal fund rate, the reduced VAR innovations u_t can be represented as $u_t = [u_t^{mp} u_t^{r\prime}]'$, where u_t^{mp} and u_t^r represent the reduced form residual associated with our policy indicator and u_t^r the reduced form residual associated with all other variables included in Y_t. Hence, given that the reduced form residuals are a linear combination of the structural shocks ϵ_t, the structural shocks contained in ϵ_t is represented as $\epsilon_t = [\epsilon_t^{mp} \epsilon_t^{r\prime}]'$ where ϵ_t^{mp} represents the structural shock associated with the policy indicator and ϵ_t^r represents the structural shock associated with all other endogenous variables at period t.

Z_t represents the vector of the instruments for our policy indicator, in our case the instruments are the surprises to the price of Fed Funds futures in short windows of 30 minutes around monetary policy announcements from 1991:1 through 2012:6 taken by Gertler and Karadi (2015). To the vector of instrumental variables Z_t to be a valid set of instruments for the monetary policy shock ϵ_t^{mp} , we need $E(Z_t \epsilon_t^p) = \phi \; and E(Z_t \epsilon_t^r) = 0$, where $\phi \neq 0$.

Hence, there are two assumption that we need in order to obtain the instrument. First, the relevance condition which implies that the set of instruments has to be correlated with the structural shock of the policy indicator. The last is the exogeneity condition which implies that the set of instruments has to be uncorrelated with the structural shocks associated with the remaining endogenous variables in Y_t.

To obtain the responses of the economic and financial variables to a monetary policy shock, we run

$$Y_t = b + \sum_{j=1}^{p} \theta_j Y_{t-j} + a\epsilon_t^p \tag{A.3}$$

where $u_t = A^{-1}\epsilon_t$. a denotes the unknown column of matrix A^{-1} which represents the responses to the associated monetary policy shock. Now, we need to imposed some restrictions in order to identify column vector a. Note that we avoid the traditional identification strategy of the Cholesky identification.

This classical strategy is not realistic since we are combining both financial and economic variables and it is not plausible that a monetary policy shock should have no immediate effect on the financial variables. Besides, it could lead misleading results Gertler and Karadi (2015) and Ramey (2016) . To obtain the estimated coefficients in equation A.3, let a^{mp} be the element of a which represents the response of the policy indicator to a monetary policy shock. We need

$$u_t^{mp} = a^{mp} \varepsilon_t^{mp} \tag{A.4}$$

In the following way, let a^r be the partition of column vector a corresponding to the responses of the other variables to a monetary policy shock. Also,

$$u_t^r = a^r \varepsilon_t^{mp} \tag{A.5}$$

solving ε_t^{mp} in both equation A.4 and A.5 we obtain

$$\varepsilon_t^{mp} = \frac{u_t^{mp}}{a^{mp}} = \frac{u_t^r}{a^r} \tag{A.6}$$

and rearranging

$$u_t^r = \frac{a^r}{a^{mp}} u_t^{mp} \tag{A.7}$$

we proceed in two steps. First of all, the estimated reduced form residuals are obtained by the regression of equation A.2. Then, 2SLS regression is applied to obtain a consistent estimate of the ratio s^r/s^p in order to avoid endogeneity problems of u_t^{mp}. The first-stage regression of the 2SLS procedure consists of regressing the reduced-form residuals of the equation of the policy indicator on the set of instruments [6]. Once we obtain an estimate of u_t^{mp} that it is exogenous from u_t^r by the exogeneity assumption that the set instrument must satisfy, it is incorporated into equation A.8.

[6]We provide the first-stage regression of all specifications considered in Appendix B

$$u_t^r = \frac{a^r}{a^{mp}} \hat{u}_t^{mp} + \nu_t \tag{A.8}$$

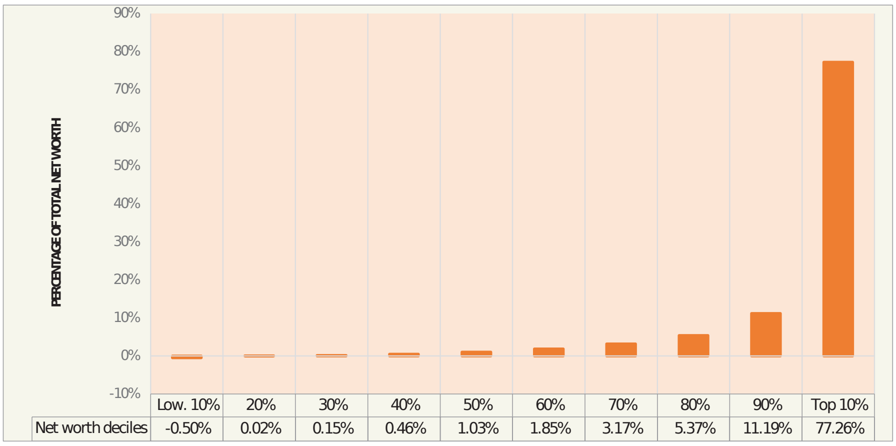
where $E(\hat{u}_t \nu_t) = 0$ by Appendix A since $\hat{u}_t$ is a linear function of ϵ_t^r. To obtain an estimate of a^{mp}, we have to use the variance-covariance matrix ($E(u_t u_t') = \Sigma$) of the reduced form of the VAR and equation (A.8). Once the estimates of a^{mp} and a^r [7] have been obtained and using each of the θ_j, we calculate the impulse response function responses to monetary policy surprises using equation A.3.

[7] For more details of how to obtain them, see Gertler and Karadi (2015)

Appendix B. Analysis of SCF (2016)

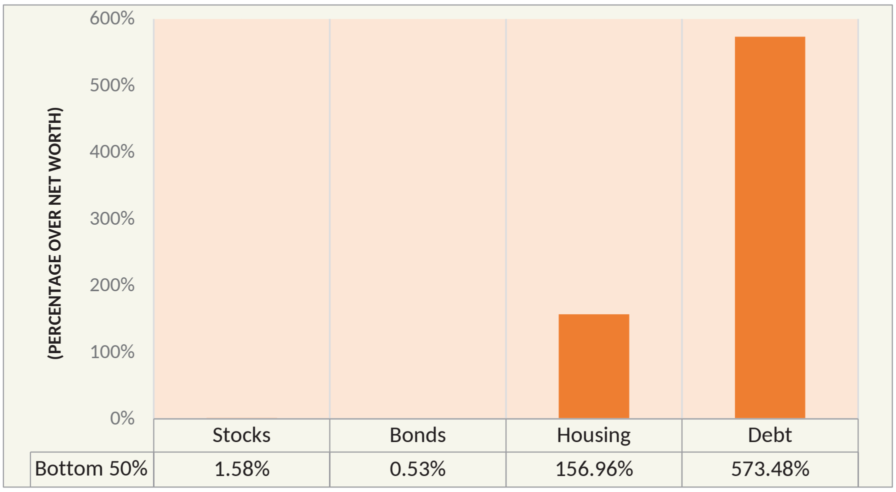
Recent studies have documented trends in either income or wealth inequality in the United States (Saez and Zucman (2016), Wolff (2016), Piketty et al. (2017) or Kuhn et al. (2017). It is well known that wealth inequality is distributed historically less equally than income, and financial assets are less equally distributed than non-financial assets (Davies and Shorrocks (2000)). Figure B.8 clearly shows that net worth is highly concentrated in the US. The lowest 10% ranked by net wealth owns, on average, a negative net worth, meaning that they own more liabilities than assets. The next 10% practically owns 0 net wealth, while the top 10% owns 77.2 percent.

Figure B.8: Distribution of net worth ranked by net worth deciles, SFC 2016



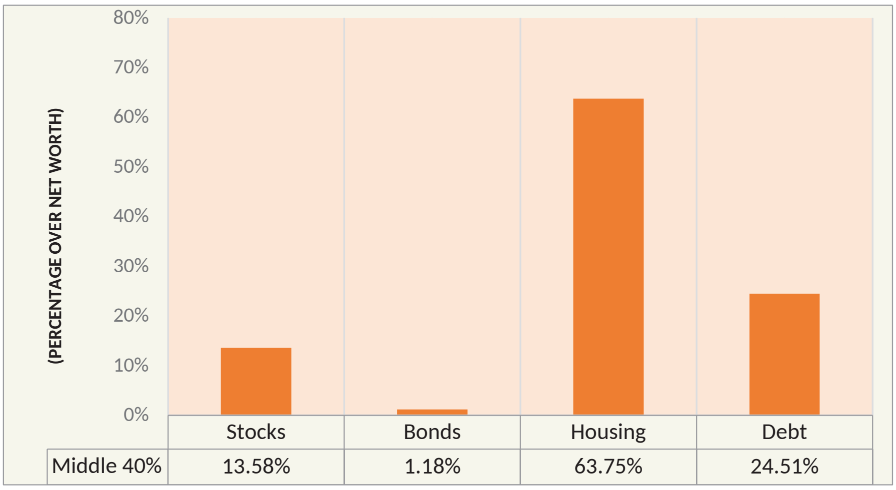
Figures B.9 - B.11 show the portfolio composition by wealth class. As shown in Figure B.9, the bottom 50% percent of households (as ranked by wealth) share a 156 percent of their net worth in housing; while they almost do not own financial assets. The ratio of debt to net worth is 537.48% percent, substantially higher than the rest of the wealthy class. This is explained because these households maintain great amounts of debt over their scarce net wealth. The relative Gini coefficient of net worth reaches 0.86 according to our estimations.

Figure B.9: Composition of household net wealth by wealth class, SFC 2016 (Bottom 50%)



As shown in figure B.10, among the middle 40 percent of US households, housing comprises 63.75 percent of their net worth, stocks 13.58 percent and bonds a scarce 1.18 percent. Debt amounts to a 24.51 percent of their net worth.

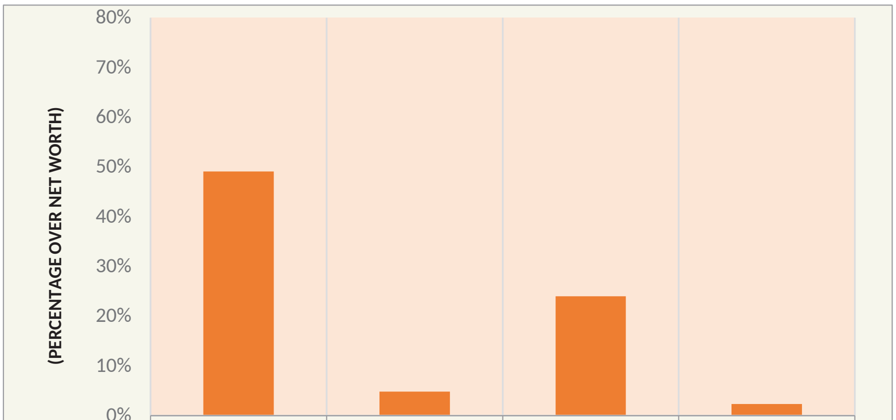
Figure B.10: Composition of household net wealth by wealth class, SFC 2016 (Middle 40%)



In contrast, figure B.11 shows that the richest ten percent of households own 49.07 percent of their net worth in stocks and a 4.86 percent in bonds.

Housing accounts for only 24.01 percent of their net wealth, a substantially smaller percentage than the bottom and the middle part of the distribution. Similarly, their debt-net worth ratio is only 2.35 percent.

Figure B.11: Composition of household net wealth by wealth class, SFC 2016 (Top 10%)



	Stocks	Bonds	Housing	Debt
Top 10%	49.07%	4.86%	24.01%	2.35%

The great differences which are showed in this Annex in portfolio composition between wealth classes translate into large disparities in rates of return on household wealth over time as shown by Wolff (2016). These disparities are important when it comes to studying the wealth distributional effects of monetary policy, specifically the portfolio channel, housing channel, as well as debt channel.