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Abstract

I explore the dynamic effects of monetary policy on the distribution of household wealth in the United States. I provide new evidence that monetary policy plays a significant role in driving persistent movements in wealth inequality. Using the new Distributional Financial Accounts and high-frequency identification, I find that contractionary monetary policy disproportionately reduces the net worth of the bottom 50% of households by wealth. By decomposing net worth into asset prices and quantities, I find that wealth dynamics for the top 1% of households follow from a reduction in equity prices while the dynamics for the bottom 50% of households are driven by high leverage ratios and a reduction in holdings of and consumer durables, consistent with a consumption smoothing motive. I show that the magnitude of these responses is larger following episodes of monetary tightening than easing for the bottom 50%.

Additionally, we study how the level of government debt affects the effectiveness of monetary policy, i.e., the elasticity of economic aggregates to interest rate changes. We build a New Keynesian model where fiscal policy is non-Ricardian and government debt is risk-free. Wealth effects generated by government bonds weaken the transmission of changes in the policy rate to output. Using data on private ownership of public debt for the U.S., we find that when government debt is one standard deviation above its mean, the response of industrial production and unemployment to an expansionary monetary shock is reduced by 0.5pp and 0.075pp, respectively, out to a three-year horizon.

Finally, I study the dynamics of the household wealth distribution in response to changes in government spending in the U.S. I find that increases in government spending raise the net worth of all groups except for the top 1%. Decomposing the responses of wealth into broad asset and liability classes, I find that responses are largely driven by an appreciation in the price of real estate. These results are consistent with a mild and temporary compression of the household wealth distribution.

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Monetary Policy and the Dynamics of Wealth Inequality

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Abstract

I explore the dynamic effects of monetary policy on the distribution of household wealth in the United States. I provide new evidence that monetary policy plays a significant role in driving persistent movements in wealth inequality. Using the new Distributional Financial Accounts and high-frequency identification, I find that contractionary monetary policy disproportionately reduces the net worth of the bottom 50% of households by wealth. By decomposing net worth into asset prices and quantities, I find that wealth dynamics for the top 1% of households follow from a reduction in equity prices while the dynamics for the bottom 50% of households are driven by high leverage ratios and a reduction in holdings of and consumer durables, consistent with a consumption smoothing motive. I show that the magnitude of these responses is larger following episodes of monetary tightening than easing for the bottom 50%.

JEL Codes: D14, D31, E44, E52, E58

Keywords: Monetary Policy, Household Heterogeneity, Wealth Inequality

5.1 Introduction

As wealth inequality continues to rise across advanced economies, policymakers are now more than ever under scrutiny for the role that their public policy decisions take in exacerbating or mitigating these trends. Consequently, economists have made a concerted effort to study the causes and consequences of inequality (Krueger, Mitman and Perri, 2016). I focus on the contribution of monetary policy to wealth inequality for two reasons. First, the U.S. Federal Reserve System now has a key role in economic stabilization as a result of gridlock in the U.S. Congress. Second, a growing body of theoretical evidence supports the view that monetary policy operates primarily through channels of redistribution (Kaplan, Moll and Violante, 2018; Auclert, 2019).[1] I focus on the distribution of wealth, building on these studies of monetary transmission, which provide ample cause to suspect that monetary policy may contribute to shaping long-run trends in wealth inequality.

I contribute to our understanding of monetary policy as a source of growing wealth inequality. I find that an identified one percentage point increase in the one-year Treasury rate reduces the net worth of each group of households I consider, with sizable heterogeneity across groups. The top 1% of households by net worth suffer a reduction of nearly 20% of their net worth, resulting from reduced equity and house prices. The bottom 50% are not so lucky, suffering a 50% reduction in net worth after five years, largely stemming from heightened leverage, reduced house prices, and a substantial reduction in holdings of consumer durables.

My work with aggregate wealth data builds on a number of prior studies that estimate dynamic responses of income, earnings, and consumption inequality to monetary policy fluctuations. Parallel to my study of wealth, (Coibion et al., 2017) study dynamic responses of income and consumption to monetary policy shocks using the Survey of Consumer Finances (SCF). The authors find that the distribution of labor earnings, total

[1] A key insight in this body of research is that, expansionary monetary policy causes a redistribution of wealth and income to households with a high marginal propensity to consume, with a variety of structural foundations.

income, consumption, and total expenditures becomes more unequal in response to contractionary monetary policy. Exploiting cross-country variation, Furceri, Loungani and Zdzienicka (2018) find that contractionary monetary policy raises income inequality, and further that the response of inequality depends on the state of the business cycle. I bridge this literature into the study of wealth dynamics by demonstrating that wealth inequality responds asymmetrically to monetary policy. As I discuss, this asymmetry allows monetary policy to contribute to long run trends in wealth inequality.

Casiraghi et al. (2018) and Lenza and Slacalek (2018) study European micro data and conclude that the effects of monetary policy on wealth are non-monotonic over the wealth distribution. Both high and low-wealth (but high-leverage) households enjoy higher capital gains with expansionary monetary policy. The authors highlight the importance of asset price movements and the unequal holdings of assets over the wealth distribution. I contribute a additional channels for consideration: heterogeneity in household leverage and an asymmetry in the portfolio rebalancing response of high- and low-wealth households by disentangling movements in wealth due to changes in asset prices from the overall change in net worth.

I conduct my analysis using the Distributional Financial Accounts (DFA), a new quarterly dataset on the distribution of household wealth (Batty et al., 2019). Specifically, I use the distribution of wealth by percentiles of wealth. I estimate the dynamic responses of wealth to monetary policy surprises at a quarterly frequency, where prior studies of household wealth were limited to annual frequencies due to the lack of data. Furthermore, I demonstrate how these responses vary for households across the wealth distribution.

I find that the dynamics of wealth inequality in response to monetary policy depend on the portfolio characteristics of a given group. The bottom 50% of households own portfolios heavily invested in real estate and consumer durables, while the top 1% of households hold a disproportionate share of their wealth as equity in both publicly traded firms and private businesses. Due to the high sensitivity of equity prices to monetary policy that I find, the top 1% of households bear a large share of market risk, with correspondingly higher average returns to wealth. These observations conform with studies of long-run wealth dynamics including those of Benhabib, Bisin and Luo (2017) and Jordà et al. (2019), who document that wealthier households have earned higher average returns on wealth due to rising returns on equity relative to housing since the 1970s. Furthermore, using Norwegian administrative data, Fagereng et al. (2020) document that this inequality in returns to wealth exists within narrow asset classes.

I show that the average price of an asset held by the top 1% falls to a greater extent than that of the bottom 50% due to the sensitivity of equity prices to monetary policy. It has been widely documented that monetary policy plays a significant role in explaining movements in asset prices, with sizable equity price movements stemming from forward guidance and large-scale asset purchases (LSAPs) (Swanson, 2015; Jordà, Schularick and Taylor, 2020; Paul, 2020). However, I show that focusing on asset prices alone fails to capture purchases and sales of assets by households in response to monetary policy shocks, which play a key role in explaining the larger response of net worth among the bottom 50% than the top 1%.

I join a growing chorus of economists who challenge the assumption that monetary policy is neutral in the sense of preserving a given distribution of income and wealth. This assumption is convenient for both policymakers looking to avoid politically insipid trade-offs and among theorists for whom shifting distributions of wealth and income create computational challenges. However, central bankers have become increasingly concerned about the role that they may play in shaping wealth inequality. Mary C. Daly, President and CEO of the San Francisco Federal Reserve Bank, contends that inequality remains an important challenge to be addressed by public policy, but expresses concerns with an explicit target for wealth inequality (Daly, 2020). Daly argues: "[W]hat I as a policy maker don't want to do is take on a mandate that would be a trade-off. I would, if we are going to reduce wealth inequality, I would have to sacrifice millions of American jobs." Daly's views conform with a line of reasoning that accommodative monetary policy, by raising asset prices, tends to exacerbate wealth inequality due to the unequal holdings of assets across the economy. Daly reasons that reducing wealth inequality would require tighter monetary policy than would be warranted by the state of inflation and unemployment. I contribute to these discussions by offering new evidence on the economically significant role that monetary policy has played in determining trends in wealth inequality. The asymmetry I find in the consequences of expansionary and contractionary monetary policies warrants caution among central bankers considering contractionary policy actions.

5.1.1 Related Literature

My work is closely related to the growing body of research on the channels of monetary transmission and household heterogeneity (McKay, Nakamura and Steinsson, 2016; Guerrieri and Lorenzoni, 2017; Challe et al., 2018; Kaplan and Violante, 2018; Bayer et al., 2019). These studies augment the canonical dynamic New Keynesian model with uninsurable idiosyncratic risk and credit constraints to explain large observed macroeconomic responses to monetary policy relative to those predicted by representative agent models. Focusing on optimal monetary policy, Gornemann, Kuester and Nakajima (2016) and Bilbiie and Ragot (2021) find substantial welfare losses in heterogeneous household economies induced by strict inflation targeting. Due to the presence of uninsurable idiosyncratic risk, monetary policy faces a trade-off between stabilizing prices and eliminating consumption volatility among households who cannot borrow to smooth their consumption. These studies find that contractionary monetary policy temporarily raises income, earnings, and consumption inequality, but causes a permanent increase in wealth inequality. This latter possibility I explore further in section 5.4.4.

Doepke and Schneider (2006) and Doepke, Schneider and Selezneva (2015) study the classic Fisher channel, finding that unexpected changes in inflation result in substantial wealth redistribution from older and wealthier households to younger middle-class households by reducing the real value of fixed incomes of the former and the real value of fixed-rate mortgage debts owed by the latter. I likewise find that housing is an important determinant of portfolio returns conditional on monetary policy, however I find that unequal ownership of equities is a more substantial factor in driving heterogeneity of household returns due to the higher sensitivity of equity prices to monetary policy. The Fisher channel is weaker in my analysis due to the weak response of consumer prices to monetary policy that I estimate relative to asset prices, with a correspondingly small role for unexpected changes in inflation in altering the real value of household portfolios.

Another natural candidate to explain changes in wealth inequality is heterogeneous earnings. As Benhabib, Bisin and Zhu (2011) and Benhabib, Bisin and Luo (2017) and many others have noted, heterogeneity in sources of income can result in changes in the income distribution if income gains are concentrated among a small group of households. However, to capture the broad inequality in the upper tail of the U.S. wealth distribution, the authors conclude that trends in earnings alone cannot explain trends in wealth inequality. Among the theories posited to produce thick tails in the wealth distribution are returns to wealth that systematically rise with wealth and the portfolio heterogeneity I study in this paper. If earnings and saving behavior cannot fully determine the wealth distribution, then other factors including monetary policy may contribute to wealth inequality directly.

The remainder of the paper is structured as follows. Section 7.2 provides an overview of the portfolio heterogeneity documented by the DFA dataset and its implications. Section 7.3 documents the procedure I use to estimate the dynamic effects of monetary policy on household wealth. Section 7.4 presents my main results, as well as decompositions by asset classes. Section 5.5 presents robustness tests, and section 7.5 concludes.

5.2 Data

The Distributional Financial Accounts (Batty et al., 2019) are a novel quarterly dataset reporting estimates of the U.S. household wealth distribution since 1989. Table 1 reports average portfolio shares by wealth group for major asset and liability classes, which paint a stark picture of heterogeneity in household wealth portfolios, both by size and by composition. The bottom 50% of households hold very few financial assets which comprise 28% of their total assets on average over the sample. Over half of the value of their assets are held in real estate with 21% in consumer durables. On the other hand, the top 1% own large asset portfolios over 83% of which are financial assets, primarily corporate equities, pension entitlements, and equity in non-corporate businesses. Despite large holdings by the top 1%, real estate comprises just 14% of their asset portfolio on average.

These figures support the findings of Kuhn, Schularick and Steins (2020), who use historical wealth surveys to highlight the importance of portfolio heterogeneity in explaining differences in returns to wealth between the rich and the poor over time. Non-financial assets, which comprise a disproportionate share of the assets held by the bottom 50%, appreciate more slowly than the financial assets held by the top 1% in greater proportions, whose asset prices inherit risk premia from a heightened exposure to aggregate market risk. As we will see, these trends are mirrored by a higher conditional volatility of asset prices borne by the top 1% in response to monetary policy surprises.

Table 1 additionally reports leverage ratios for each group of households as the ratio of total assets to net worth. Leverage ratios are a useful measure of sensitivity to financial risk, as more leveraged households face larger net worth volatility than households with higher equity ratios in response to asset price fluctuations. Whereas a fully-capitalized household will experience one-to-one changes in net worth when the value of their assets change, a household with a leverage ratio of two will lose two percent of their net worth with a one percent decrease in the value of their assets. Over the sample for which the

Table 1. Balance Sheets of U.S. Households, 1989-2021

Share of Assets (%)	Bottom 50%	Next 40%	Next 9%	Top 1%
Non-Financial Assets	71.761	42.192	26.268	17.329
Real Estate	51.154	34.567	22.352	13.635
Consumer Durables	20.607	7.625	3.916	3.694
Financial Assets	28.239	57.808	73.732	82.671
Checkable Deposits and Currency	1.767	1.134	1.007	0.783
Time deposits and short-term investments	4.325	8.289	8.227	6.783
Money market fund shares	0.371	1.313	2.323	2.671
Debt securities	0.721	2.088	4.479	10.525
U.S. government and municipal securities	0.575	1.466	3.270	7.875
Corporate and foreign bonds	0.146	0.622	1.209	2.650
Loans	0.092	0.275	0.943	2.159
Other loans and advances	0.032	0.147	0.652	1.848
Mortgages	0.060	0.128	0.291	0.310
Corporate equities	2.376	7.042	16.862	30.513
Life insurance reserves	2.254	1.982	1.364	1.208
Pension entitlements	10.830	29.290	28.325	7.256
Equity in non-corporate business	2.477	4.960	9.498	20.398
Miscellaneous assets	3.025	1.435	0.704	0.374
Net Worth (Capital ratio)	28.338	81.238	92.116	97.059

Share of Liabilities (%)	Bottom 50%	Next 40%	Next 9%	Top 1%
Loans	99.910	99.723	99.549	99.050
Home mortgages	60.161	77.725	82.124	68.645
Consumer credit	37.026	19.512	10.191	8.193
Depository institution loans n.e.c.	0.794	0.464	0.461	2.368
Other loans and advances	1.929	2.022	6.773	19.844
Deferred and unpaid life insurance premiums	0.090	0.277	0.451	0.950

Notes: The table reports mean share of each asset in total assets and each liability in total liabilities for each group between 1989 and 2020. Definitions are summarized in the text, and described in detail in Batty et al. (2019) and documentation for Financial Accounts table B.101.h.

DFAs are available, the average capital ratio of the bottom 50% of households is barely over one-quarter, while the top 1% of households are nearly fully capitalized on average. These systematic differences in leverage ratios are an important factor in explaining the sensitivity of household wealth to monetary policy shocks. Perhaps unsurprisingly, this leverage primarily appears in housing, where the bottom 50% of households collectively own just under 16% of the value of their homes, while the top 1% hold over 85% of their real estate as home equity. Of course, these numbers mask heterogeneity within these groups of households, which may be substantial especially at the lower tail of the household wealth distribution, where we would see insolvent households with negative home equity.

Figure 29 plots a decomposition of the balance sheets of each household quantile group by wealth over time. The net worth of the bottom 50% of households fluctuates without a discernible trend, falling near zero in the wake of the Global Financial Crisis, while each other quantile group exhibits net worth trending upward. Although all groups experience deep losses during the crisis, the top 1% of households collectively sufferend a loss of just over 21% of their net worth between 2007:Q3 and the trough at 2009:Q1, while the bottom 50% saw over 81% of their net worth erased between 2007:Q1 and the trough, which occurred much later in 2010:Q2. The wealth of the bottom 50% only passed its pre-crisis peak in 2019:Q2, while the top 1% regained their lost wealth by 2012:Q1. Considering unconditional trend growth over the 1989-2021 sample, the top 1% experienced gains in net worth of 4.3% per annum, while the bottom 50% experienced gains of just under 1.3% per annum, consistent with deep portfolio heterogeneity and potentially heterogeneity in returns.

As noted, data availability poses a major challenge to the systematic study of wealth in the U.S., a shortcoming partially remedied by the triennial cross-sectional SCF conducted by the Federal Reserve Board. However, the low frequency of the SCF presents a difficulty in studying movements in wealth in the short run in response to policy changes.

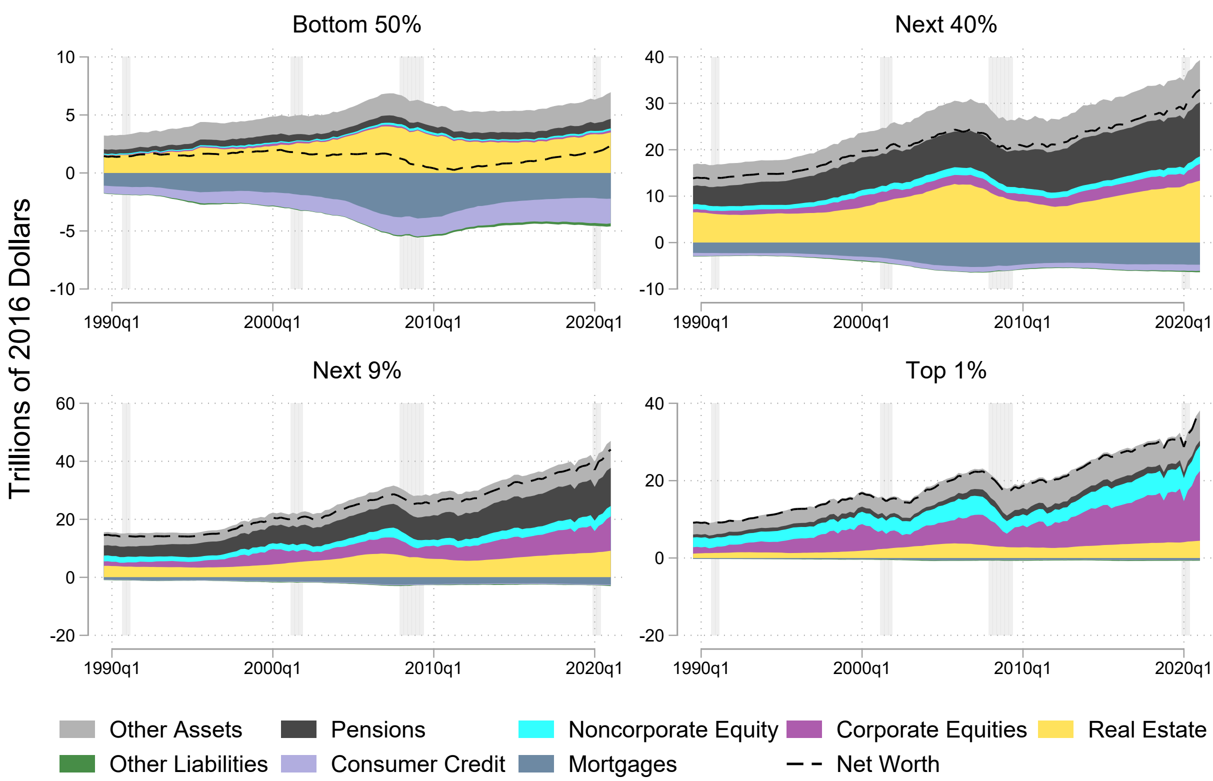


Figure 1. Balance Sheet Decompositions

Notes: Balance sheet decomposition for the bottom 50% and top 10% of households by wealth in the U.S. Shaded region indicates NBER recession.

Batty et al. (2019) document the procedure used to construct the DFA dataset, which combined the SCF with quarterly aggregate household wealth data provided by the Financial Accounts of the United States. The authors construct measures of wealth for each household quantile group adhering closely to the structure of table B.101.h of the Financial Accounts. The authors employ the temporal disaggregation method proposed by Chow and Lin (1971), by reconciling triennial SCF observations with related quarterly Financial Accounts data.[2]

5.3 Methods

5.3.1 IV - Local Projections

In order to trace the dynamic effects of unexpected monetary policy shocks on the wealth distribution, I rely on instrumental variable local projection (IV-LP) estimation following Jordà (2005), which consists of estimating quantile impulse responses via IV regression separately at each horizon. The choice of estimation procedure is a topic of debate in empirical macroeconomics literature. As discussed by (Montiel Olea and Plagborg-Møller, 2021), local projections perform well in comparison to alternative impulse response function estimation procedures such as a VAR when data are persistent and when forecast horizons are long. Since wealth distributions tend to shift slowly over time, a VAR system with a limited lag structure may not be sufficient to determine whether temporary shocks can generate persistent outcomes. Due to the limited sample length available using the current DFA dataset, a VAR with sufficient lags to determine persistence and a large set of control variables would place pressure on the number of degrees of freedom available to estimate impulse responses.

My baseline IV-LP specification is the system of equations for each horizon $h = 0 \ldots H$

[2] The method consists of assuming that low-frequency observations provided by the SCF are drawn from a latent high-frequency series, and forecasting the "missing" observations by using relevant high-frequency regressors.

and each household quantile group indexed by i, given by

$$\Delta^h y_{i,t+h} = \alpha^{i,h} + \beta^{i,h} \Delta R_t + \boldsymbol{\delta}^{i,h} \boldsymbol{X}_{i,t} + e^i_{t+h} \tag{1}$$

where y^i_t is the log of real net worth of group i and R_t is the one-year government bond rate, and $\Delta^h y_{i,t+h} = y_{i,t+h} - y_{i,t-1}$. The impulse response function for group i is given by the series $\{\beta^{i,h}\}^H_{h=0}$ As the forecast errors of a standard LP system are likely to be serially correlated, I use a lag-augmented local projection design, which allows for valid inference with standard Eicker-Huber-White standard errors (Montiel Olea and Plagborg-Møller, 2021). Beyond a single lag of y_t, my baseline specification includes no additional controls, which become redundant due to the procedure I use to generate the instrument series.[3]

I consider four household wealth quantile groups: the top 1%, the 1% to the 90%, the 50% to 90%, and the bottom 50%. Following Gertler and Karadi, I use the one-year bond rate as my indicator variable rather than the federal funds rate for two main reasons. First, interest rates with longer maturities are less sensitive than the federal funds rate to the ZLB, which is a challenge given that the federal funds rate remained near zero for almost one-third of my sample (Swanson and Williams, 2014). Second, interest rates on bonds with longer maturities reflect the expected path of future short-term interest rates as well as expectations of unconventional tools that operate on term premia. As the Federal Reserve becomes increasingly reliant on large-scale asset purchases and forward guidance to achieve its policy goals, the current stance of the federal funds rate becomes as a weaker measure of the stance of monetary policy, particularly during ZLB episodes.

The stance of monetary policy is, of course, determined endogenously in response to macroeconomic conditions. This is a standard identification problem common to empirical macroeconomic studies (Nakamura and Steinsson, 2018). As a result, estimates from equation 1 derived by OLS will be biased and inconsistent due to the contemporaneous

[3]Valid inference for IV-LP requires, among other things, strict lead-lag exogeneity of the instrument. This can be bought by augmenting the LP system with additional controls rendering that restriction conditionally true.

correlation between ΔR_t and e_{t+h}. This bias may be corrected by using a valid instrument. As Stock and Watson (2018) and Miranda-Agrippino and Ricco (2019) document, correct inference with an IV-LP specification such as the system of equations (1) requires a set of instruments Z_t satisfying the following conditions:

$$\begin{aligned}&\mathbb{E}[e_t^1 Z_t'] = \phi' \neq 0 \text{ (relevance)},\\&\mathbb{E}[e_t^i Z_t'] = 0 \text{ (contemporaneous exogeneity)},\\&\mathbb{E}[e_{t+j} Z_t'] = 0 \text{ for } j \neq 0 \text{ (lead-lag exogeneity)},\end{aligned}$$

where e_t^1 is the error of the equation corresponding to the indicator variable. I describe the procedure for developing such an instrument below.

5.3.2 Identification

In order to capture exogenous innovations to monetary policy, I follow Mertens and Ravn (2013) and Stock and Watson (2018) by employing an external instruments approach to identification. My choice of instrument is the high-frequency fed funds futures surprise series examined by Gurkaynak, Sack and Swanson (2004) and Bernanke and Kuttner (2005). This instrument is defined as the difference in three-month fed funds future rates beginning ten minutes prior to an announcement by the Federal Open Market Committee (FOMC) and ending twenty minutes after. Since fed funds futures rates prior to an FOMC announcement incorporate expectations about monetary policy actions, any movement within this time frame must reflect news contained in the announcement that are not anticipated by market participants. The key identifying assumption of this approach is that within this thirty-minute window, any change in fed funds futures rates reflects the FOMC announcement alone, rather than any other source of information. This assumption is equivalent to the contemporaneous exogeneity condition described above.

Rather than using the fed funds futures surprises to directly estimate impulse response functions, I follow Gertler and Karadi (2015) in using these surprises as an external instrument to identify latent monetary policy shocks in an estimated proxy VAR. The primary benefit of using the Gertler and Karadi proxy VAR approach is that structural monetary policy shocks can be identified over a longer sample than that for which the external instrument is available. In the present case, the DFA dataset spans 1989 to 2021, while the Gurkaynak, Sack and Swanson high-frequency instrument set spans 1988 through 2016. Consequently, the Gertler and Karadi method allows for the addition of nearly five years of additional structural shock data beyond what would be available with the high-frequency instrument.

Furthermore, by running the Fed funds futures instrument through the proxy VAR, Cloyne et al. (2018) note that any residual predictability of the instrument is purged.[4] As noted by Ramey (2016), the raw fed funds futures instrument suffers from serial correlation, which would violate the lead-lag exogeneity condition needed for a valid instrument. However, the structural shock series implied by the proxy VAR is purged of this serial correlation, producing a Durbin-Watson d-statistic of 1.98, while a Breusch-Godfrey test results in a p-value of 0.3368, failing to reject the null hypothesis of no serial correlation.

I consider a monthly VAR with twelve lags including the following variables: the log of industrial production, the log of the consumer price index, the one-year government bond rate, and the Gilchrist and Zakrajšek (2012) excess bond premium. I then sum the shocks into a quarterly series to conform with the frequency of the DFA data. The structural form of the proxy VAR is given by

$$\mathbf{Y}_t = \sum_{j=1}^{J} \mathbf{B}_j \mathbf{Y}_{t-j} + \mathbf{s}\varepsilon_t \tag{2}$$

where $\mathbf{s}$ is the structural impact matrix that maps latent structural shocks into reduced

[4] This result allows me to estimate equation (1) without controls as long as they are included in the proxy SVAR used to identify the shock series.

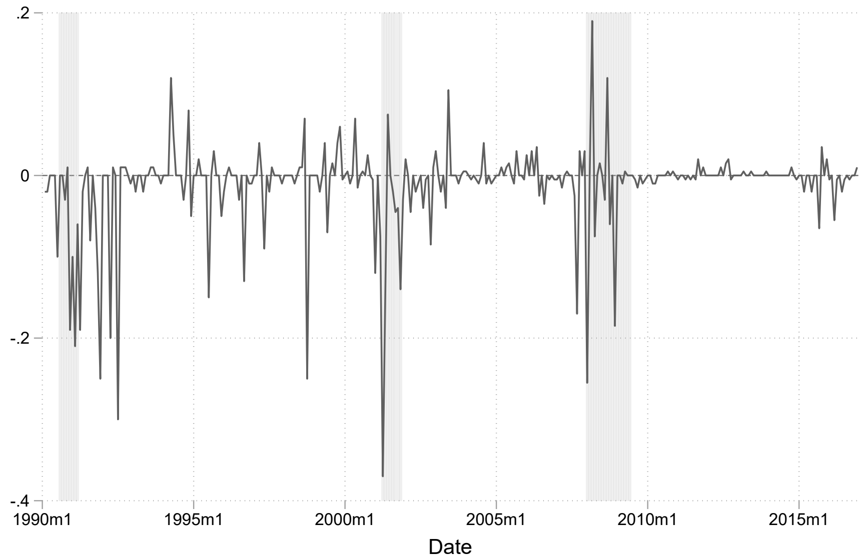
form surprises. Ordinarily, the structural impact matrix cannot be identified without additional restrictions. Common methods used in the literature include imposing recursive ordering restrictions (Blanchard and Perotti, 2002; Christiano, Eichenbaum and Evans, 2005; Auerbach and Gorodnichenko, 2012), narrative approaches (Romer and Romer, 2004, 2010; Cloyne and Hürtgen, 2016), and sign restrictions (Mountford and Uhlig, 2009). However, the exclusion restriction satisfied by the fed funds future surprise series provides sufficient restrictions to identify the mapping between reduced form interest rate surprises and structural monetary policy shocks.[5] Figure 2a plots the raw fed funds future surprises.

Figure 2b presents the implied structural shock series that I use as an instrument in estimating equation (1). Of note, the plot captures a series of large contractionary shocks corresponding to the onset of the Great Recession. These shocks can be interpreted as evidence that between Q4 2007 and Q4 2008, market participants anticipated a greater degree of monetary easing than the FOMC provided. This interpretation is supported by the slow response of the FOMC to the beginning of the financial crisis in mid-2007 until December 2008. Notably, FOMC statements continued to cite inflationary concerns in maintaining a positive target for the Federal funds rate until their October 28th-29th meeting in 2008.

As a point of reference, I estimate equation (1) using a set of monthly macroeconomic variables commonly studied as outcomes in the literature. Figure 3 presents impulse responses of these variables to the shock series. Outcome variables are measured as a percent of their year-0 level computed as the log change multiplied by 100, except in the case of interest rates, which are measured in percentage points. I estimate a contraction in industrial production of 4.2pp associated a gradual rise in the unemployment rate of 1.2pp after forty months, while the CPI falls by 1.7 pp out to four years. These results are

[5] With partial identification, the structural impact matrix becomes block invertible. In practice, the identified mapping can then be found by a three-step procedure outlined by Mertens and Ravn (2013) on page 5.

(a) High-frequency Fed funds futures surprises



(b) Proxy-VAR implied monetary policy shocks

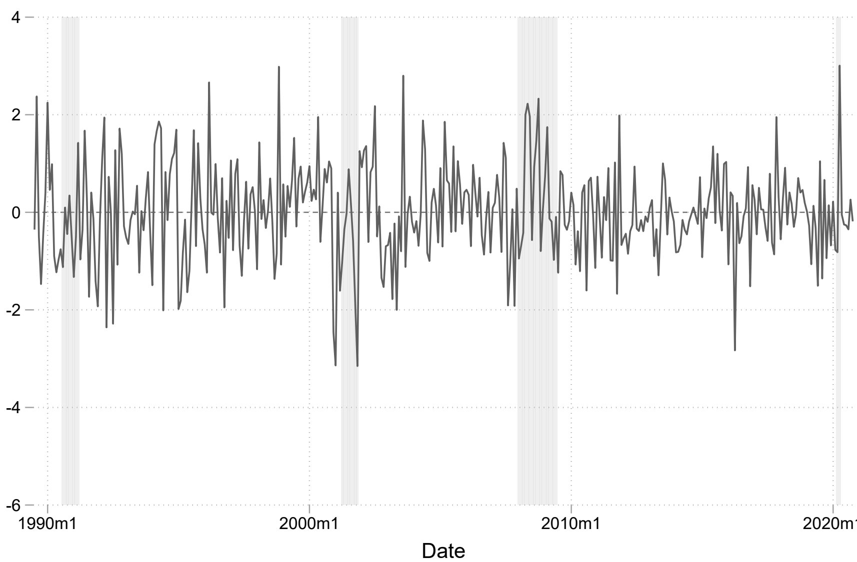


Figure 2. Gertler and Karadi (2015) High-Frequency Instrument and Implied Structural Shocks
Notes: Shaded region indicates NBER recession.

broadly comparable to those of previous literature. Gertler and Karadi estimate impulse responses directly from the proxy VAR and find that a 0.2pp increase in the one-year rate results in a roughly 0.4pp reduction in IP after two years, with a roughly 0.1pp drop in the CPI. Paul (2020) likewise finds that a 0.1pp increase in the Federal funds rate is associated with a 0.5pp drop in IP and a statistically insignificant drop in the CPI. As a point of departure with Gertler and Karadi, the local projections approach estimates a more persistent increase in the one-year Treasury rate than that obtained via the proxy VAR, which explains a more persistent response of macroeconomic variables and asset prices.[6]

I also consider four additional price indices in figure 4 for reasons that will become clear in section 5.4.1. The CPI for durable goods for which the impulse response is not statistically significant past the first year. This insensitivity will be an important factor in helping us understand the dynamics of wealth for the bottom 50% of households, who hold a disproportionate share of their assets in durables. I consider stock prices measured by the S&P 500 Index, which falls in response to the monetary policy shock in line with asset pricing theory. I find that stock prices fall by roughly 5pp on impact, reaching a 20pp drop within one year, and approaching a trough after nearly four years corresponding to a drop of 32pp. I consider the S&P Case-Shiller U.S. Home Price Index as a proxy for the price of real estate. As noted in section 7.2, middle-class households hold the lion's share of their wealth in their homes. As a result, the dynamics of house prices will be critical for explaining the responses of wealth for this group. I estimate that a 1pp shock to the one-year rate causes a gradual decline in house prices that reaches a trough out to four years with a 10pp drop. Finally, I use price return data from the Bloomberg-Barclays Aggregate Bond Index as a proxy for bond prices, which falls by 6pp on impact before returning to the mean.

These estimates are well in line with the literature on the effects of monetary policy

[6] Although it confounds comparisons to previous studies, this persistence is thankfully not a result of autocorrelation in the instrument series, as I demonstrate in section 5.5.

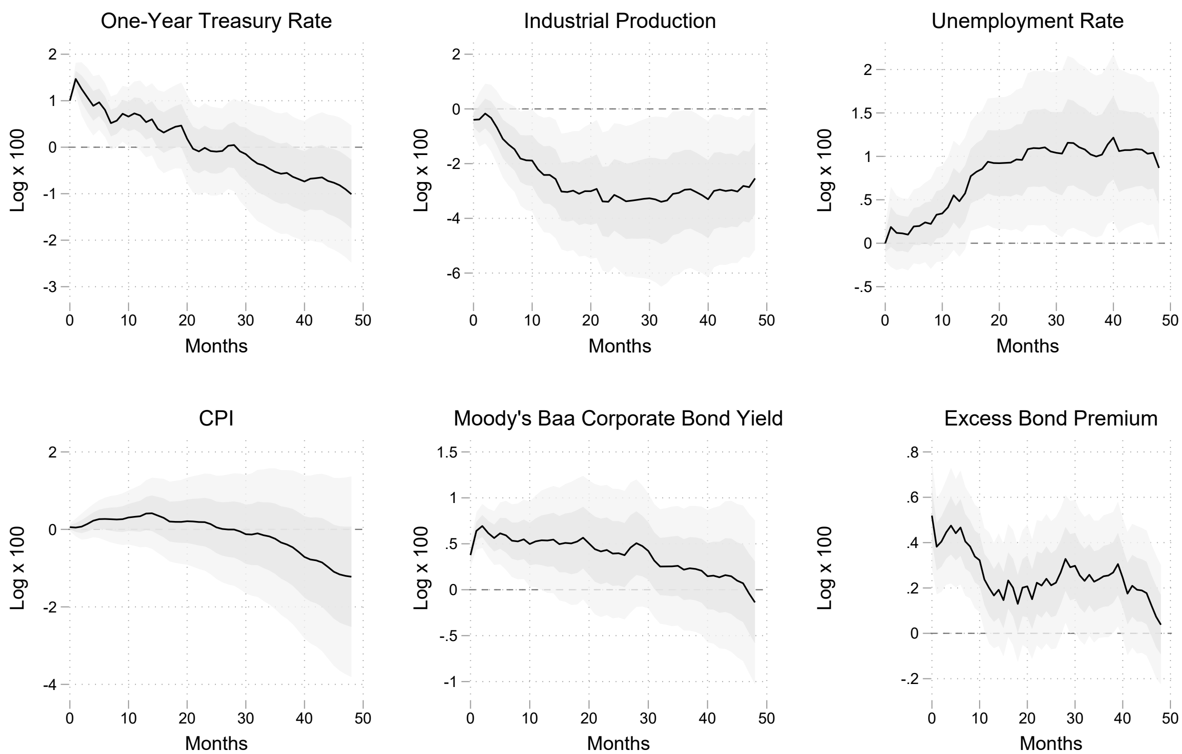


Figure 3. Macroeconomic Variables (1973-2021)

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate. Presented with one- and two- standard error confidence bands. See text.

on asset prices. For comparison, Bernanke and Kuttner (2005) find that a 1pp shock to the Federal funds rate depresses stock prices by between 2pp and 5pp on impact, while Gurkaynak, Sack and Swanson (2004) find that a 0.25pp increase in the one-year rate depresses stock prices by roughly 1pp on impact. Paul (2020) finds that a 0.1pp increase in the Federal funds rate is associated with a 2pp drop in stock prices within one year, and a 1/3pp drop in house prices out to forty months. On the other hand, the results I obtain via local projections produce impulse responses that are noticeably more persistent than would obtain under comparable VAR specifications.

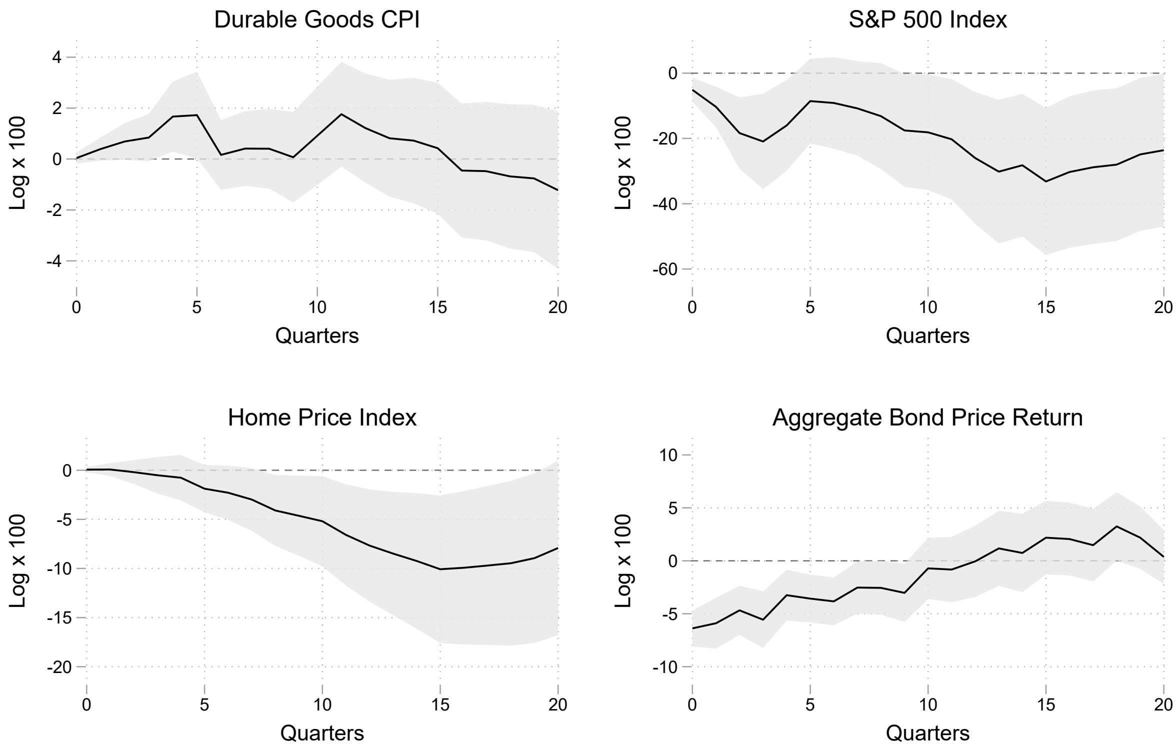


Figure 4. Price Indices (1989-2021)

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate. Presented with one- and two- standard error confidence bands. See text.

5.4 Results

Moving forward with my analysis of household wealth, I present impulse responses of the net worth of each group to the implied monetary policy shock in figure 5. A monetary policy surprise inducing a 1 percentage point increase in the one-year Treasury rate induces a significant and persistent reduction in net worth for all groups, with a disproportionate loss of wealth borne by the bottom 50% of households. The top 1% of households experience a loss of 21% of their net worth in response to the monetary policy shock, while the bottom 50% of households experience a persistent reduction in their wealth with a trough of 51% after 19 quarters. Of note, estimated responses for the bottom 50% are substantially noisier than those of the other quantile bins owing to the low average

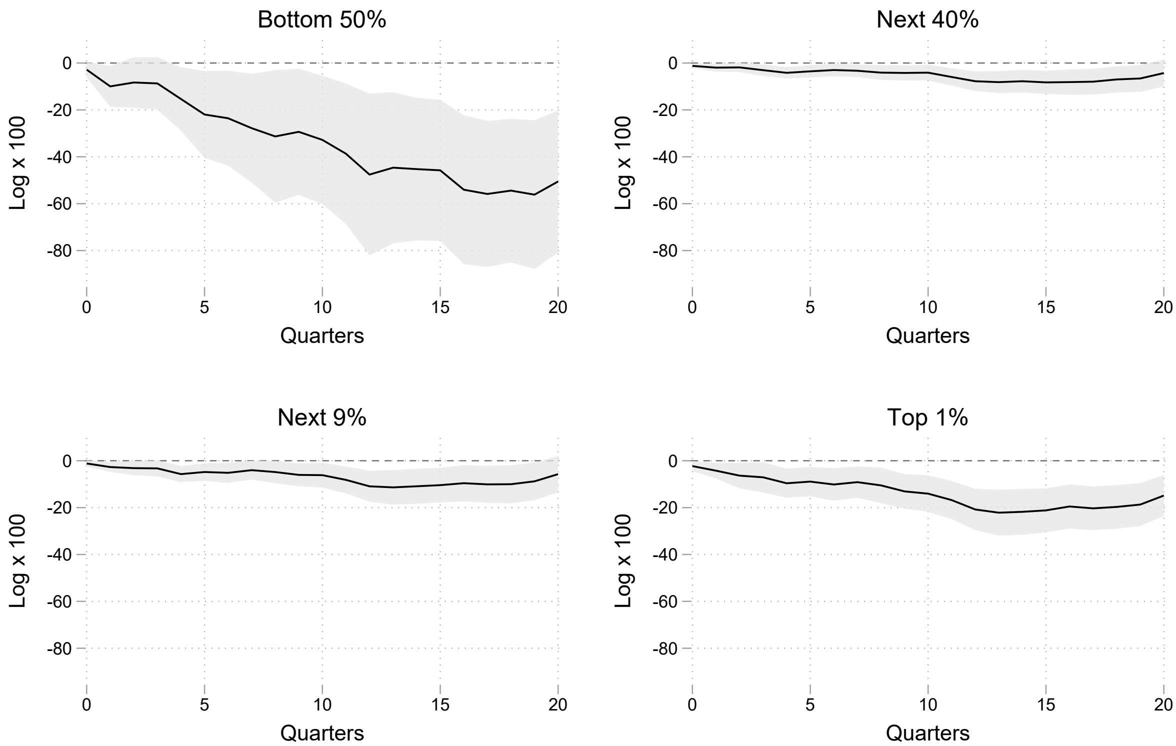


Figure 5. Net Worth

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate. Presented with one standard error confidence bands. See text.

wealth held by this group. As a result, proportional changes in wealth exhibit a high variance in response to shocks of a given magnitude. Despite this, we can firmly reject the hypothesis that responses are equivalent between the bottom 50% and the remaining groups.

5.4.1 Disentangling Price and Quantity Changes

A change in net worth can reflect multiple causes. First, a reduction in the prices of assets or an increase in the prices of liabilities both reduce the value of household portfolios given a fixed quantity of assets and liabilities, amplified by the leverage ratio of the household. To the extent that households across the wealth distribution systematically choose to hold different portfolios, these *valuation effects* will induce differential responses to monetary policy shocks. It is important to be clear about the sources of heterogeneity in valuation effects. In the U.S., the majority of household liabilities take the form of fixed-rate mortgages. As a result, monetary policy will result in diminished wealth effects relative to a country such as the U.K. for which mortgages are institutionally refinanced at regular rates (Cloyne, Ferreira and Surico, 2020). Considering consumer credit, at any given point, the ratio of non-revolving to revolving consumer credit ranges from 1.5 to 3.3. Further, since the rapid rise in student loan debt began in the early 2000s, no less than 80% of student loan debt has been originated by the federal government, which exclusively offers fixed-rate contracts. Taken together, these factors suggest that valuation effects will operate primarily on the assets side of household balance sheets.

Second, households can respond to contractionary shocks by altering the size or composition of their wealth portfolios. These *composition effects* may reflect changes in behavior on the part of households altering the structure and size of their balance sheets to stabilize consumption. Of course, changes in the size and composition of wealth portfolios do not necessarily indicate a change in net worth. A household that responds to an adverse shock by selling their car has only traded one asset for another of equal value. On the other hand, a household with an underwater mortgage may discharge their debts in bankruptcy, which may increase their net worth by resolving negative equity. For a change in the quantity of assets held to produce a change in net worth, households must either be selling assets or incurring new liabilities without a corresponding asset purchase.

In order to disentangle these two effects, I create an asset price index for each group of households, formed as a weighted sum of asset prices with weights determined by the sample average share of a given asset in the wealth portfolio of the group. Table 2 presents the price index I use corresponding to a given class of asset. For dividend-bearing assets I consider only measures of capital gains. In order to price household pension entitlements, I rely on data from the OECD Global Pension Statistics database, which aggregates data

Table 2. Asset Price Indices

Asset Class	Price Index	Source
Real Estate	S&P CoreLogic Case-Shiller Home Price Index	S&P Dow Jones Indices
Consumer Durables	Consumer Price Index for All Urban Consumers: Durables in U.S. City Average	U.S. Bureau of Labor Statistics
U.S. government and municipal securities	S&P U.S. Government Bond Index	S&P Dow Jones Indices
Corporate and foreign bonds	Bloomberg Barclays Aggregate Bond Index	Bloomberg and Barclays
Corporate equities	S&P 500 Index	S&P Dow Jones Indices
Equity in non-corporate business	S&P 500 Index	S&P Dow Jones Indices

from the Federal Reserve Board and the U.S. Department of Labor, which reports yearly estimates of the composition of pension holdings by asset class. I form an index using the weights provided and the prices specified for each component asset class. For assets classes with a fixed nominal price including checkable deposits, currency, time deposits, money market fund shares, and loans held as assets, the price is normalized to one. Finally, the resulting price index is deflated by the consumer price index.

Impulse responses of group-level price indices are presented in figure 6. For each group, the average asset price falls significantly, but with an increasing sensitivity with wealth, largely reflecting the higher shares of equities in the portfolios of the next 40% and top 1% of households. The bottom 50% experience an average asset price decline of 16% within four years, while the top 1% experience a decline of 28%.

These results seem to conflict with results for overall wealth by group presented in figure 5, which finds a more substantial proportional drop in the net worth of the bottom 50% than for the remaining households, but again valuation effects explain only part of the story. To understand how composition effects help determine the responses of wealth for each group, I decompose impulse responses for net worth by these two channels. Figure 7 superimposes the impulse responses of average asset prices multiplied by the average leverage ratio and overall net worth. I multiply the asset price impulse response

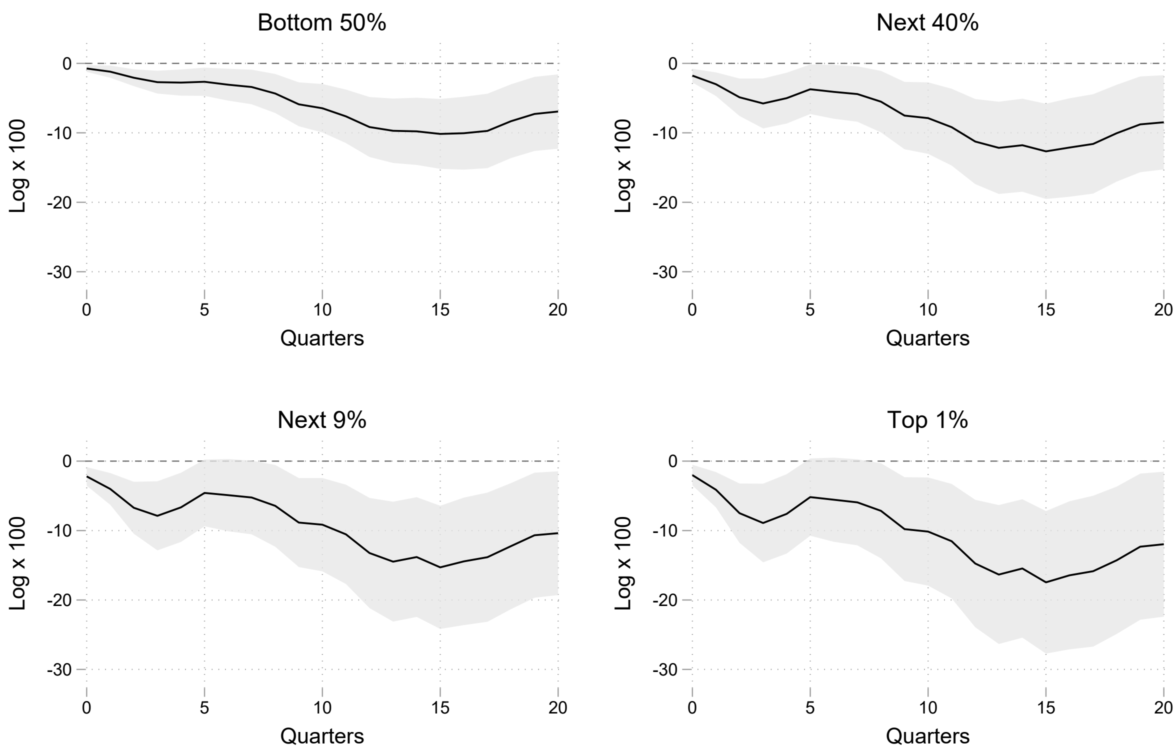


Figure 6. Portfolio Prices

Notes: Impulse responses of the average asset price index for each group to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate.

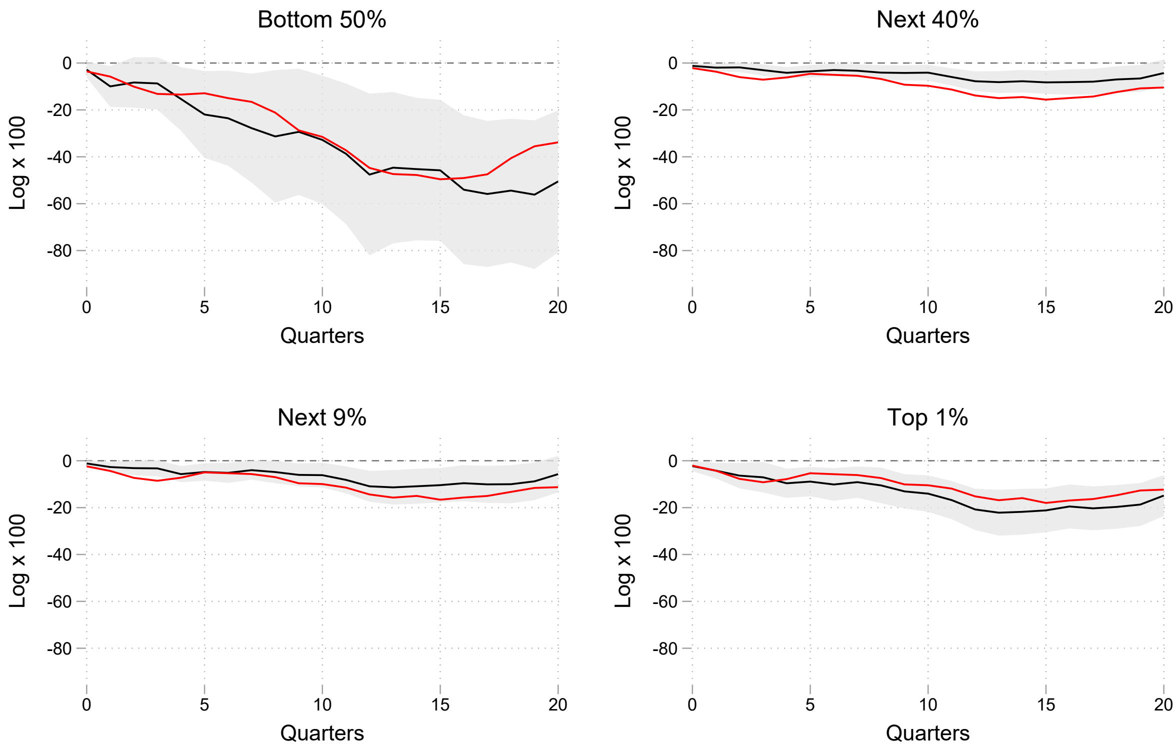


Figure 7. Net Worth with Prices

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate. Red lines are the responses of the average asset price index for each group.

by leverage to allow us to see the contribution of levered asset price changes to net worth. The difference between these two impulse responses can be interpreted as the magnitude of the composition effect.

Despite the relatively small drop in average asset prices of this group of 10% out to four years, the trough of net worth is a reduction of 51%. This can be expalained by a leverage ratio of the bottom 50% that averages at 4.9. implying a composition effect that explains the remaining share of the response of net worth. To see this, observe that the impulse response for the leveraged asset price of the bottom 50% almost never crosses the impulse response of net worth for that group. On the other hand, the top 1% of households face larger average asset price reductions. However, the composition effect for this group is less prominent, and the leverage of this group is substantially lower,

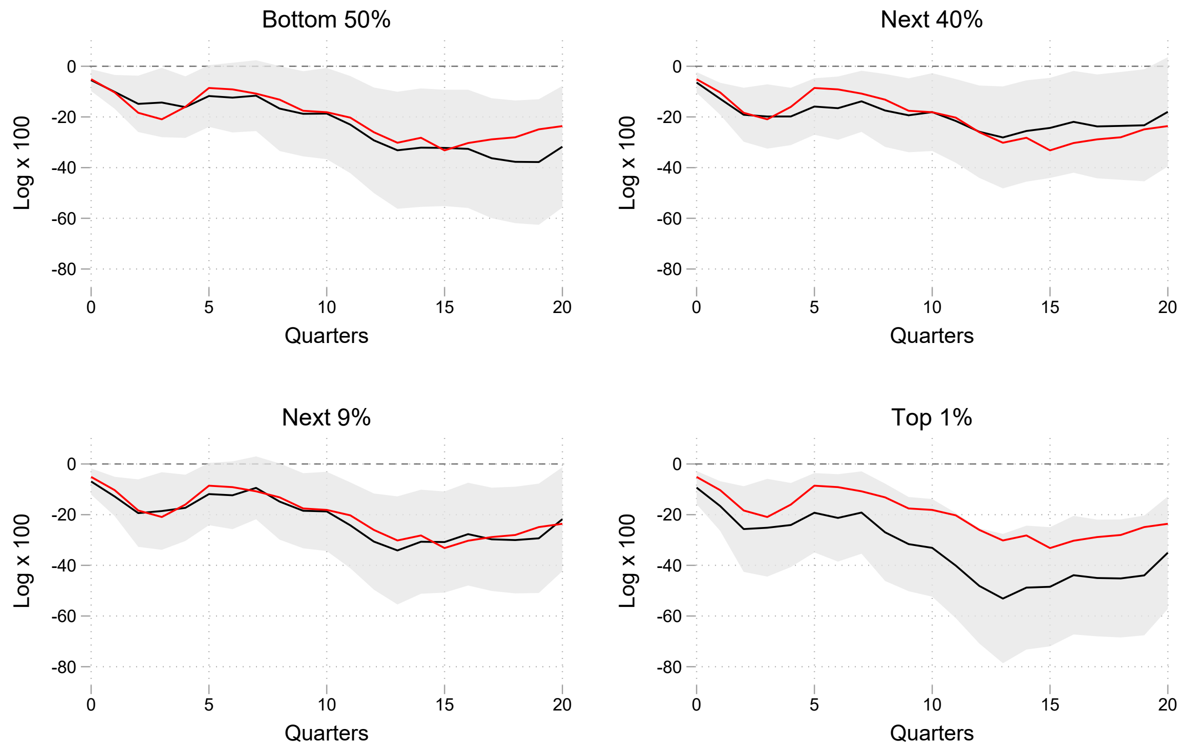


Figure 8. Corporate Equities

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate. Red lines are the impulse response of the S&P 500.

which mitigates the impact of unfavorable asset price movements on overall net worth.

5.4.2 Decomposing Wealth

Decomposing valuation and composition effects by asset class sheds light on household behavior explaining these responses. To begin, I study the dynamic response of corporate equities by group to monetary policy presented in figure 8. Responses of equities across groups follow a broadly similar pattern. The bottom 50% of households face a drop in the value of their equities of 35% within four years, with a drop of nearly 50% for the top 1% of households. The responses of the S&P 500 index drive the bulk of the response for each group, while the higher sensitivity of the equity portfolios of the top 10% of households may reflect a heightened preference for riskier assets among wealthier households.

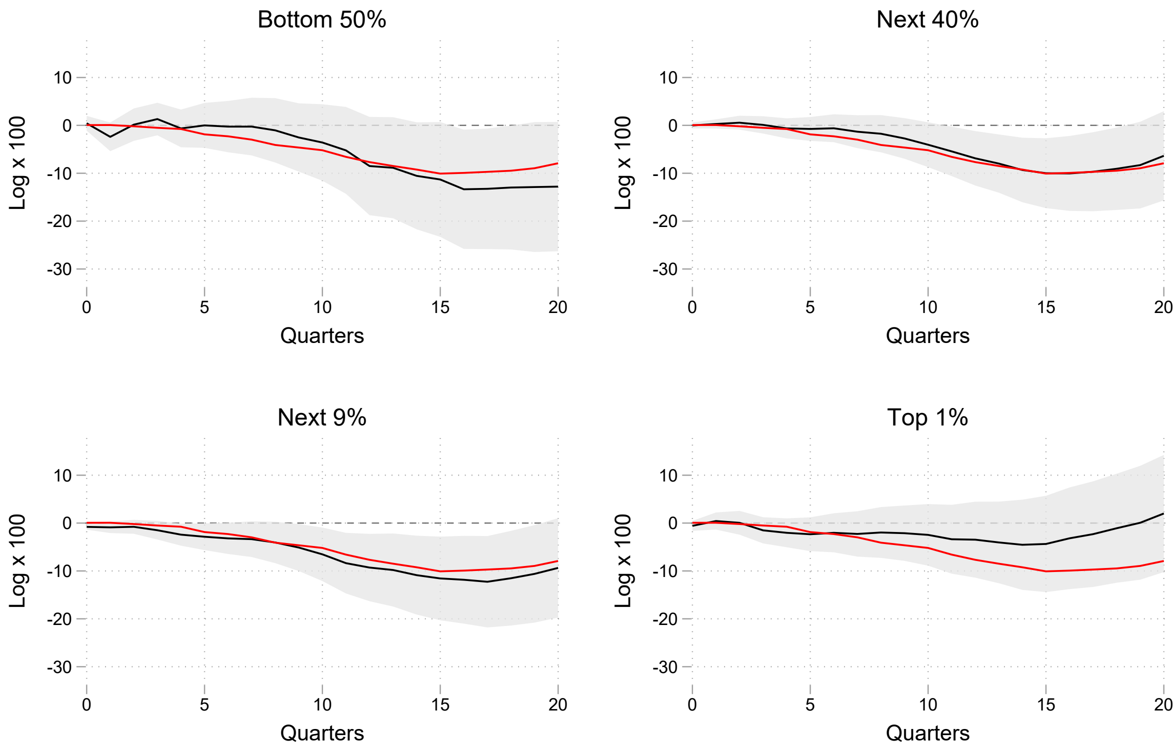


Figure 9. Real Estate

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate. Red lines are the response of the S&P/Case-Shiller home price index.

On the other hand, examining the responses of real estate shows a different pattern. As presented in figure 9, the responses of the next 40% and next 9% of households are nearly identical to those of the house price index, while the bottom 50% show a response that is larger in magnitude and more persistent. This discrepancy cannot be entirely attributed to valuation effects alone. After three years, the response of this group diverges from the path of home prices, suggesting an increasing role for composition effects in housing. This may reflect several behaviors, such as drawing down the equity in housing to finance current consumption. Out to five years, nearly half of the decline in real estate of the bottom 50% is attributable to this composition channel.

Consumer durables, presented in figure 10, show a similar pattern to real estate. All except for the bottom 50% of households face no statistically distinguishable response to

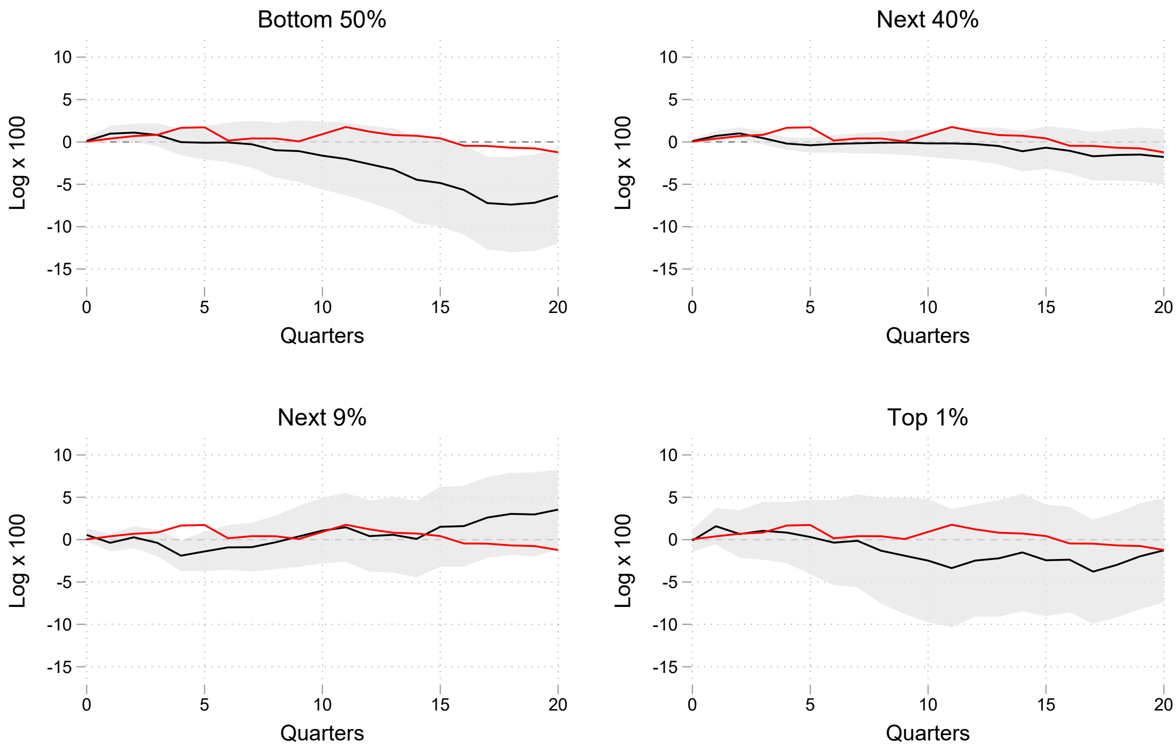


Figure 10. Consumer Durables

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate. Red lines are the response of the CPI for durable goods.

their durables holdings, which comprise a small share of their overall asset portfolios. As noted in section 7.2, the bottom 50% of households hold nearly 30% of the value of their asset portfolio in consumer durables. Although the consumer price index for durables does not respond significantly to monetary policy, the bottom 50% face a loss of nearly 10% of the value of their durables which can be attributed almost entirely to composition effects.

As I argue above, the composition response of wealth to monetary policy is largely determined by the assets side of household balance sheets. Figure 11 reports the responses of mortgage debt to monetary policy. The bottom 50% and top 1% experience declines in the outstanding home mortgage debt. This decrease likely reflects two causes. First, households with low home equity may declare bankruptcy in response to a reduction in their incomes, discharging their mortgage debts. Second, as contractionary monetary policy raises rates on adjustable-rate mortgages, households may substitute towards rental housing or lower-cost housing. Figure 12 reports impulse responses of consumer credit, which appears to fall for the bottom 90% of households in the wake of a monetary contraction, although the response is largely statistically insignificant.

5.4.3 Wealth Shares

To determine whether monetary policy is neutral with respect to the distribution of wealth, I estimate response of the share of wealth held by households of a given group to monetary policy shocks. Traditionally, fractional outcomes present a challenge for econometricians when the outcome is bounded. However, there are good reasons to believe that wealth shares need not be bounded. Households on the lower tail of the wealth distribution would be expected to hold negative equity whether due to underwater mortgages, the use of credit to finance current consumption, or due to financing of non-marketable human capital through student loans. Consequently, the total share of wealth held by the remaining households must exceed one. Accordingly, few alterations are needed to the system of equations defined by (1). In the DFA sample, the bottom 50% of households by wealth own the lowest share of wealth of any group studied but never collectively report negative wealth in any quarter spanning 1989-2020. The results of this exercise are provided in figure 13.

The bottom 50% of households face a large drop in net worth, with a peak point estimate of nearly 60%, largely driven by composition effects. Due to the low average level of wealth held by this group, relatively small shifts constitute large movements proportional to a monetary policy shock of arbitrary magnitude. Unlike the top 50% of households, the portfolio price response for the bottom 50% is more muted, owing to their high portfolio share of low-return assets including housing and consumer durables, with prices less sensitive to monetary policy than the high-equity portfolios held by the top 50%. Taken

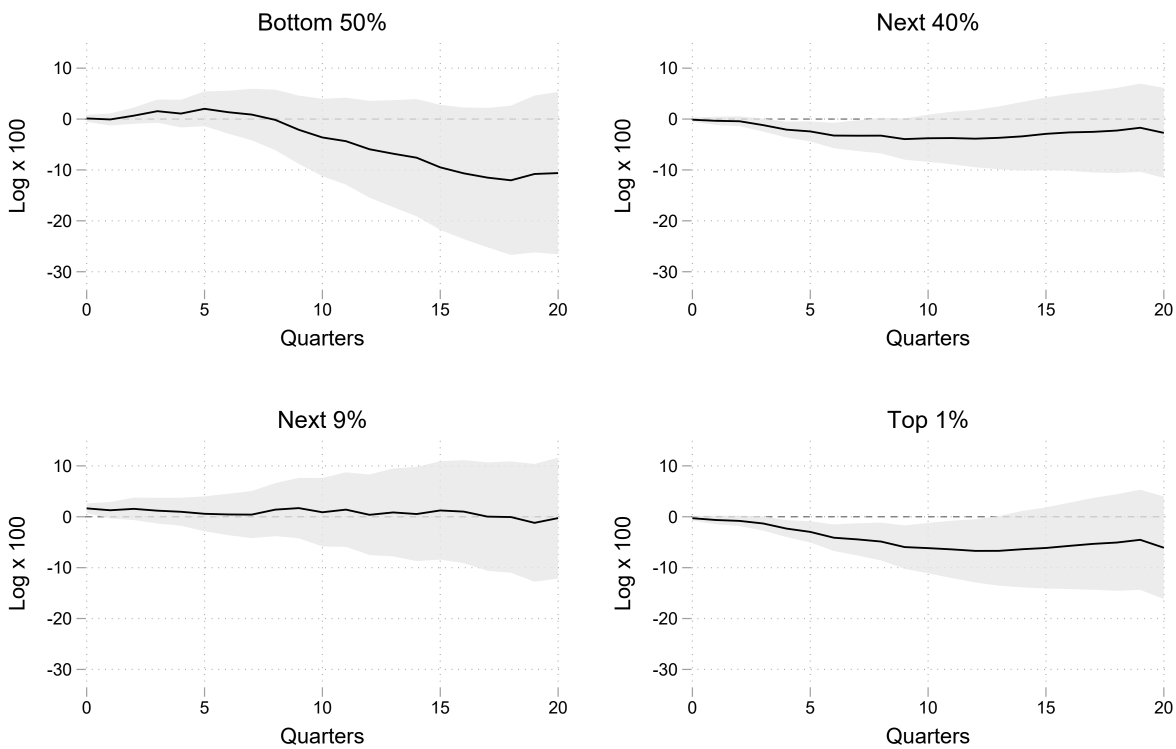


Figure 11. Home Mortgages

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate.

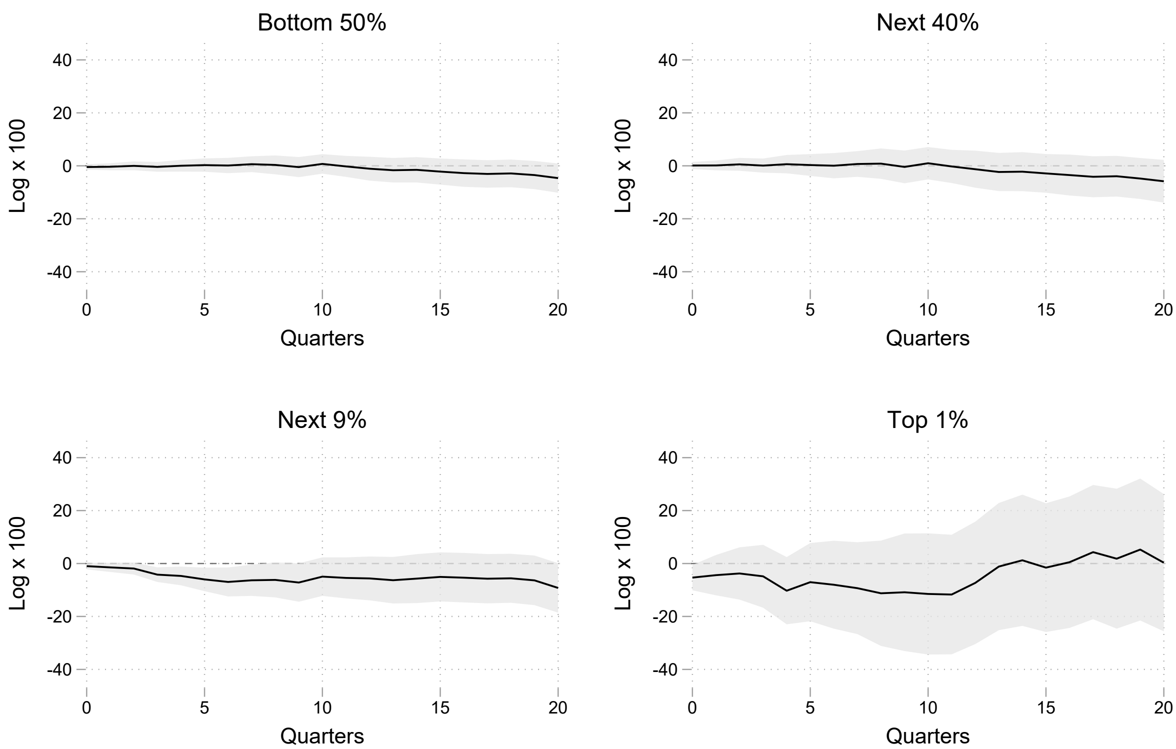


Figure 12. Consumer Credit

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate.

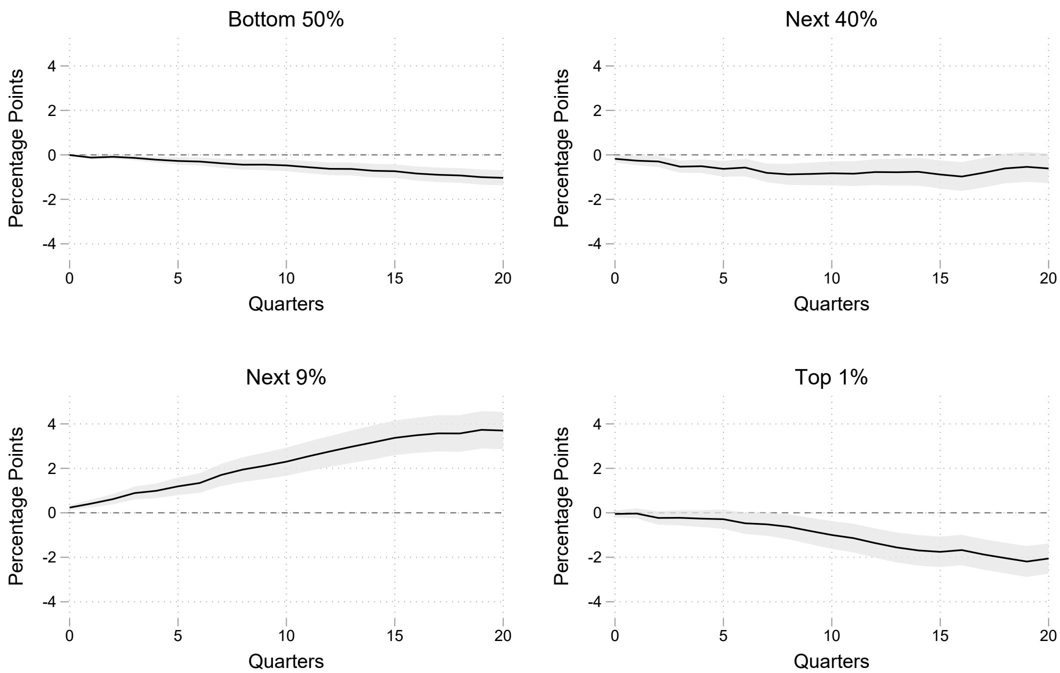


Figure 13. Wealth Shares

Notes: Impulse responses of the share of wealth held by each group to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate.

together, valuation effects cannot explain the large response of wealth of the bottom 50% of households, leaving portfolio composition effects to explain the bulk of the response. Unlike the top 50% of households whose portfolio composition adjusts to dampen the response of overall wealth, the bottom 50% can be seen to draw down assets in a way that amplifies the shock to overall wealth.

Switching focus to the distribution of household wealth, figure 13 presents impulse responses for the shares of net worth held by each quantile. Reflecting results in levels, the top 1% experience a persistent decline in their overall wealth share by nearly 2% within five years. The bottom 50% experience a decline in their wealth share, exceeding 0.5% within five years, that does not recover within five years. It is worth noting again that the very low average share of total household wealth held by the bottom 50% results in a relatively small drop in their wealth share. Correspondingly, the next 40% and next 9%

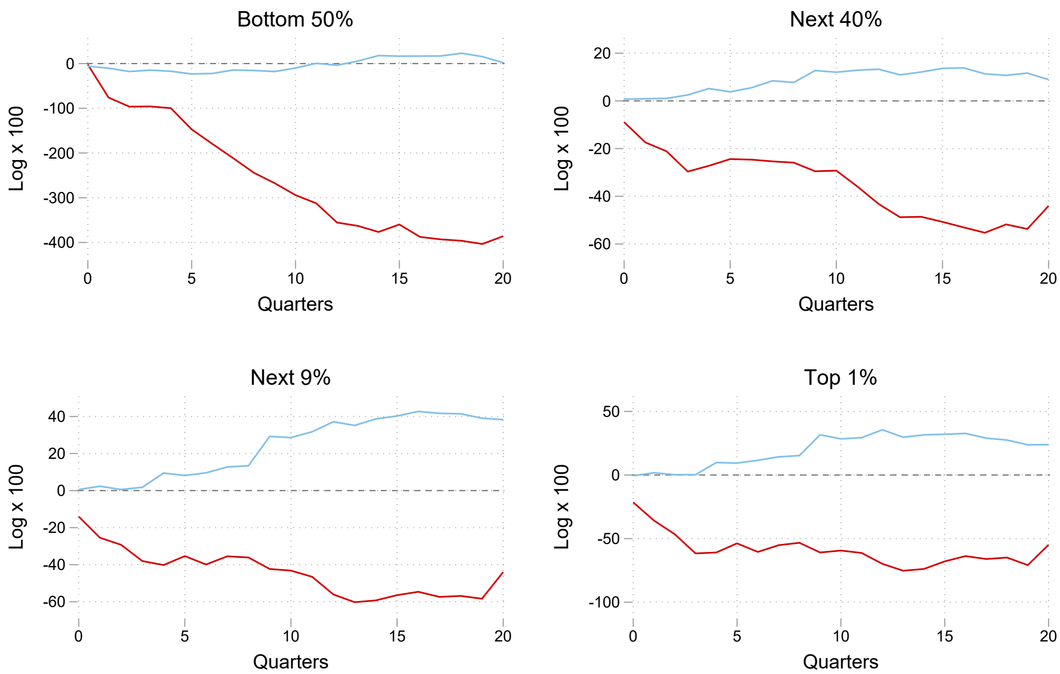


Figure 14. Asymmetric Effects of Monetary Policy

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point change in the one-year Treasury rate. Red lines indicate responses to a contractionary shock, and blue lines indicate responses to an expansionary shock.

of households gain over 1% relative to their initial share of wealth, mirroring the decline in shares held by the top 1% and bottom 50%. Taken together, these results suggest that the distribution of household wealth suffers a large negative mean shock, with relative redistribution from the top 1% and bottom 50% to the remaining 49% of households.

5.4.4 Asymmetric Effects of Positive and Negative Shocks

As noted in section 7.1.1, large and heterogeneous effects of monetary policy on household wealth may be consistent with a stable long-run wealth distribution if shocks are mean zero and induce symmetrical effects whether shocks are expansionary or contractionary. In order to test for symmetry of outcomes, I estimate equation (1) separately over the subsamples on which the fed fund futures instrument is positive, and subsequently where it is negative. Figure 14 reports impulse responses of net worth for all groups for both subsamples.

These estimates show a clear asymmetry for the bottom 50% and next 40% of households, with larger effects in the wake of a contractionary monetary policy shock. These results are in line with Furceri, Loungani and Zdzienicka (2018) among others who find asymmetric effects of monetary tightenings and loosenings on income inequality. This asymmetry is particularly pronounced for the bottom 50% of households, who are estimated to suffer a near complete loss of wealth out to five years after a contractionary shock, while experiencing a peak gain of nearly 75% in the case of an expansionary shock. By contrast the top 1% and next 9% face nearly symmetrical responses in the wake of monetary expansions and contractions.

Practically speaking, the large asymmetry in the response of the bottom 50% likely reflects the drawing down of assets after a tightening episode to finance current consumption, which preclude those same households from accumulating wealth with increases in asset prices that follow subsequent loosenings. Additionally, the high leverage ratio of this group implies that similarly sized reductions in the value of assets result in outsized changes in net worth. The other groups, by contrast, primarily suffer due to price changes after a contraction, but broadly maintaining the same quantities in their portfolios. As a result, these households are well placed to enjoy capital gains on appreciating assets with a subsequent loosening. These results provide a complementary analysis to Angrist, Jordà and Kuersteiner (2018) and Tenreyro and Thwaites (2016), who find that monetary policy is more effective in reducing economic activity than providing stimulus, and that monetary policy is less effective in a recession than in an expansion.

As noted, this wide asymmetry opens the door for long-term effects of monetary policy on the wealth distribution. To understand how asymmetry relates to persistent outcomes, consider a monetary policy authority following a standard Taylor-type rule with symmetric, Gaussian errors. In this economy, the monetary authority is equally likely to err on the side of expansionary policy as contractionary. However, as a result of low-wealth households dis-saving in response to contractionary shocks, the average response of the bottom 50% of households is biased downward relative to the average response of the top 1%. Over time, the accumulation of wealth losses in response to a given history of monetary shocks can cause a substantial widening of the wealth distribution, a phenomenon for which I test below.

5.4.5 Contribution of Monetary Policy

Given the asymmetry of wealth responses, it is important to ask whether the Federal Reserve makes an economically meaningful contribution to changes in the wealth distribution. Macroeconomists have made strides in determining how much discretion central bankers really exert over monetary policy. Jordà and Taylor (2019), for instance, find that interest rates across major advanced economies have been driven primarily by the endogenous response of central bankers to forces outside of their control, including changing demographics and sluggish productivity growth. Furthermore, to the extent that macroeconomists employ parametric reaction functions to describe central bank behavior theoretically, we concede that a significant portion of observed variance in interest rates reflects the systematic response of central bankers in attempting to meet their policy mandates.

These considerations should lead us to believe that the sorts of monetary policy shocks I consider comprise a relatively small share of variance in overall monetary policy actions, and further explain a small share of the variance of household wealth. To test this theory, I perform a forecast error variance decomposition using the R^2 method of Gorodnichenko and Lee (2020). By this procedure, the share of forecast-error variance attributable to the monetary policy shock is estimated by the R^2 of a series of regressions of the form

$$\hat{f}_{t+h} = \sum_{i=0}^{h} \phi^{h,i} z_{t+i} + \nu_{t+h} \tag{3}$$

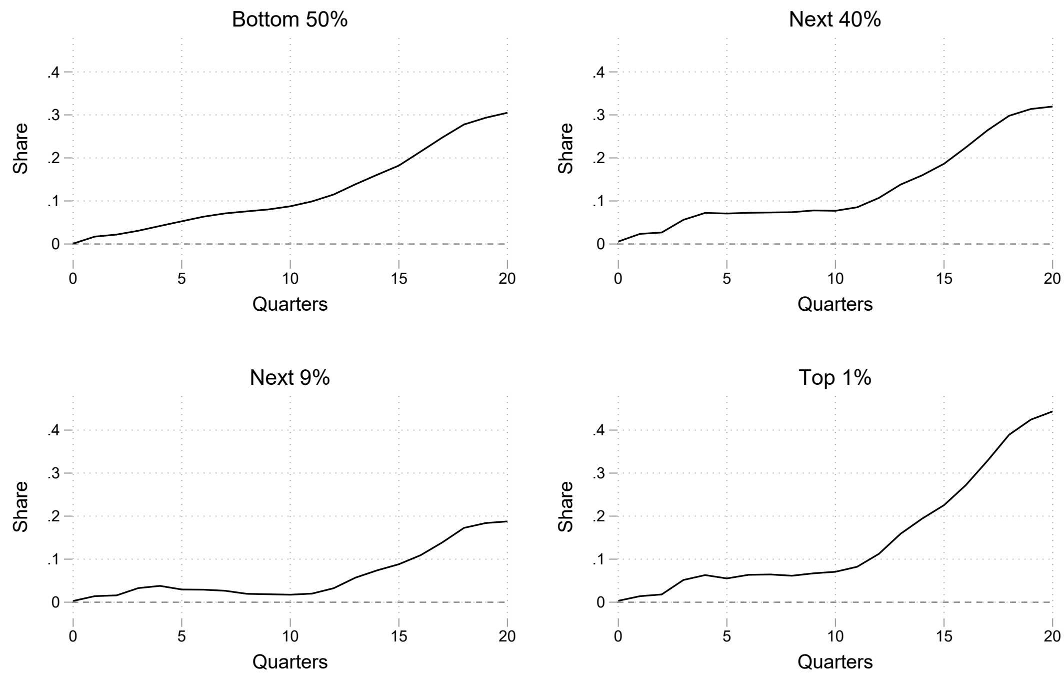


Figure 15. Forecast Error Variance Decomposition

Notes: Forecast error variance decomposition measuring the share of forecast error variance explained by monetary policy shocks at each horizon.

where $\hat{f}_{t+h}$ is the forecast error of wealth obtained by regressing $y_{t+h} - y_{t-1}$ on all control variables used in equation 1, and z_t is the period-t realization of the monetary policy shock. A constant is unnecessary in this regression, as both the forecast error and shocks have a zero mean.

The results of this exercise suggest that a substantial share of forecast error variance of household wealth can be attributed to monetary policy surprises. Out to five years, monetary policy shocks are estimated to explain approximately 30% of forecast error variance for all groups except for the top 1% to 10% group. This result seems large, but previous literature helps us place it in context. Coibion et al. (2017) perform a similar decomposition for income, earnings, and consumption inequality and find that over 10% of forecast error variance for income inequality can be attributed to monetary policy shocks out to five years, with shares exceeding 20% for expenditures and consumption. By contrast, wealth exhibits less volatility than income or consumption, but more sensitivity to changes in asset prices including those caused by monetary policy shocks.

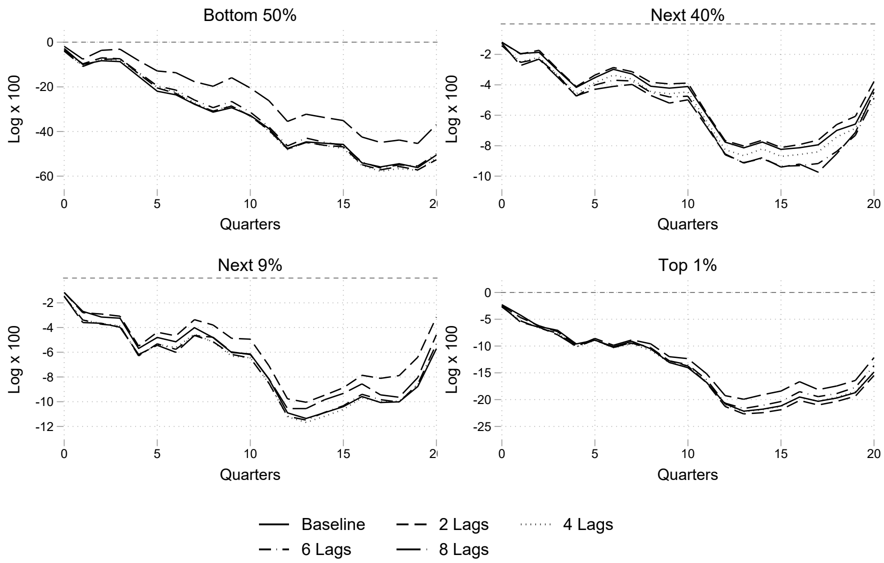
5.5 Robustness

Due to the recency of the DFA becoming public and the nature of my identification strategy, it's worth noting substantial uncertainty associated with these measures. As noted in section 7.3.2, the system of equations I estimate with local projections doesn't require any control variables as long as the instrument satisfies an instrument validity assumption. In extracting my instrument from the structural form of a Gertler and Karadi (2015) VAR, the instrument will be purged of any predictability by the control variables included in the VAR. However, as a further test of endogeneity, I alter the system of equations in equation 1 to include additional lags of the outcome variable. Results are presented in figure 16a for two, four, six, and eight lags. Overall, each added specification shows a path very similar to that of the impulse responses estimated using the baseline local projections. The similarity of these results gives some comfort that the proxy VAR-implied shock series is a valid instrument.

In my baseline specification, I estimate both the proxy VAR and equation (1) using the one-year Treasury rate. As an additional robustness test, I repeat this procedure using the federal funds rate as well as the two- and five-year Treasury rates as indicator variables. Due to the term structure of interest rates, a surprise in the fed fund futures market that is expected to induce temporary movements in short-term interest rates will have a diminished effect on interest rates on bonds with long maturities. This fact confounds impulse responses estimated using an instrumental variables approach, as each is mechanically scaled to induce a one percentage point increase in the indicator variable on impact. To reflect structural shocks of a comparable magnitude I rescale impulse responses to reflect a one percentage point increase in the one-year Treasury rate.

Results are reported in 16b. Impulse responses are broadly similar to those estimated

(a) Robustness to Alternative Specifications



(b) . Robustness to Alternative Indicators

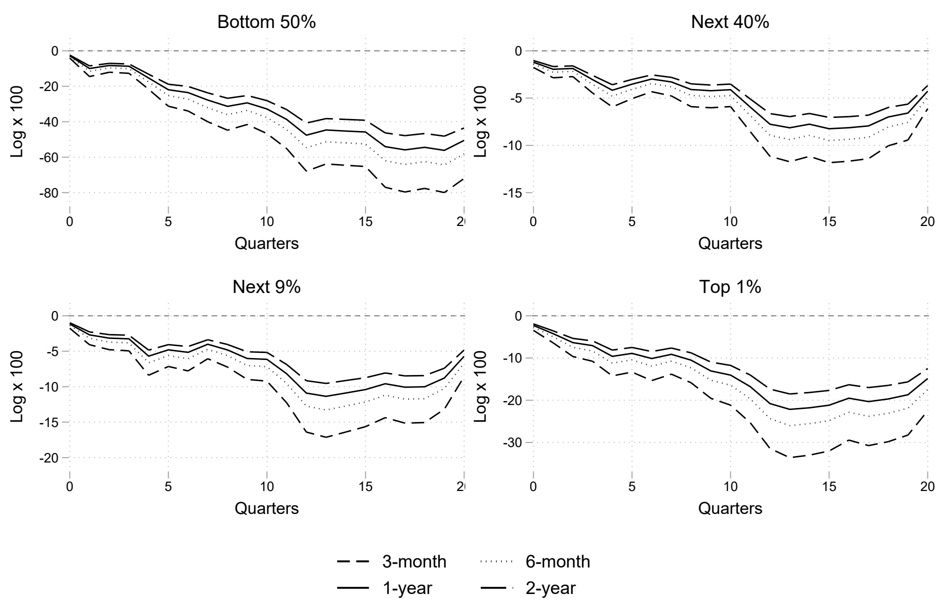


Figure 16. Robustness Tests

Notes: Impulse responses to a monetary policy shock inducing a 1 percentage point increase in the one-year Treasury rate.

using the baseline using the one-year Treasury rate, with the exception of the specification using the five-year rate. This is likely due to movements in term premia that cannot be resolved by rescaling the impact coefficient. Even still, the impulse responses are very closely matched in the immediate aftermath of the shock, and in the longer term.

5.6 Conclusion

Recent trends in economic inequality have been met by broad perceptions that public policy can play a role in producing equitable outcomes. As I document, monetary policy plays a more substantial role in determining the distribution of household wealth than previously believed. Contractionary monetary policy shocks disproportionately reduce the net worth of the bottom 50% of households and reduce their ownership share of total wealth. This is despite the higher sensitivity of the average asset of more wealthy households to interest rate changes. I conclude that the excess sensitivity of wealth exhibited by the bottom 50% of households must be a result of both high leverage and drawing down of assets to finance current consumption. This result conforms with predictions from the growing literature tying the transmission of monetary policy to heterogeneity in the marginal propensity to consume. As changes in wealth affect the welfare of households, wealth inequality should play a key role in models with household heterogeneity, and researchers must be skeptical of welfare analysis conducted using representative agent models.

Furthermore, I find that monetary policy has historically played a large role in shifting the wealth distribution, accounting for 30% to 40% of forecast error variance of wealth for each group of households. This finding suggests that the wealth distribution is not an object determined by forces exogenous to policy and highlights the need for policymakers to take seriously their role in determining the distribution of wealth.

Finally, I find that larger wealth responses result from a monetary tightening than loosening, supporting a robust system of automatic stabilizers to prevent long-run increases in wealth inequality. In light of this evidence, monetary policymakers correct to be cautious when implementing tight monetary policy without sufficient evidence of accelerating inflation. These findings support the sentiments behind the changes to the Federal Reserve's monetary policy strategy announced in August 2020 (Powell, 2020). Specifically, in announcing an asymmetric employment target with more weight assigned to shortfalls in employment, the Federal Reserve has signaled its concern with the negative consequences of tight monetary policy, and now acknowledges that equitable outcomes are more likely in a growing economy.

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Monetary Policy and Government Debt

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We study how the level of government debt affects the effectiveness of monetary policy, i.e., the elasticity of economic aggregates to interest rate changes. We build a New Keynesian model where fiscal policy is non-Ricardian and government debt is risk-free. Wealth effects generated by government bonds weaken the transmission of changes in the policy rate to output. Using data on private ownership of public debt for the U.S., we find that when government debt is one standard deviation above its mean, the response of industrial production and unemployment to an expansionary monetary shock is reduced by 0.5pp and 0.075pp, respectively, out to a three-year horizon.

6.1 Introduction

Government debt has been on the rise in many advanced economies, and it is projected that it will continue increasing in the next decades (Yared, 2019). For example, U.S. government debt currently represents more than 100% of GDP, while it was less than 50% in the 1990s. Moreover, the CBO projects that the number will surpass 200% by 2051. The importance of public debt in shaping economic outcomes is widely recognized in macroeconomics. Its relevance covers a variety of questions, from its role as a tool to smooth the government's fiscal needs (Barro 1979) to generating a burden (D'Erasmo, Mendoza and Zhang 2016) and triggering recessions or slowing growth (Reinhart, Reinhart and Rogoff 2012). In this paper, we explore the role of government debt in the monetary transmission mechanism.

Monetary policy has become the main macroeconomic stabilization policy tool in advanced economies. It is generally expected that central banks will reduce the policy rate to stimulate the economy in recessions and increase it to "cool down" economies that face the threat of excessive inflation. However, little is known about how the effectiveness of monetary policy interacts with the level of government debt. The textbook analysis implies that government debt has no impact on the effect of monetary policy on the real economy (see Woodford, 2001; Galí, 2015). In contrast, models that emphasize the importance of monetary and fiscal interactions highlight the relevance of government debt in the dynamics of the economy but do not consider the consequences of high debt levels for the effectiveness of monetary policy. This is the focus of our paper.

We study the role of government debt in a New Keynesian model in continuous time. Since our focus is on developed economies, we abstract from default risk and assume that government debt is safe in nominal terms.[1] Moreover, we assume that fiscal policy is non-Ricardian or, in Leeper (1991) terminology, the economy is in an "active fiscal/passive monetary" policy regime. In this setting, the government's budget constraint becomes a

[1] See Arellano, Bai and Mihalache (2020) for a model of monetary policy and sovereign default risk.

relevant equilibrium condition, and government debt affects the real economy through wealth effects that are not fully offset by tax policy. Our main theoretical result is that monetary policy is less effective in economies with a higher level of public debt, meaning that the response of output to changes in the nominal interest rate is attenuated relative to low-debt economies. We then explore the model's predictions empirically and find that they are consistent with the U.S. data.

To understand the intuition behind the results, consider an economy where the monetary authority increases the nominal interest rate. In the presence of nominal rigidities, this implies an increase in the real interest rate and a reduction in initial consumption. The magnitude of the effect depends on two forces. First, there is the standard intertemporal substitution effect: when interest rates go up, households reduce present consumption in favor of future consumption. Second, there is the change in the households' wealth generated by the change in policy.

Households' wealth depends on their labor income and their financial assets. Wages, employment, and profits from ownership of firms respond to monetary policy only indirectly from the general equilibrium forces in the economy. In contrast, holdings of government bonds are directly affected by changes in monetary policy. Suppose all government debt is short-term. Then, an increase in the nominal interest rate represents a *positive wealth effect* from the bond holdings, as households get a higher return for their savings.[2] Absent a fiscal offset, this channel *weakens* the recessionary effects of contractionary monetary policy interventions. Crucially, the wealth effect generated by government debt is proportional to the stock of debt held by the households, where a larger stock generates a larger wealth effect.

Our results are in sharp contrast to the predictions obtained from the standard equilibrium selection (the so-called "Taylor equilibrium"), in which fiscal variables are irrelevant to the determination of equilibrium. Notably, this stark difference is not driven by differ-

[2]Note that if government debt is positive, the household sector is a *net saver* in the aggregate, so it benefits from an increase in the interest rate when debt is short term.

ences in the wealth effects associated with government bonds. Monetary policy *always* affects the valuation and return of government debt, independently of the equilibrium selection criterion. However, the standard selection neutralizes these wealth effects by assuming offsetting lump-sum transfers, such that the net effect is always zero. Thus, different government debt levels affect the fiscal response to changes in monetary policy, but they do not affect the dynamics of households' wealth and, therefore, the response of consumption to changes in the policy rate. In contrast, transfers do not offset these wealth effects in our non-Ricardian setting, opening the possibility that the level of government debt affects the dynamics of the economy.

We then extend the main results to an economy with long-term government debt. In this case, monetary policy generates an additional wealth effect that operates through the repricing of assets. An increase in the policy rate reduces the price of long-term government bonds, generating a *negative wealth effect*. Whether this repricing channel is sufficient to overturn the positive effect of higher returns on households' savings depends on the duration of the debt. While the positive effect is independent of the duration of government debt, the negative effect is stronger the longer the duration. Whether the net effect is a positive or a negative wealth effect ultimately depends on whether a higher interest rate increases or reduces the government debt burden since a positive wealth effect is the counterpart of an increase in the government debt burden (and vice versa). Thus, if contractionary monetary policy increases the government's debt burden, then households will experience a positive wealth effect, and monetary policy becomes weaker with the level of government debt. Notably, the net effect is more likely to be positive the more sticky prices are. In the extreme case in which prices are fully rigid, the wealth effect of a contractionary monetary shock is positive for any duration lower than that of a consol.

Finally, we explore the validity of the model's implications on the U.S. data. We study the interaction between identified monetary policy shocks using the Romer and Romer (2004) narrative approach and the public debt position of private investors using the data from Hall, Payne and Sargent (2018). We extend the Jordà (2005) local projections method to study this interaction in a dynamic setting, and we find that high levels of government debt attenuate the effects of monetary policy on industrial production and the unemployment rate. When government debt held by the private sector is one standard deviation above the mean, the response of industrial production is diminished by 0.5pp, and the response of the unemployment rate is reduced by 0.075pp, at a three-year horizon. These results suggest that the level of government debt is an important source of time variation in the monetary transmission, such that higher levels of debt weaken the transmission of monetary policy.

Literature Review This paper is related to several strands of literature. First, the paper is connected to the literature that studies the real effects of government debt.[3] Ball and Mankiw (1995) study the crowding-out effect of government debt, while Reinhart, Reinhart and Rogoff (2012) argue that high levels of debt are associated with lower long-run growth. Our paper identifies the relationship between public debt and monetary policy as a new channel through which government debt can affect the economy.

Our paper relates to discussions of sustainable public debt and stabilization policy. D'Erasmo, Mendoza and Zhang (2016) study empirical and theoretical models of sovereign default and show the conditions under which public debt can be considered sustainable when the government cannot commit to repaying its debts. Leeper, Leith and Liu (2016) show that in the absence of commitment, optimal monetary policy faces an inflation bias in part to stabilize the real value of government debt. Davig, Leeper and Walker (2011) study the theoretical limits of a government's ability to finance its debt through taxation and find that the tail events associated with this limit imply an upward bias in inflation expectations that present a challenge to monetary policymakers. These mechanisms highlight the interdependence of monetary policy and the structure of government finances.

[3]See Elmendorf and Mankiw (1999) for a comprehensive review.

Additionally, our paper contributes to the theoretical literature on New Keynesian models and the Fiscal Theory of the Price Level (FTPL). Leeper (1991), Sims (1994) and Woodford (2001) are early developments of the FTPL. Kim (2003) provides an analysis combining studying the effects of the FTPL in a New Keynesian model. Caramp and Silva (2021) show that fiscal policy is a crucial determinant of the wealth effects in the monetary transmission mechanism. We extend their analysis and focus on the role of government debt in shaping the effectiveness of monetary policy. Closely related is Cochrane (2001), who identifies the importance of maturity in determining the path of inflation under the FTPL. Our analysis differs from his in that we study the interaction between the level of debt and the effectiveness of monetary policy.

Finally, our paper builds upon recent advances in econometric methods to examine the interaction between monetary policy and government debt. Estimating the effects of monetary policy has a long history in macroeconomics.[4] In the spirit of Tenreyro and Thwaites (2016); Angrist, Jordà and Kuersteiner (2018); Barnichon, Matthes and Ziegenbein (2022) and others, we augment the Jordà (2005) local projections model with nonlinear interactions to study the effect of government debt on the transmission mechanism of monetary policy.[5]

Outline The rest of the paper is organized as follows. Section 6.2 describes the model and Section 6.3 studies the equilibrium dynamics. Section 6.4 presents the main results of the paper: the relationship between the level of debt and monetary policy. Section 6.5 conducts the empirical analysis and Section 6.6 concludes. All the proofs are in Appendix 6.7.

[4] See the literature review of Ramey (2016).

[5] See also Broner et al. (2022), Ottonello and Winberry (2020) and Alessandri and Venditti (2022).

6.2 The Model

Time is continuous and denoted by $t \in \mathbb{R}_+$. The economy is populated by a large number of identical, infinitely-lived households and a continuum of firms that produce final and intermediate goods. Final good producers operate in a perfectly competitive market and combine intermediate goods using a CES aggregator with elasticity $\epsilon > 1$. Intermediate-goods producers use labor as the only factor of production to produce a differentiated good that is traded in monopolistically competitive markets. We assume that intermediate-goods firms face a pricing friction à la Calvo. Moreover, there is an infinitely-lived government that sets monetary and fiscal policy.

We study the determination of equilibrium of an economy in which fiscal policy is described by a non-Ricardian rule, in the sense that primary surpluses do not automatically adjust to satisfy the budget constraint *for every* sequence of endogenous and exogenous variables (see Woodford, 2001). We shall see that this assumption is crucial to obtain that the level of government debt matters for the economy's response to policy changes.

Households. Households have preferences given by

$$\int_0^\infty e^{-\rho t}\left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi}\right] dt, \tag{4}$$

where C_t denotes consumption in period t, N_t is hours worked, $\rho > 0$ is the instantaneous discount factor, and $\sigma, \phi \geq 0$. They face an intertemporal budget constraint given by

$$\int_0^\infty e^{-\int_0^t i_s ds} P_t C_t dt \leq \frac{B_0}{P_0} + \int_0^\infty e^{-\int_0^t i_s ds}\left[W_t N_t + \Pi_t + P_t T_t\right] dt, \tag{5}$$

where i_t represents the nominal interest rate, B_t is a short-term (instantaneous) nominal bond, W_t is the nominal wage, Π_t is aggregate nominal profits, T_t is a government lump-sum transfer, and P_t is the price level. Moreover, they are subject to the usual No-Ponzi condition

$$\lim_{t\to\infty} e^{-\int_0^t i_s ds} B_t \geq 0.$$

The households' objective is to choose sequences $[C_t, N_t, B_{t+1}]_{t\geq 0}$ to maximize (4) subject to (5) for every $t \geq 0$, and the No-Ponzi condition, given B_0. The households' optimality conditions are given by

$$N_t^{\phi} C_t^{\sigma} = \frac{W_t}{P_t},$$
$$\frac{\dot{C}_t}{C_t} = \sigma^{-1}(i_t - \pi_t - \rho).$$

Firms. There are two types of firms in the economy: final goods producers and intermediate goods producers. Final goods producers operate in a perfectly competitive market and combine a unit mass of intermediate goods $Y_t(i)$, for $i \in [0, 1]$, using the production function

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}. \tag{6}$$

The problem of a final goods producer is given by

$$\max_{[Y_t(i)]_{i\in[0,1]}} P_t Y_t - \int_0^1 P_t(i) Y_t(i) di$$

subject to (6). The solution to this problem gives the standard CES demand

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} Y_t, \tag{7}$$

where $P_t \equiv \left(\int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$ is the aggregate price level.

Intermediate goods are produced using the following technology:

$$Y_t(i) = N_t(i)^{1-\gamma},$$

with $\gamma \in [0,1)$. Intermediate goods firms choose the price for their good, $P_t(i)$, subject to the demand for their good, given by (7), taking the aggregate price level, P_t, and aggregate output, Y_t, as given. As is standard in New Keynesian models, we assume that firms are subject to a pricing friction à la Calvo: firms are allowed to reset their prices with Poisson intensity ρ_δ. Moreover, we assume that the government levies a constant sales tax τ. Let P_t^* denote the price chosen by a firm that can set their price in period t. Then, P_t^* is the solution to the following problem:

$$\max_{P_t^*} \int_0^\infty e^{-(\rho+\rho_\delta)s} \left(\frac{C_{t+s}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+s}} \left[(1-\tau)P_t^* Y_{t+s|t} - W_{t+s} Y_{t+s|t}^{\frac{1}{1-\gamma}}\right] ds,$$

where $e^{-\rho s}\left(\frac{C_{t+s}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+s}}$ is the households' stochastic discount factor for nominal payoffs, $Y_{t+s|t}$ represents the demand function faced at period $t+s$ by a producer that last set price in period t,

$$Y_{t+s|t} = \left(\frac{P_t^*}{P_{t+s}}\right)^{-\epsilon} Y_{t+s},$$

Y_t denotes the aggregate demand at period t, and we used that $N_{t+s}(i) = Y_{t+s|t}^{\frac{1}{1-\gamma}}$. The first-order condition associated with this problem is given by

$$\int_0^\infty e^{-(\rho+\rho_\delta)s} \left(\frac{C_{t+s}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+s}} \left[(1-\tau)P_t^* Y_{t+s|t} - \frac{\epsilon}{\epsilon-1}\frac{1}{1-\gamma} W_{t+s} Y_{t+s|t}^{\frac{1}{1-\gamma}}\right] ds = 0.$$

Since P_0 is predetermined in this continuous time setting, we normalize it to one, i.e., $P_0 = 1$.

Government. The government's intertemporal budget constraint is given by

$$D_0^g = \int_0^\infty e^{-\int_0^t i_s ds} \left[\tau Y_t - T_t\right] dt,$$

where D_0^g denotes the government debt level in period 0. Note that we are assuming that government debt is short-term (instantaneous) here. We extend the analysis to long-term bonds in Section 6.4.

An important feature for the determination of equilibrium is that fiscal policy is described by a non-Ricardian rule, in the sense that primary surpluses do not automatically adjust to satisfy the budget constraint *for every* sequence of endogenous and exogenous variables. In this paper, we assume that the sequence $\{i_t\}_{t\geq 0}$ is exogenously given, and the lump-sum transfer $\{T_t\}_{t\geq 0}$ is constant at its steady-state level, T. Our main results survive a generalization of the policy rules as long as fiscal policy does not adjust to fully neutralize the wealth effects generated by government bonds and monetary policy follows a "passive" rule in the sense of Leeper (1991). Assuming a given path of policy variables simplifies the exposition.

Market clearing and the aggregate price level. The market clearing condition for goods and bonds are given by

$$C_t = Y_t, \qquad B_t = D_t^g.$$

Applying an appropriate law of large numbers, we get that the aggregate price level is an average of prices set in different periods:

$$P_t = \left(\int_{-\infty}^{t} \rho_\delta e^{-\rho_\delta(t-s)}(P_s^*)^{1-\epsilon} ds\right)^{\frac{1}{1-\epsilon}} \iff P_t^{1-\epsilon} = \int_{-\infty}^{t} \rho_\delta e^{-\rho_\delta(t-s)}(P_s^*)^{1-\epsilon} ds.$$

Differentiating the expression above, we get

$$(1-\epsilon)P_t^{1-\epsilon}\frac{\dot{P}_t}{P_t} = \rho_\delta(P_t^*)^{1-\epsilon} - \rho_\delta P_t^{1-\epsilon}.$$

Defining the inflation rate as $\pi_t \equiv \frac{\dot{P}_t}{P_t}$, we get

$$\pi_t = \frac{\rho_\delta}{\epsilon-1}\left[1 - \left(\frac{P_t^*}{P_t}\right)^{1-\epsilon}\right].$$

Steady-state equilibrium and the irrelevance of government debt. Let the variables without subscript denote their value in the zero-inflation steady state. In this equilibrium, policy is such that: i) the fiscal variables are constant, i.e., $T_t = T$ for all t; ii) the nominal interest rate is $i_t = \rho$ for all t. The steady-state allocation satisfies

$$C = Y = \left[\frac{1}{(1-\tau)(1-\gamma)} \frac{\epsilon}{\epsilon - 1} \right]^{\frac{1-\gamma}{\gamma+\varphi-\sigma(1-\gamma)}} \tag{8}$$

$$N = Y^{\frac{1}{1-\gamma}} \tag{9}$$

$$D^g = \frac{\tau Y - T}{\rho}. \tag{10}$$

These equations lead to the following result.

Proposition 1. *Given τ, the steady-state level of output, consumption and labor are independent of the level of government debt, D^g.*

The steady-state levels of output, consumption, and labor of the economy are determined by equations (8)-(9), which are independent of the level of debt, conditional on τ. Then, equation (10) determines the combination of lump-sum transfers and debt levels consistent with the government's budget constraint. For example, a higher level of steady-state debt is associated with a lower level of lump-sum transfers (recall that these are transfers *to* the agents), which are used to pay the interest on the debt. The following corollary provides a benchmark for the analysis that follows.

Corollary 1.1. *Consider two economies like the one described here, with the same preferences and technologies. If the steady-state level of distortionary taxes coincides, their steady-state level of output, consumption, and labor also coincide.*

This result provides a useful benchmark for the exercises we perform in the following sections. It states that two economies that differ only in their steady-state level of debt feature the same steady-state allocation. However, we will show that, despite this, their dynamics after a monetary shock may differ.

6.3 Equilibrium Dynamics

To study the dynamics of the economy, we log-linearize the equilibrium conditions around a steady-state that features a constant path for the policy variables and zero inflation. Let

$$c_t = \log(C_t) - \log(C) \quad \text{and} \quad y_t = \log(Y_t) - \log(Y).$$

Given the path of the nominal interest rate, $\{i_t\}_{t \geq 0}$, the equilibrium is characterized by

$$\dot{c}_t = \sigma^{-1}(i_t - \pi_t - \rho), \tag{11}$$

$$\dot{\pi}_t = \rho \pi_t - \kappa c_t, \tag{12}$$

and the intertemporal budget constraint

$$\int_0^\infty e^{-\rho t} c_t dt = \int_0^\infty e^{-\rho t} \left[(1-\tau) y_t + \varsigma_d (i_t - \pi_t - \rho)\right] dt, \tag{13}$$

where κ is a positive constant defined in the appendix, and ς_d is the debt-to-gdp ratio in the steady state (recall that the lump-sum transfers are constant, i.e. $T_t = T \; \forall t$).[6] Equation (11) is the households' Euler equation and equation (12) is the Phillips curve, which arises from the intermediate-goods firms optimal pricing decisions. Finally, equation (13) is the households' budget constraint, which states that the present value of consumption equals the present value of *after-tax* income from wages and profits, plus the interest income from government bond holdings. Noting that the Euler equation implies

$$\int_0^\infty e^{-\rho t} \rho \sigma \left(c_t - c_0\right) dt = \int_0^\infty e^{-\rho s} \left(i_t - \pi_t - \rho\right) ds,$$

[6]See Appendix 6.7.1 for the full derivation.

we can rewrite the budget constraint as

$$\int_0^\infty e^{-\rho t} c_t dt = \int_0^\infty e^{-\rho t} \left[(1-\tau) y_t + \rho \varsigma_d \sigma (c_t - c_0) \right] dt, \tag{14}$$

where the last term on the right-hand side represents the change in the real rate of return on government bonds.

Next, we solve the model. We start with the case of rigid prices, which allows a simple characterization. After that, we solve the general case with sticky prices.

Rigid prices. Before solving the full model, let's consider the case with rigid prices, i.e., $\kappa = 0$ so $\pi_t = 0 \; \forall t$. The households' Euler equation implies

$$c_t = \underbrace{c_0}_{\text{level}} + \underbrace{\sigma^{-1} \int_0^t (i_s - \rho) ds}_{\text{slope}}. \tag{15}$$

The Euler equation determines the *slope* of the consumption path, which depends on the path of the interest rate and the EIS, σ^{-1}. The *level* of the consumption path is determined by the households' budget constraint. Plugging equation (15) into the intertemporal budget constraint (14), using the market-clearing condition in the goods market, and after some algebra, we get

$$c_0 = -\sigma^{-1} \frac{\tau - \rho \varsigma_d \sigma}{\tau} \int_0^\infty e^{-\rho t} (i_t - \rho) dt.$$

Thus, the Euler equation determines the *slope* of the consumption path while the intercept (and the level) is determined by intertemporal budget constraint. Note that the debt-to-GDP ratio ς_d is a crucial component of the determination of c_0.

Sticky prices. It is useful to define the following two constants (which are the eigenvalues of the system given by (11) and (12)):

$$\overline{\omega} = \frac{\rho + \sqrt{\rho^2 + 4\kappa\sigma^{-1}}}{2} > 0, \quad \underline{\omega} = \frac{\rho - \sqrt{\rho^2 + 4\kappa\sigma^{-1}}}{2} < 0.$$

The next proposition characterizes the solution of the system (11), (12) and (14) in closed form.

Proposition 2. *The equilibrium path for consumption is given by*

$$c_t = e^{\underline{\omega} t} c_0 + c_t^m,$$

where

$$c_t^m \equiv \frac{\sigma^{-1}}{\overline{\omega} - \underline{\omega}} e^{\underline{\omega} t} \left[\int_0^t \left(\overline{\omega} e^{-\underline{\omega} s} - \underline{\omega} e^{-\overline{\omega} s} \right) (i_s - \rho)\, ds + \underline{\omega} \left(e^{(\overline{\omega} - \underline{\omega})t} - 1 \right) \int_t^\infty e^{-\overline{\omega} s} (i_s - \rho)\, ds \right],$$

and the initial value c_0 is given by

$$c_0 = \int_0^\infty e^{-\rho t} \chi_{m,t} (i_t - \rho) dt,$$

where $\chi_{m,t} \equiv -\sigma^{-1} \frac{\tau - \rho\varsigma_d \sigma}{\tau - \underline{\omega}\varsigma_d \sigma} e^{\underline{\omega} t}$. Given the path for the nominal interest rate, $\{i_t\}_{t\geq 0}$, the path of consumption, $\{c_t\}_{t\geq 0}$, is uniquely determined.

Proposition 2 characterizes the equilibrium path of consumption in the non-Ricardian regime in which lump-sum transfers are constant. This solution differs from that of the standard equilibrium selection, which relies on an interest rate rule that satisfies the "Taylor principle." The standard selection drops the budget constraint (14) and instead adds an interest rate rule of the form

$$i_t = \rho + \phi_\pi \pi_t + \varepsilon_t, \tag{16}$$

where $\phi_\pi > 1$ and ϵ_t represents an innovation of the rule relative to its systematic response to inflation.[7] Then, the equilibrium of the economy is the solution to the system of equations given by (11), (12) and (16). However, there is no guarantee that such a solution will satisfy the budget constraint (14). This problem is resolved by assuming that the path of the lump-sum transfer $\{T_t\}_{t\geq 0}$ automatically adjusts to satisfy the constraint. In contrast, the solution in Proposition 2 is obtained by setting a given path for the nominal interest rate $\{i_t\}_{t\geq 0}$ and assuming that the path of the lump-sum transfer *does not* react to the change in monetary policy. A key feature of this solution is that c_0 depends on the debt-to-GDP ratio, ς_d.

In what follows, we make the following assumption to obtain standard comparative statics.

Assumption 1. *$\tau > \rho\varsigma_d\sigma$.*

The left-hand side of Assumption 1 captures the first-order effect of an increase in consumption on tax revenues. The right-hand side captures the first-order effect of the increase in consumption in $t > 0$ on the interest payments on the debt. An increase in consumption pushes real interest rates up by σ, while the interest payments on the debt in the steady-state are given by $\rho\varsigma_d$. Hence, Assumption 1 implies that a boom in consumption increases government revenues by more than it increases the financing costs, so that it improves the government's finances overall.[8] Notably, $\tau > 0$ is a necessary condition for the assumption to hold. Under this condition, we get the following result.

Proposition 3. *Suppose Assumption 1 holds. Then, for all $t \geq 0$,*

$$\frac{\partial c_0}{\partial i_t} < 0.$$

[7] The rule can also depend on output, y_t. The core idea does not depend on this.

[8] More formally, note that the government's budget constraint is $\int_0^\infty e^{-\rho t}\left[\tau c_t - \rho\varsigma_d\sigma\left(c_t - c_0\right)\right] dt = 0$. Taking the derivative of the right-hand side with respect to c_t, we get $e^{-\rho t}\left(\tau - \rho\varsigma_d\sigma\right)$. Thus, Assumption 1 implies that the revenue effect of a consumption boom outweighs the increase in interest payments from the change in the real rate.

Proposition 3 establishes that the model generates standard comparative statics with respect to monetary policy shocks, that is, a that contractionary monetary policy reduces consumption in period 0. Assumption 1 is crucial in delivering this result as strong wealth effects could overturn it. To understand why this is the case, note that a monetary shock triggers two effects. First, we have the standard intertemporal substitution effect, which operates through changes in the relative price of current and future consumption, namely, the real interest rate. Through this channel, an increase in the nominal interest rate tilts the path of consumption upward.[9] Thus, fixing the households' wealth, the new path will have a lower level of consumption in period 0. This is the standard channel emphasized in the New Keynesian literature. Second, monetary policy generates *wealth effects*. Households' wealth depends on their labor income and their financial assets. Wages, employment, and profits from the ownership of firms respond to monetary policy only indirectly. In contrast, holdings of government bonds are directly affected by changes in monetary policy. The increase in the real rate *increases* the households' interest income which, because of the non-Ricardian fiscal policy, is not offset by a change in lump-sum transfers. Thus, this becomes a *positive* wealth effect for the households. Assumption 1 guarantees that this positive wealth effect does not overturn the substitution effect. It does so by guaranteeing that an increase in initial consumption is not affordable: the increase in its cost would be greater than the increase in the households' after-tax income (that is, $1 > (1-\tau) + \sigma\varsigma_d\rho$). Thus, consumption in period 0 has to decline.

The next section presents the paper's main theoretical result, namely, that the level of government debt affects the effectiveness of monetary stabilization policy. As we will see, the wealth effects emphasized above will be a crucial component for the results.

[9] From the Euler equation we have $\dot{c}_t > 0 \iff i_t - \pi_t > \rho$.

6.4 Government Debt and Stabilization Policies

In this section, we explore how the level of government debt affects the effectiveness of monetary policy interventions, that is, the effect of government debt on the elasticity of output to interest rate changes. As a benchmark, we begin by presenting the irrelevance of the level of government debt in the standard Taylor equilibrium.

Irrelevance of debt in the Taylor equilibrium. Consider the equilibrium of an economy characterized by equations (11), (12) and (16), with $\phi > 1$ (and lump-sum transfers that adjust so that equation (14) is also satisfied). The next proposition states that the level of debt is irrelevant to the economy's response to monetary shocks.

Proposition 4. *Consider the equilibrium of an economy described by* (11)*,* (12) *and* (16)*, with* $\phi > 1$*. Then,*

$$\frac{\partial^2 c_0}{\partial \varepsilon_t \partial \varsigma_d} = 0.$$

The result in Proposition 4 formalizes a well-known result from the literature: fiscal variables do not affect the response of the economy to monetary shocks. Note, however, that this result does not imply that the wealth effects emphasized in the previous section are absent in this equilibrium. On the contrary, these wealth effects are present but neutralized by an automatic (or *passive*) adjustment of the lump-sum transfers. In particular, we have that

$$\frac{\partial^2 \int_0^\infty e^{-\rho t}\left[\varsigma_d(i_t - \pi_t - \rho) + T_t\right] dt}{\partial \varepsilon_t \partial \varsigma_d} = \int_0^\infty e^{-\rho t}\left[\left(\frac{\partial i_t}{\partial \varepsilon_t} - \frac{\partial \pi_t}{\partial \varepsilon_t}\right) + \frac{\partial^2 T_t}{\partial \varepsilon_t \partial \varsigma_d}\right] dt = 0,$$

that is, the change in (the present value of) lump-sum transfers after a monetary shock moves one-to-one with the change in total interest payments given a change in the level of government debt. This is not the case in the non-Ricardian regime.

Government debt in the non-Ricardian regime. Consider two economies that have the same technology, preferences, distortionary taxes, and pricing frictions but differ in the steady-state level of government debt. As we showed in Proposition 1, both economies have the same equilibrium allocation in steady-state. The next proposition shows that the response of consumption to policy shocks is attenuated in the economy with a higher level of government debt.

Proposition 5. *Suppose Assumption 1 holds. Then, the effect of monetary policy is decreasing in the level of government debt, that is*

$$\frac{\partial^2 c_0}{\partial i_t \partial \varsigma_d} > 0.$$

Proposition 3 established that an increase in the nominal interest rate reduces initial consumption. We explained that there were two effects: a substitution effect and a wealth effect. Note that the substitution effect is independent of the level of government debt; it only depends on the elasticity of intertemporal substitution, σ^{-1}. In contrast, the wealth effect depends on the level of government debt: the effect is stronger the larger the households' holdings. And since the wealth effect is *positive* after a *contractionary* monetary shock, the impact of monetary policy on initial consumption *decreases* with the level of government debt.[10]

It is important to note that while we have primarily focused on the effects of policy changes on period-0 consumption, the conclusions apply to the whole path. Recall that

$$c_t = e^{\underline{\omega} t} c_0 + c_t^m.$$

From Proposition 2 we know that c_t^m is independent of ς_d. Thus, by finding the effect of debt on initial consumption, we obtain the effect on the entire consumption path.

To summarize, we have shown that the efficacy of monetary policy decreases with the

[10]Note that as long as Assumption 1 is satisfied, contractionary monetary policy always reduces initial consumption.

level of government debt. An important limitation of the results is that we have assumed that government debt is short-term. In reality, most government debt is long-term (e.g., the average maturity of U.S. debt is around five years). Next, we explore how the presence of long-term government bonds affects the results.

Long-Term Bonds. Let's assume now that the government can also issue long-term nominal debt. The long-term bond is a perpetuity with exponentially decaying coupons, as in Woodford (2001). Formally, one unit of the bond at date t corresponds to a promise to pay $e^{-\rho_L(s-t)}$ in nominal terms at every date $s \geq t$. The price of the bond is given by

$$q_{L,t} = \int_t^\infty e^{-\int_t^s i_z dz} e^{-\rho_L(s-t)} ds = \int_t^\infty e^{-\int_t^s (i_z+\rho_L)dz} ds,$$

and the bond duration in steady state is $\frac{1}{\rho+\rho_L}$. Hence, by varying ρ_L we can study how the results change with the duration of government debt.

The households' per-period budget constraint is now given by

$$\dot{B}_{S,t} + q_{L,t}\dot{B}_{L,t} = i_t B_{S,t} + (1 - q_{L,t}\rho_L) B_{L,t} + W_t N_t + \Pi_t + P_t T_t - P_t C_t,$$

where $(1 - q_{L,t}\rho_L)B_{L,t}$ represents the coupon payment net of the "depreciation" of the bond. Then, the households' intertemporal budget constraint is given by

$$\int_0^\infty e^{-\int_0^t i_s ds} P_t C_t dt = D^g_{S,0} + q_{L,0} D^g_{L,0} + \int_0^\infty e^{-\int_0^t i_s ds} \left(W_t N_t + \Pi_t + T_t\right) dt,$$

where we have already imposed market-clearing in the bonds market, and $D^g_{S,0}$ and $D^g_{L,0}$ denote the stock of short-term and long-term government bonds, respectively. Notably, initial debt now depends on the price of the long-term bond. This is the only difference with respect to the previous model. The following result provides the benchmark for this economy with long-term bonds.

Proposition 6. *Given τ, the steady-state level of output, consumption and labor are independent of the level and duration of government debt.*

This result is an extension of Proposition 1 and Corollary 1.1. It says that not only the steady-state *level* of debt, D_S^g and D_L^g, is irrelevant for the steady-state allocation, but the duration of long-term debt, ρ_L, as well.

Let's now consider the response of the economy to monetary policy shocks. The Euler equation and the Phillips curve are still given by equations (11) and (12), respectively. The only difference is in the intertemporal budget constraint, which in its log-linear form is now given by

$$\int_0^\infty e^{-\rho t} c_t dt = \int_0^\infty e^{-\rho t} \left[(1-\tau)y_t + \sigma\rho\varsigma_d(c_t - c_0)\right] dt + d_0^g \varsigma_d,$$

where, up to first order,

$$d_0^g = \varsigma_L q_{L,0},$$

and

$$q_{L,t} = -\int_t^\infty e^{-(\rho+\rho_L)s}(i_s - \rho)ds,$$

and where ς_L denotes the steady-state fraction of debt that is long-term, that is $\varsigma_L \equiv \frac{q_L D_L^g}{D_S^g + q_L D_L^g}$.[11] Plugging these expressions into the budget constraint, we get

$$\int_0^\infty e^{-\rho t} c_t dt = \int_0^\infty e^{-\rho t} \left[(1-\tau)y_t + \sigma\rho\varsigma_d(c_t - c_0)\right] dt - \varsigma_d\varsigma_L \int_0^\infty e^{-(\rho+\rho_L)t}(i_t - \rho)dt.$$

Hence, the budget constraint has an additional term that depends on the nominal interest rate, i_t, the fraction of long-term bonds, ς_L, and the bond's duration, ρ_L.

Solving the new system of equations, we get

$$c_0 = \int_0^\infty e^{-\rho t}\chi_{m,t}(i_t - \rho)dt - \frac{\overline{\omega}\varsigma_d\varsigma_L}{\tau - \underline{\omega}\varsigma_d\sigma}\int_0^\infty e^{-(\rho+\rho_L)t}(i_t - \rho)dt,$$

[11] In a slight abuse of notation, we denote by $q_{L,t}$ the log-linear approximation of the bond price.

where $\chi_{m,t}$ is defined as in Proposition 2. The next proposition extends Proposition 5 to the model with long-term government debt.

Proposition 7. *Suppose Assumption 1 holds. Then, an increase in the nominal interest rate reduces initial consumption, and the effect is stronger the higher the fraction of long-term debt and the higher the bond duration, that is,*

$$\frac{\partial c_0}{\partial i_t} < 0, \quad \frac{\partial^2 c_0}{\partial i_t \partial \varsigma_L} < 0, \quad \frac{\partial^2 c_0}{\partial i_t \partial \rho_L}\Big|_{t>0} > 0.$$

Moreover, if $\rho_L > |\underline{\omega}|$*,*

$$\frac{\partial^2 c_0}{\partial i_t \partial \varsigma_d}\Big|_{t>0} > 0.$$

Long-term bonds introduce a new channel relative to the model in Section 6.2: the response of the bond price to interest rate changes. Note that increases in the nominal interest rate always reduce the bond price. Thus, long-term bonds reinforce the contractionary effects of higher nominal rates. Moreover, this effect is stronger the higher the fraction of long-term debt and the longer its duration. Thus, the longer the duration of government debt, the stronger the effects of monetary policy. Crucially, there is a threshold duration of government debt such that if the duration of government debt is *lower* than the threshold, the positive effect of the change in the rate of return of bonds dominates the negative effect of repricing, and higher government debt leads to weaker monetary policy. This threshold is given by the absolute value of the negative eigenvalue of the New Keynesian system of differential equations. In the extreme of rigid prices, that is, if $\kappa = 0$, we have that $\underline{\omega} = 0$, so any duration shorter than a consol generates a weaker transmission. Intuitively, the result depends on whether an increase in the nominal interest increases or reduces the government's debt burden. Note that the positive wealth effect of government bonds we have emphasized until now is the counterpart of a *negative* effect on the government's budget, that is, an increase in the debt burden. Similarly, if an increase in the nominal interest reduced the government debt burden, then this would imply a *neg-*

ative wealth effect for the households. As noted above, when prices are more sticky (or the Phillips curve is relatively flat, as argued to be the case for the U.S., see Hazell et al., 2022), almost any finite duration of government debt implies that higher nominal interest rates increase the government's debt burden and, therefore, the level of government debt weakens the effect of monetary policy.

To conclude, we have found that if the duration of government debt is not too long, the efficacy of monetary policy decreases in the stock of government debt. In the next section, we test the model's predictions by exploring the connection between the level of government debt and the effectiveness of monetary policy empirically.

6.5 Empirical Evidence

In this section, we evaluate the validity of the model's implications on U.S. data. Section 6.5.1 describes the data. Section 6.5.2 presents the econometric specification and reports the empirical results.

6.5.1 Data

Our baseline sample runs from March 1969 to December 2007. Most of the macroeconomic series we use are taken from standard sources: the industrial production index (Federal Reserve Board of Governors release G.17 Industrial Production and Capacity Utilization); the U-3 measure of the unemployment rate (BLS Current Population Survey); the consumer price index for sll urban consumers (BLS Consumer Price Index); the producer price index for all commodities (BLS Producer Price Index); and the federal funds effective rate (Federal Reserve Board of Governors H.15 Selected Interest Rates).

As the measure of the stock of government debt we use data on privately held U.S. government debt from provided by Hall, Payne and Sargent (2018).[12] Figure 17 plots the path of the market value of privately held U.S. government debt spanning our sample

[12] The most recent vintage of this data set may be found on George J. Hall's website: https://people.brandeis.edu/ ghall/

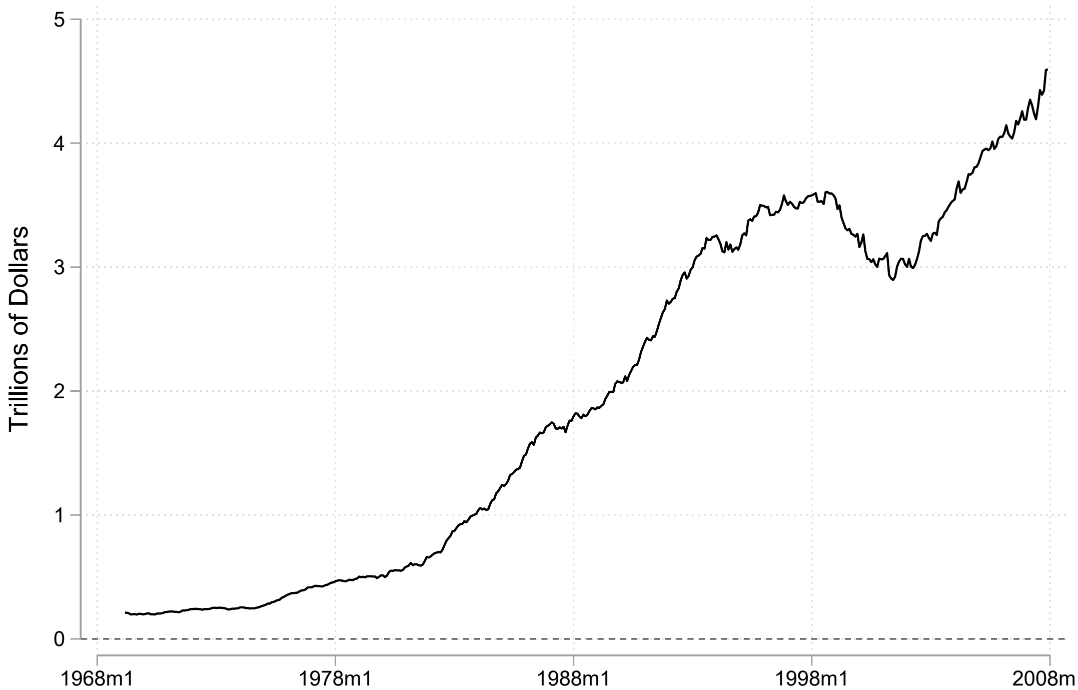

Figure 17. Market Value of Privately-Held U.S. Government Debt

Notes: From Hall, Payne and Sargent (2018).

period. In our baseline analysis, we divide this measure by the industrial production index multiplied by the consumer price index. We then standardize the measure to have a mean of zero and a standard deviation of one. Figure 18 plots the resulting debt measure. The normalized debt measure reaches a trough from 1970 until the early 1980s, before rising until the mid-90s during the Clinton administration, when it decreases steadily until it stabilizes in the early 2000s.

Monetary policy changes are typically endogenous to changes in the macroeconomic outlook. Following the literature, we rely on the Romer and Romer (2004) narrative measure of monetary policy shocks. We use an extended sample of shocks available from March 1969 through December 2007 as estimated in Wieland and Yang (2020).[13] The Romer and Romer measure is estimated by regressing changes in the federal funds rate on

[13]This series and the code for its estimation are maintained at https://www.openicpsr.org/openicpsr/project/135741/version/V1/view.

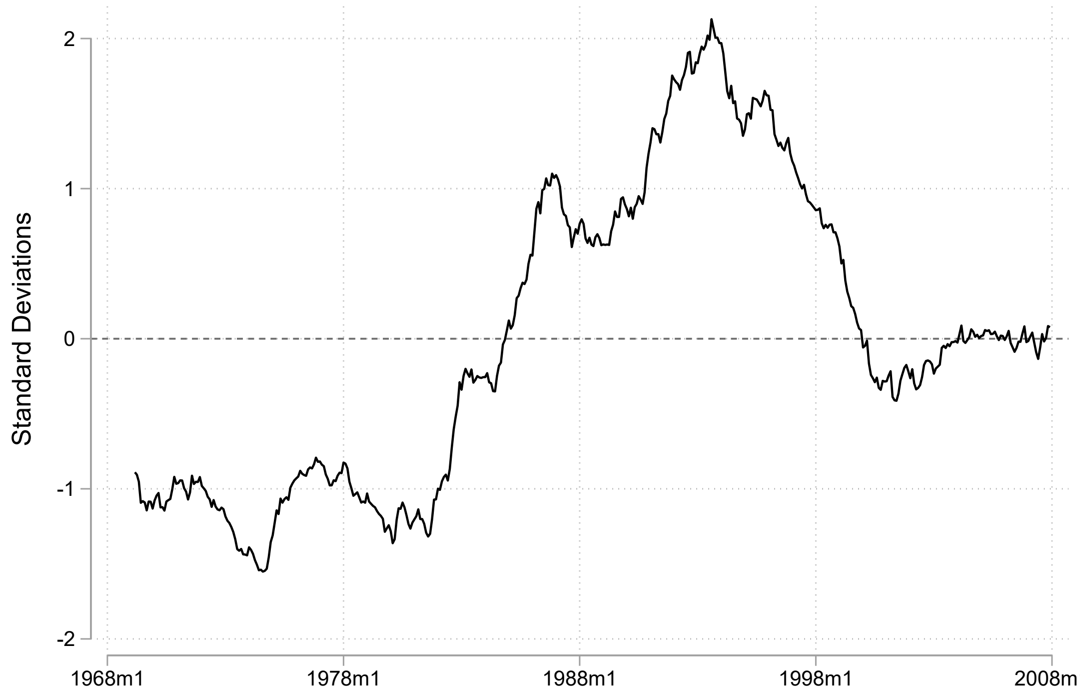

Figure 18. Standardized Debt Measure

Notes: From Hall, Payne and Sargent (2018) and authors' calculations. The standardized value of the market value of privately-held U.S. government debt as a ratio to the CPI multiplied by industrial production.

internal Federal Reserve Greenbook forecasts of the unemployment rate, industrial production, and CPI inflation. The residual of this regression is taken to represent changes in the stance of monetary policy purged of systematic responses to current and expected future economic news. Figure 19 plots the shock measure.

6.5.2 Empirical Methodology

For our empirical exercise, we employ a nonlinear variant of the Jordà (2005) local projections estimator studied by Gonçalves et al. (2021), in which we incorporate a role for privately-held government debt in the transmission of monetary policy shocks. This method has been used by Tenreyro and Thwaites (2016) and Angrist, Jordà and Kuersteiner (2018) to study the asymmetric effects of monetary policy over the business cycle, and by Barnichon, Matthes and Ziegenbein (2022) to study asymmetries and state-

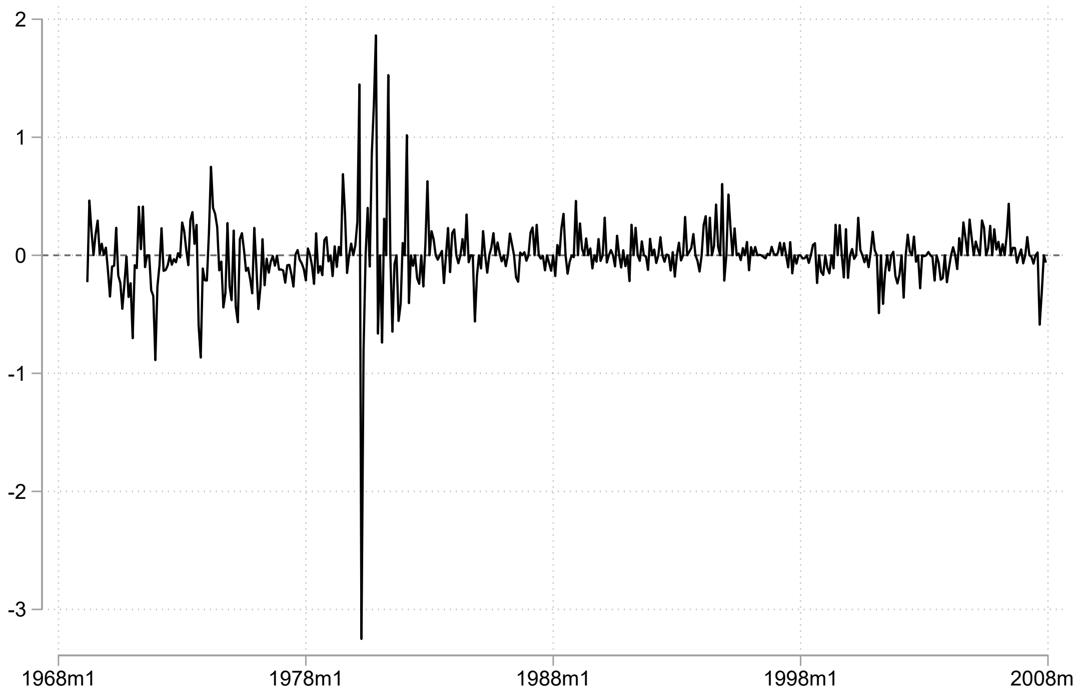

Figure 19. Identified Monetary Policy Shocks

Notes: Estimated by Wieland and Yang (2020) based on the methodology of Romer and Romer (2004).

dependence in the propagation of credit shocks. The methods we use are similar to those of Broner et al. (2022), who study whether variation in the share of public debt held by foreigners can explain the magnitude of government spending multipliers.

Let Z_t be our standardized measure of privately-held U.S. government debt and ϵ_t^{MP} be our identified monetary policy shock series, and $\mathbf{X}_t$ be a vector of controls. Our baseline nonlinear local projections specification consists of the sequence of linear regressions given by

$$\Delta^h y_{t+h} = \alpha^h + \beta^h \epsilon_t^{MP} + \delta^h Z_{t-1} + \gamma^h Z_{t-1}\epsilon_t^{MP} + \sum_{i=1}^{I} \mathbf{X}_{t-i}\boldsymbol{\theta}^h + \ \omega_{t+h}, \tag{17}$$

where $h = 0 \dots H$. As the debt measure we are interested in is a predetermined (state) variable at time t, we introduce the debt variable with a lag. Our control variables include lags of the shock series, the log of industrial production, the log of the consumer price index, the log of the producer price index, and the federal funds rate. These variables enter with a lag so as not to impose any restrictions on the contemporaneous response to monetary policy shocks. In our baseline specification, we set $H = 36$ and $I = 12$.[14] Throughout our analysis, we estimate standard errors using the approach of Newey and West (1987) to correct for serial correlation.

The cumulative impulse response of the monetary policy shock at time t on our outcome variables out to horizon h is a function of the debt measure, and equal to

$$IRF(Z_{t-1}) = \beta^h + \gamma^h Z_{t-1}.$$

As the debt measure is standardized, we obtain the impulse response at the *average debt level* by setting $Z_{t-1} = 0$, in which case the cumulative impulse response function is simply the sequence $\{\beta^h\}_{h=0}^{H}$. Additionally, we consider the case in which the standardized debt measure is one standard deviation above its sample mean by setting $Z_{t-1} = 1$, in which case the cumulative impulse response function is the sequence $\{\beta^h + \gamma^h\}_{h=0}^{H}$. The sequence $\{\gamma^h\}_{h=0}^{H}$ then represents the cumulative interaction between publicly-held government debt and monetary policy.

As a benchmark, the results in Figure 20 show the cumulative impulse responses estimated via local projections excluding the debt interaction term in equation (17), and are largely consistent with the results for the Romer and Romer (2004) shock series as presented by Ramey (2016) in Figure 2, panel B. As one standard deviation increase in the Romer and Romer (2004) measure induces an increase in the Federal funds rate by over 0.6pp within six months, reducing industrial production by over half of a percentage point within two years, while unemployment rises by nearly 0.2pp. As documented by Ramey (2016) among others, the Romer and Romer series produces several puzzles, in-

[14]Our results are robust to altering the number of lags, which we demonstrate in appendix 6.8.1. Moreover, we consider a specification with a full set of interaction terms between the controls and the debt variable, as proposed by Cloyne, Jordà and Taylor (2020) in their Oaxaca-Blinder decomposition. All our results are robust to this alternative.

Figure 20. Monetary Policy Shocks in the Linear Model

Notes: Cumulative impulse responses to a one standard deviation increase in the Romer and Romer (2004) monetary policy shock measure. 90% confidence intervals are provided.

cluding an apparently expansionary effect on industrial production and unemployment on impact, as well as a significant and persistent "price puzzle".[15]

Results for equation (17) are presented in Figure 21. The impulse response functions represented in blue show the effects of a one standard deviation Romer and Romer shock when our debt measure is at its sample mean. Consistent with the literature, these responses show a drop in industrial production of nearly 0.5pp within one year, together with an increase in the unemployment rate of 0.1pp at the two-year mark. As noted, the impulse response of the CPI appears to exhibit the price puzzle, rising by 0.2pp out to two years. Shown in red are the same impulse responses when privately-held government debt is one standard deviation above the sample mean entering period t. By

[15] As we demonstrate in appendix 6.8.2, our results survive the use of shocks identified via high-frequency movements in financial markets as proposed by Gurkaynak, Sack and Swanson (2004) and Bernanke and Kuttner (2005), which don't exhibit the price puzzle.

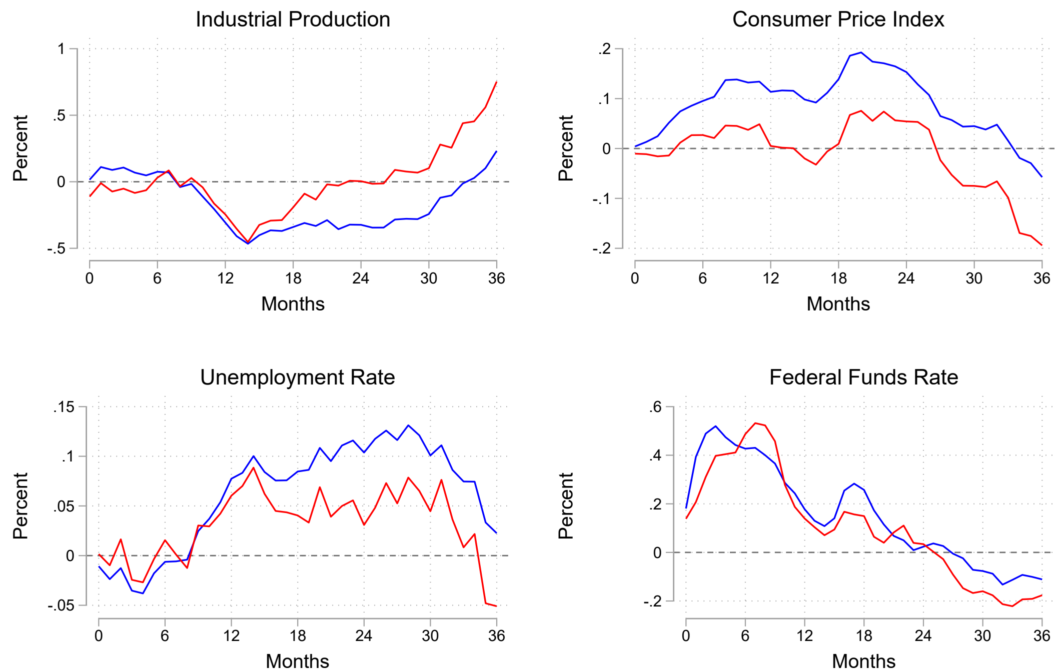

Figure 21. Monetary Policy Shocks in the Nonlinear Model

Notes: Cumulative impulse responses to a one standard deviation increase in the Romer and Romer (2004) monetary policy shock measure. The impulse response function in blue represents the case in which privately-held government debt is at the sample mean. The red impulse response function represents the case in which the debt measure is one standard deviation above the sample mean.

contrast, these impulse responses show a diminished response of industrial production and unemployment. Industrial production falls in line with the mean case but recovers more quickly after the one-year mark. Likewise, unemployment recovers more quickly in the case with high debt, rising by 0.5pp rather than above 1.0pp in the mean-debt case. These results are consistent with high levels of privately-held government debt, reducing the contractionary impulse of the monetary policy shock.

Figure 22 plots the cumulative interaction between privately-held government debt and the Romer and Romer shock, which is equal to the difference between the impulse response functions presented in Figure 21. As noted, the level of debt causes a statistically significant difference in the impulse response functions of industrial production and the unemployment rate to the Romer and Romer shock. On impact and within the first year,

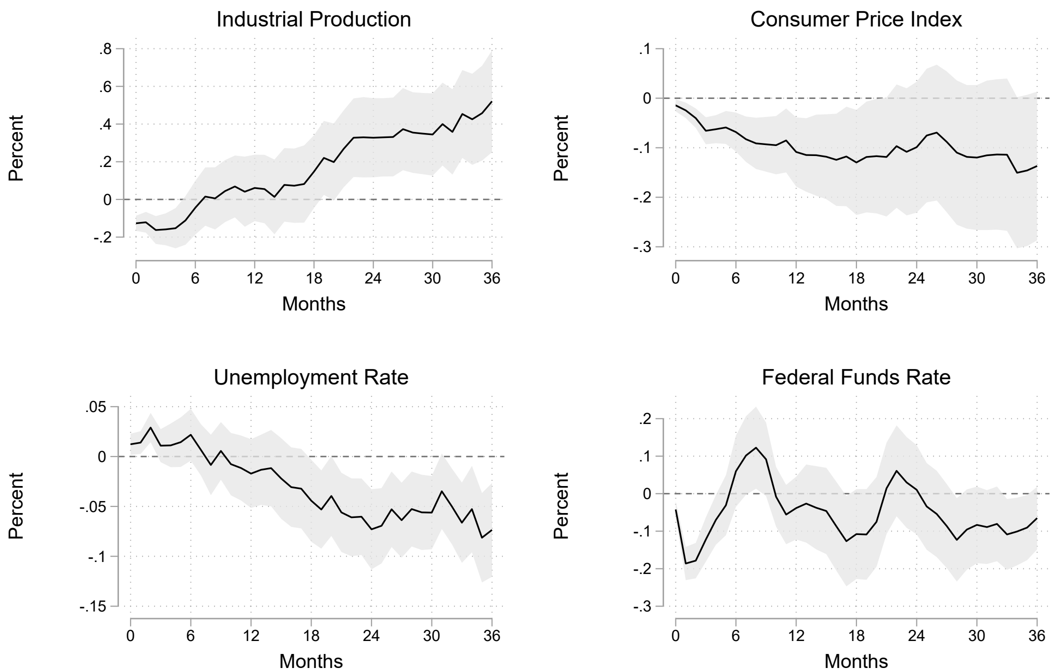

Figure 22. Cumulative Interactions in the Nonlinear Model

Notes: The cumulative interaction between monetary policy shocks and the debt measure after a one standard deviation increase in the Romer and Romer (2004) monetary policy shock measure. 90% confidence intervals are provided.

the impulse responses in the high- and mean-debt cases are generally statistically indistinguishable. When our debt measure is one standard deviation above its sample mean, the response of industrial production reflects a nearly 0.5pp increase relative to the mean case within three years. Similarly, the increase in the unemployment rate is over 0.075pp lower in the high-debt case out to three years.

These findings are consistent with the implications of the model laid out in Sections 6.2 to 6.4. Namely, when government debt is higher, the effectiveness of monetary policy, measured as the elasticity of output to changes in the path of the nominal interest rate, decreases.

6.6 Conclusion

This paper explores the role of government debt in the monetary transmission mechanism. We build a New Keynesian model where fiscal variables affect the determination of equilibrium. We find that the effectiveness of monetary policy becomes weaker in high-debt economies. Behind this result, there is a wealth effect from the revaluation of public debt after a change in the nominal interest rate. We test the model's implications empirically and find that high government debt levels attenuate the effects of monetary policy on industrial production and the unemployment rate, consistent with the model.

This analysis has important implications for the conduct of monetary policy. Most advanced economies are currently experiencing high levels of debt. Our findings imply that the efficacy of monetary policy decreases in these environments, calling for stronger interventions to stabilize the economy. However, this recommendation conflicts with the secular decline of policy rates, which limits the room for monetary policy accommodation. In light of this, future research should focus on understanding how other policy tools (e.g., unconventional monetary policy and fiscal policy) are affected by government debt.

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6.7 Proofs

Proof of Proposition 1.

Equations (8)-(9) determine $\{Y, C, N\}$, which are independet of D^g conditional on τ.

■

Proof of Proposition 1.1.

Immediate from Proposition 1.

■

Proof of Proposition 2.

The system given by (11) and (12) can be written in matrix form:

$$\begin{bmatrix} \dot{\pi}_t \\ \dot{c}_t \end{bmatrix} = \begin{bmatrix} \rho & -\kappa \\ -\sigma^1 & 0 \end{bmatrix} \begin{bmatrix} \pi_t \\ c_t \end{bmatrix} + \begin{bmatrix} 0 \\ m_t \end{bmatrix}$$

where

$$m_t \equiv \sigma^{-1}(i_t - \rho).$$

Let the eigenvalues of the coefficient matrix be denoted by

$$\overline{\omega} = \frac{\rho + \sqrt{\rho^2 + 4\sigma^{-1}\kappa}}{2} \quad \text{and} \quad \underline{\omega} = \frac{\rho - \sqrt{\rho^2 + 4\sigma^{-1}\kappa}}{2}.$$

The matrix of coefficients can be decomposed as

$$\begin{bmatrix} \rho & -\kappa \\ -\sigma^{-1} & 0 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ -(\sigma\overline{\omega})^{-1} & -(\sigma\underline{\omega})^{-1} \end{bmatrix} \begin{bmatrix} \overline{\omega} & 0 \\ 0 & \underline{\omega} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ -(\sigma\overline{\omega})^{-1} & -(\sigma\underline{\omega})^{-1} \end{bmatrix}^{-1}.$$

Note that $\overline{\omega} + \underline{\omega} = \rho$, $\overline{\omega}\underline{\omega} = -\sigma^{-1}\kappa$, $\overline{\omega} - \underline{\omega} = \sqrt{\rho^2 + 4\sigma^{-1}\kappa}$, and that if prices are rigid, i.e. $\kappa = 0$, then $\underline{\omega} = 0$.

Define the following transformation of our original variables

$$Z_t = \begin{bmatrix} Z_{1,t} \\ Z_{2,t} \end{bmatrix} \equiv \frac{\kappa}{\overline{\omega} - \underline{\omega}} \begin{bmatrix} -(\sigma\underline{\omega})^{-1} & -1 \\ (\sigma\overline{\omega})^{-1} & 1 \end{bmatrix} \begin{bmatrix} \pi_t \\ c_t \end{bmatrix}$$

The system in the new coordinates can be written as

$$\begin{bmatrix} \dot{Z}_{1,t} \\ \dot{Z}_{2,t} \end{bmatrix} = \begin{bmatrix} \overline{\omega} & 0 \\ 0 & \underline{\omega} \end{bmatrix} \begin{bmatrix} Z_{1,t} \\ Z_{2,t} \end{bmatrix} + \begin{bmatrix} \eta_{1,t} \\ \eta_{2,t} \end{bmatrix}$$

where

$$\begin{bmatrix} \eta_{1,t} \\ \eta_{2,t} \end{bmatrix} \equiv \frac{\kappa}{\overline{\omega} - \underline{\omega}} \begin{bmatrix} -(\sigma\underline{\omega})^{-1} & -1 \\ (\sigma\overline{\omega})^{-1} & 1 \end{bmatrix} \begin{bmatrix} 0 \\ m_t \end{bmatrix}$$

Since we are focusing on bounded solutions, we can solve the first equation forward and the second backward to get

$$\begin{aligned} Z_{1,t} &= -\int_t^\infty e^{-\overline{\omega}(s-t)} \eta_{1,s} ds, \\ Z_{2,t} &= e^{\underline{\omega} t} Z_{2,0} + \int_0^t e^{\underline{\omega}(t-s)} \eta_{2,s} ds. \end{aligned}$$

In terms of the original variables, we have

$$\begin{bmatrix} \pi_t \\ c_t \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ -(\sigma\overline{\omega})^{-1} & -(\sigma\underline{\omega})^{-1} \end{bmatrix} \begin{bmatrix} -\int_t^\infty e^{-\overline{\omega}(s-t)} \eta_{1,s} ds \\ e^{\underline{\omega} t} Z_{2,0} + \int_0^t e^{\underline{\omega}(t-s)} \eta_{2,s} ds \end{bmatrix},$$

or

$$\begin{aligned} \pi_t &= e^{\underline{\omega} t} Z_{2,0} + \int_0^t e^{\underline{\omega}(t-s)} \eta_{2,s} ds - \int_t^\infty e^{-\overline{\omega}(s-t)} \eta_{1,s} ds, \\ c_t &= -e^{\underline{\omega} t} \frac{Z_{2,0}}{\sigma\underline{\omega}} - \int_0^t e^{\underline{\omega}(t-s)} \frac{\eta_{2,s}}{\sigma\underline{\omega}} + \int_t^\infty e^{-\overline{\omega}(s-t)} \frac{\eta_{1,s}}{\sigma\overline{\omega}} ds. \end{aligned}$$

Evaluating in $t = 0$ we get

$$\begin{aligned} \pi_0 &= Z_{2,0} - \int_0^\infty e^{-\overline{\omega} t} \eta_{1,t} dt, \\ c_0 &= -\frac{Z_{2,0}}{\sigma\underline{\omega}} + \int_0^\infty e^{-\overline{\omega} t} \frac{\eta_{1,t}}{\sigma\overline{\omega}} dt, \end{aligned}$$

and therefore, we can rewrite the system as

$$\pi_t = e^{\underline{\omega} t}\pi_0 + e^{\underline{\omega} t}\int_0^t \left(e^{-\overline{\omega} s}\eta_{1,s} + e^{-\underline{\omega} s}\eta_{2,s}\right) ds - \left(e^{\overline{\omega} t} - e^{\underline{\omega} t}\right)\int_t^\infty e^{-\overline{\omega} s}\eta_{1,s} ds,$$
$$c_t = e^{\underline{\omega} t}c_0 - \sigma^{-1}e^{\underline{\omega} t}\int_0^t \left(e^{-\overline{\omega} s}\frac{\eta_{1,s}}{\overline{\omega}} + e^{-\underline{\omega} s}\frac{\eta_{2,s}}{\underline{\omega}}\right) ds + \frac{e^{\overline{\omega} t} - e^{\underline{\omega} t}}{\overline{\omega}}\int_t^\infty e^{-\overline{\omega} s}\eta_{1,s} ds.$$

Writing the system in terms of the original shocks, we obtain

$$c_t = c_t^m + e^{\underline{\omega} t}c_0, \tag{18}$$

where

$$c_t^m = \frac{\sigma^{-1}}{\overline{\omega} - \underline{\omega}}e^{\underline{\omega} t}\left[\int_0^t \left(\overline{\omega} e^{-\underline{\omega} s} - \underline{\omega} e^{-\overline{\omega} s}\right)(i_s - \rho) ds + \underline{\omega}\left(e^{(\overline{\omega} - \underline{\omega})t} - 1\right)\int_t^\infty e^{-\overline{\omega} s}(i_s - \rho) ds\right].$$

It remains to determine c_0. Plugging (18) in the budget constraint (14), we get

$$c_0 = -\frac{\overline{\omega}}{\tau - \sigma\underline{\omega}\varsigma_d}\int_0^\infty e^{-\rho t}\left(\tau - \sigma\rho\varsigma_d\right)c_t^m dt.$$

Note that

$$\int_0^\infty e^{-\rho t}c_t^m dt = \frac{\sigma^{-1}}{\overline{\omega}}\int_0^\infty e^{-\rho t}e^{\underline{\omega} t}\left(i_t - \rho\right) dt.$$

Then, the intertemporal budget constraint can then be written as

$$c_0 = \int_0^\infty e^{-\rho t}\chi_{m,t}(i_t - \rho) dt,$$

where

$$\chi_{m,t} = -\sigma^{-1}\frac{\tau - \rho\varsigma_d\sigma}{\tau - \underline{\omega}\varsigma_d\sigma}e^{\underline{\omega} t}.$$

■

Proof of Proposition 3.

Note that $\frac{\partial c_0}{\partial i_t} = e^{-\rho t}\chi_{m,t}$, hence $sign\left(\frac{\partial c_0}{\partial i_t}\right) = sign\left(\chi_{m,t}\right)$. Since $\underline{\omega} < 0$, it is immediate that $\chi_{m,t} < 0$ if and only if Assumption 1 is satisfied.

■

Proof of Proposition 4.

The Taylor equilibrium is the unique solution to

$$\dot{c}_t = \sigma^{-1}(i_t - \pi_t - \rho),$$

$$\dot{\pi}_t = \rho\pi_t - \kappa c_t,$$

$$i_t = \rho + \phi_\pi \pi_t + \varepsilon_t.$$

This system is independent of ς_d, hence the solution is independent of ς_d.

■

Proof of Proposition 5.

We have $\frac{\partial^2 c_0}{\partial i_t \partial \varsigma_d} \propto \frac{\partial \chi_{m,t}}{\partial \varsigma_d} = \sigma^{-1}\frac{\overline{\omega}\sigma\tau}{\left(\tau - \underline{\omega}\varsigma_d\sigma\right)^2}e^{\underline{\omega}t} > 0.$

■

Proof of Proposition 6.

Immediate from Proposition 1, replacing D^g by $D^g_S + \frac{D^g_L}{\rho + \rho_L}$.

■

Proof of Proposition 7.

We have $\frac{\partial c_0}{\partial i_t} = e^{-\rho t}\chi_{m,t} - e^{-(\rho+\rho_L)t}\frac{\overline{\omega}\varsigma_d\varsigma_L}{\tau - \underline{\omega}\sigma\varsigma_d}$. Since $\chi_{m,t} < 0$, then $\frac{\partial c_0}{\partial i_t} < 0$. Moreover, fixing ς_d, we have $\frac{\partial^2 c_0}{\partial i_t \partial \varsigma_L} = -e^{-(\rho+\rho_L)t}\frac{\overline{\omega}\varsigma_d}{\tau - \underline{\omega}\sigma\varsigma_d} < 0$, and $\frac{\partial^2 c_0}{\partial i_t \partial \rho_L} = te^{-(\rho+\rho_L)t}\frac{\overline{\omega}\varsigma_d\varsigma_L}{\tau - \underline{\omega}\sigma\varsigma_d} > 0$ for $t > 0$. Finally, we have $\frac{\partial^2 c_0}{\partial i_t \partial \varsigma_d} = \frac{\overline{\omega}\tau}{\left(\tau - \underline{\omega}\varsigma_d\sigma\right)^2}e^{-(\rho-\underline{\omega})t}\left(1 - \varsigma_L e^{-(\rho_L + \underline{\omega})t}\right)$. If $\rho_L + \underline{\omega} > 0$, then $e^{-(\rho_L+\underline{\omega})t} < 1$ for all $t > 0$. Since $\varsigma_L \in [0,1]$, this implies that $\frac{\partial^2 c_0}{\partial i_t \partial \varsigma_d} > 0$ for $t > 0$.

■

6.7.1 Model log-linearization

The intertemporal Euler equation is given by

$$\frac{\dot{C}_t}{C_t} = \sigma^{-1}(i_t - \pi_t - \rho).$$

Since $c_t = \log\left(\frac{C_t}{C}\right)$, $\dot{c}_t = \frac{\dot{C}_t}{C_t}$, and then, up to first order,

$$\dot{c}_t = \sigma^{-1}(i_t - \pi_t - \rho).$$

The intratemporal Euler equation is

$$\frac{W_t}{P_t} = N_t^{\phi} C_t^{\sigma}.$$

Hence, up to first order,

$$w_t - p_t = \phi n_t + \sigma c_t. \tag{19}$$

The aggregate resource constraint is given by

$$C_t = Y_t,$$

hence,

$$c_t = y_t. \tag{20}$$

The intermediate-goods firms production function is

$$Y_t(i) = N_t(i)^{1-\gamma}.$$

Then, up to first order,

$$y_t(i) = (1-\gamma)n_t(i).$$

Noting that $\int_0^1 y_t(i)di = y_t$ and $\int_0^1 n_t(i)di = n_t$, we have

$$y_t = (1-\gamma)n_t. \tag{21}$$

The inflation rate is given by

$$\pi_t = \frac{\rho_\delta}{\epsilon - 1}\left[1 - \left(\frac{P_t^*}{P_t}\right)^{1-\epsilon}\right].$$

Then, up to first order,

$$\pi_t = \rho_\delta(p_t^* - p_t). \tag{22}$$

The optimal pricing equation is given by

$$\int_0^\infty e^{-(\rho+\rho_\delta)s}\left(\frac{C_{t+s}}{C_t}\right)^{-\sigma}\left[(1-\tau)\left(\frac{P_t}{P_{t+s}}\right)^{1-\epsilon}\left(\frac{P_t^*}{P_t}\right)^{1-\epsilon}Y_{t+s} - \right.$$
$$\left. \frac{\epsilon}{\epsilon-1}\frac{1}{1-\gamma}\frac{W_{t+s}}{P_{t+s}}\left(\frac{P_t}{P_{t+s}}\right)^{-\frac{\epsilon}{1-\gamma}}\left(\frac{P_t^*}{P_t}\right)^{-\frac{\epsilon}{1-\gamma}}Y_{t+s}^{\frac{1}{1-\gamma}}\right] ds = 0.$$

Then, up to first order,

$$\int_0^\infty e^{-(\rho+\rho_\delta)s}\left[(1-\tau)Y\left((1-\epsilon)\left(p_t - p_{t+s} + p_t^* - p_t\right) + y_{t+s}\right) - \frac{\epsilon}{\epsilon-1}\frac{1}{1-\gamma}\frac{W}{P}Y^{\frac{1}{1-\gamma}}\right.$$
$$\left.\left((w_{t+s} - p_{t+s}) + \frac{\epsilon}{1-\gamma}\left(p_t - p_{t+s} + p_t^* - p_t\right) - \frac{1}{1-\gamma}y_{t+s}\right)\right] ds = 0.$$

Noting that $(1-\tau)Y = \frac{\epsilon}{\epsilon-1}\frac{1}{1-\gamma}\frac{W}{P}Y^{\frac{1}{1-\gamma}}$, we can rewrite this equation as

$$\int_0^\infty e^{-(\rho+\rho_\delta)s}\left[\frac{1-\gamma+\epsilon\gamma}{1-\gamma}\left(p_t - p_{t+s} + p_t^* - p_t\right) - \frac{\gamma}{1-\gamma}y_{t+s} - (w_{t+s} - p_{t+s})\right] ds = 0.$$

Combining with equations (19), (20) and (21), we get

$$\int_0^\infty e^{-(\rho+\rho_\delta)s}\left[\frac{1-\gamma+\epsilon\gamma}{1-\gamma}\left(p_t - p_{t+s} + p_t^* - p_t\right) - \left(\sigma + \frac{\gamma+\phi}{1-\gamma}\right)c_{t+s}\right] ds = 0.$$

And using equation (22), we can rewrite this equation as

$$\pi_t = \rho_\delta \left(\rho + \rho_\delta\right) \int_0^\infty e^{-(\rho+\rho_\delta)s} \left[\left(p_{t+s} - p_t\right) + \frac{1-\gamma}{1-\gamma+\epsilon\gamma} \left(\sigma + \frac{\gamma+\phi}{1-\gamma}\right) c_{t+s} \right] ds.$$

Differentiating over time, we get

$$\dot{\pi}_t = -\rho_\delta \left(\rho + \rho_\delta\right) \frac{1-\gamma}{1-\gamma+\epsilon\gamma} \left(\sigma + \frac{\gamma+\phi}{1-\gamma}\right) c_t + \left(\rho + \rho_\delta\right) \pi_t - \left(\rho + \rho_\delta\right) \rho_\delta \int_t^\infty e^{-(\rho+\rho_\delta)(s-t)} \dot{p}_t ds.$$

Noting that $\dot{p}_t = \pi_t$, we obtain the log-linear New Keynesian Phillips curve:

$$\dot{\pi}_t = \rho \pi_t - \kappa c_t,$$

where $\kappa \equiv \rho_\delta \left(\rho + \rho_\delta\right) \frac{1-\gamma}{1-\gamma+\epsilon\gamma} \left(\sigma + \frac{\gamma+\phi}{1-\gamma}\right)$.

Finally, note that the households' intertemporal budget constraint is given by

$$\int_0^\infty e^{-\int_0^t (i_s - \pi_s) ds} C_t dt = \frac{B_0}{P_0} + \int_0^\infty e^{-\int_0^t (i_s - \pi_s) ds} \left[\left(1 - \tau\right) Y_t + T_t \right] dt,$$

where we used that $\frac{W_t N_t}{P_t} + \frac{\Pi_t}{P_t} = \left(1 - \tau\right) Y_t$. Then, up to first order,

$$\int_0^\infty e^{-\rho t} C c_t dt - \frac{C}{\rho} \int_0^\infty e^{-\rho t} \left(i_t - \pi_t - \rho\right) ds = \int_0^\infty e^{-\rho t} \left(1 - \tau\right) Y y_t dt - \frac{\left(1 - \tau\right) Y + T}{\rho} \int_0^\infty e^{-\rho t} \left(i_t - \pi_t - \rho\right) dt,$$

where we used that $T_t = T \; \forall t$. Noting that $\left(1 - \tau\right) Y + T - C = T - \tau Y = -\rho D^g$, and letting $\varsigma_d \equiv \frac{D^g}{Y}$, we get

$$\int_0^\infty e^{-\rho t} c_t dt = \int_0^\infty e^{-\rho t} \left[\left(1 - \tau\right) y_t + \varsigma_d \left(i_t - \pi_t - \rho\right) \right] dt.$$

6.8 Robustness

6.8.1 Robustness to Alternative Lag Lengths

We consider whether our empirical results are sensitive to the lag length, I, in equation (17). Figures 23 and 24 replicate Figures 20 and 22, varying the number of lags used of both the control variables and the monetary policy shock. As seen in the figures, the estimated cumulative impulse response functions and the cumulative interaction are remarkably insensitive to the choice of lag length.

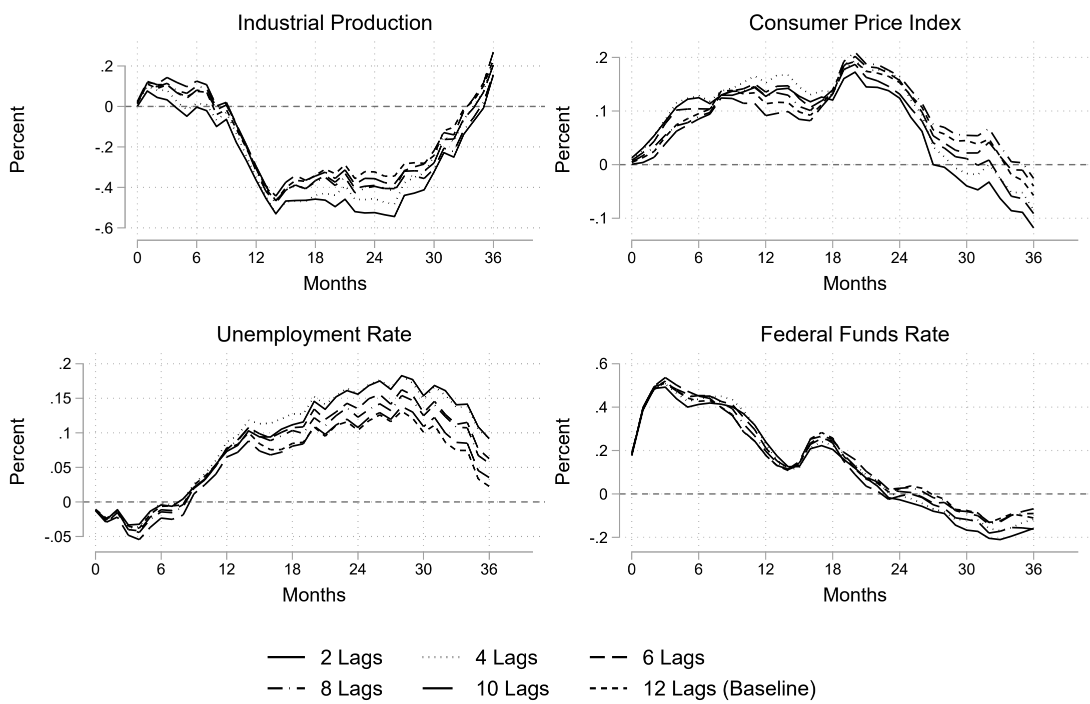

Figure 23. Robustness to Alternative Lag Lengths in the Linear Model

Notes: Cumulative impulse responses to a one standard deviation increase in the Romer and Romer (2004) monetary policy shock measure.

6.8.2 Robustness to Alternative Monetary Policy Shocks

We consider whether our empirical results are sensitive to an alternative method of identifying monetary policy shocks. In the spirit of Gurkaynak, Sack and Swanson (2004) and

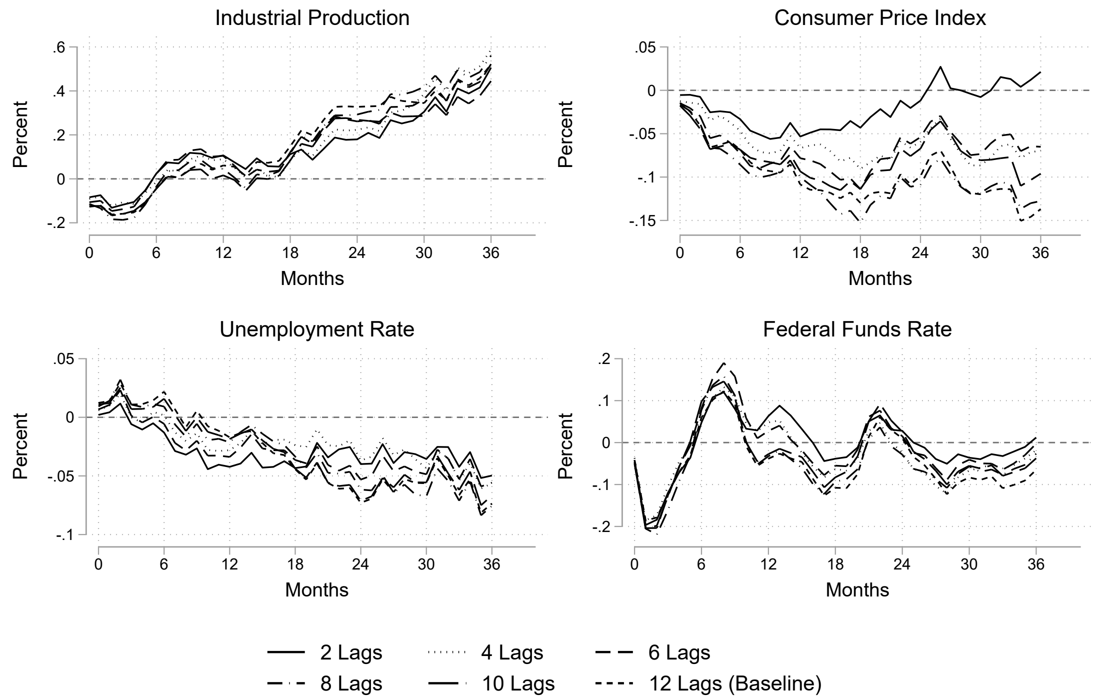

Figure 24. Robustness to Alternative Lag Lengths in the Nonlinear Model

Notes: The cumulative interaction between monetary policy shocks and the debt measure after a one standard deviation increase in the Romer and Romer (2004) monetary policy shock measure.

Bernanke and Kuttner (2005), we consider monetary policy shocks identified by high-frequency variation in federal funds futures markets. The key identifying assumption underlying these methods is that any variation in the three-month ahead fed funds futures rate within a narrow window of time bracketing an announcement by the Federal Open Market Committee should reflect the announcement alone, rather than news about macroeconomic events. We use the shock series estimated by Miranda-Agrippino and Ricco (2021) which purges the raw financial market shocks of the "information effect" of central bank announcements by regressing the measure on Greenbook forecasts of macroeconomic data available to the Federal Reserve officials at the time of an announcement. Figure 25 plots this shock measure.

Figures 26 and 27 replicate Figures 20 and 22, replacing the Romer and Romer (2004) shock measure with the measure identified by Miranda-Agrippino and Ricco, which

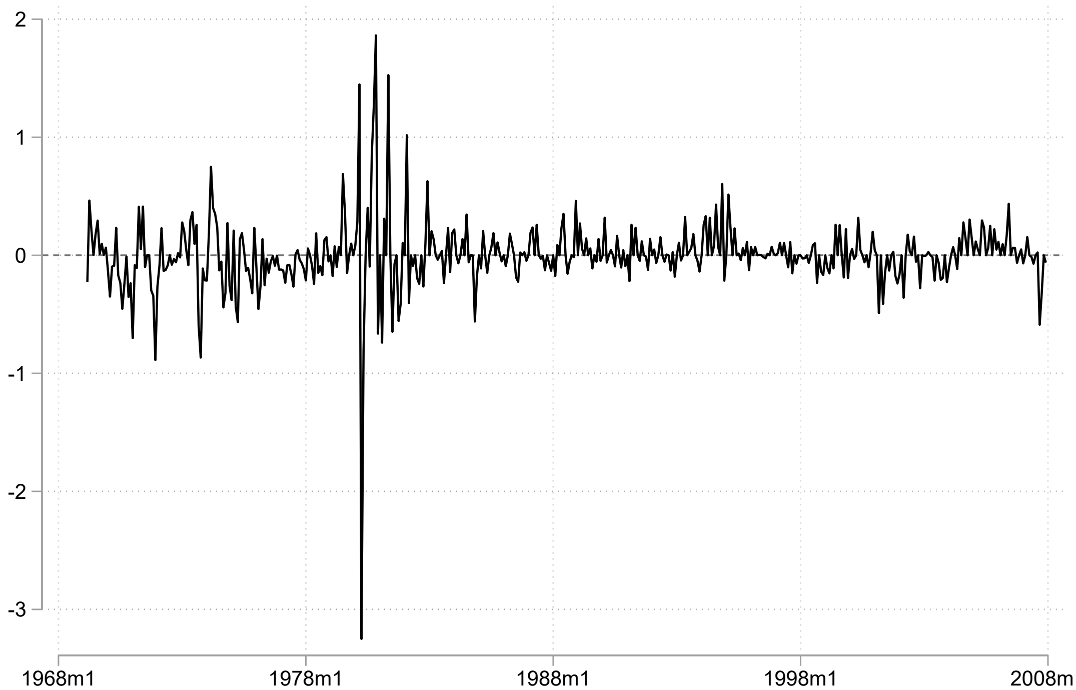

Figure 25. Identified Monetary Policy Shocks

Notes: Estimated by Miranda-Agrippino and Ricco (2021).

spans January 1991 to December 2009. We estimate cumulative impulse responses using equation (17) with twelve lags of the following control variables: the log of industrial production, the log of the consumer price index, the Gilchrist and Zakrajšek (2012) excess bond premium, and the one-year Treasury rate. Of additional note, we follow Miranda-Agrippino and Ricco in using the one-year Treasury rate as our fndicator of the stance of monetary policy rather than the federal funds rate.

In Figure 26, we note two observations. First, the Miranda-Agrippino and Ricco shocks induce contractionary responses of industrial production and the unemployment rate that are similar in magnitude to those induced by the Romer and Romer measure despite the minimal overlap in the two samples. Second, unlike the responses using the Romer and Romer series, the response of the consumer price index exhibits no significant price puzzle.

As noted, Figure 27 plots the estimated cumulative interaction between privately-held

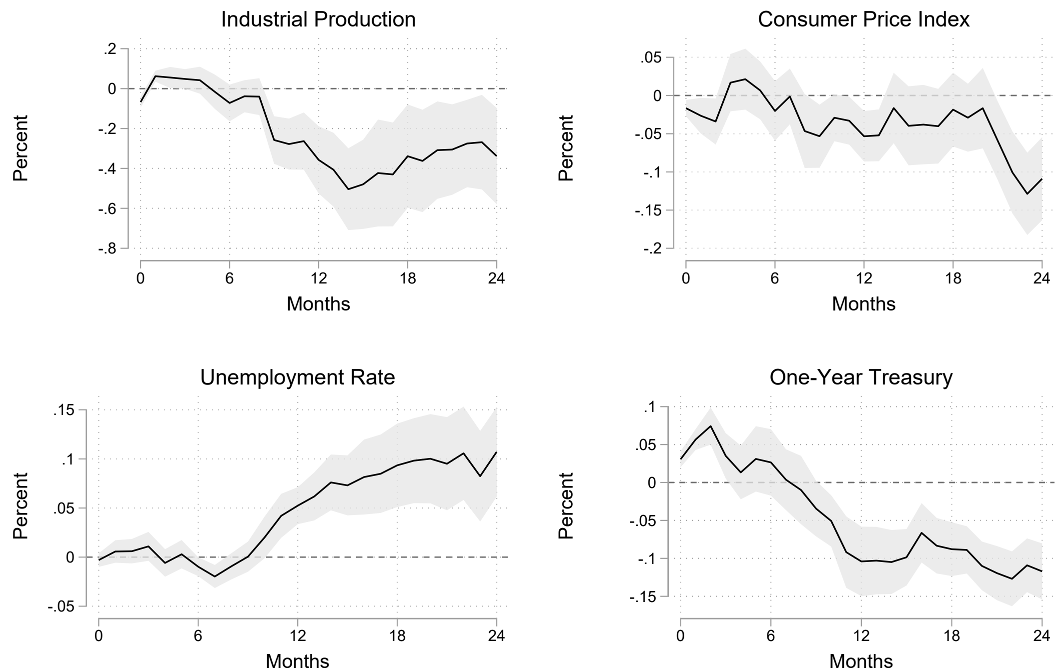

Figure 26. High-Frequency Identification in the Linear Model

Notes: Cumulative impulse responses to a one standard deviation increase in the Miranda-Agrippino and Ricco (2021) monetary policy shock measure.

government debt and monetary policy using the high-frequency identified shocks. An economy with privately-held government debt one standard deviation above the mean exhibits less severe responses of industrial production, with declines dampened by between 0.3 and 0.4pp out to two years. Furthermore, the unemployment rate rises by nearly 0.1pp less in the high-debt case than in the mean debt case within two years. These results have the same direction as those under the Romer and Romer shocks and provide evidence for the dampening mechanism explored in the main text.

6.8.3 Oaxaca-Blinder Local Projections

As an additional robustness test, we alter equation (17) following Cloyne, Jordà and Taylor (2020) to admit a Blinder-Oaxaca decomposition of estimated impulse responses (Blinder, 1973; Oaxaca, 1973). As noted by Cloyne, Jordà and Taylor, the Blinder-Oaxaca

Figure 27. High-Frequency Identification in the Nonlinear Model

Notes: The cumulative interaction between monetary policy shocks and the debt measure after a one standard deviation increase in the Miranda-Agrippino and Ricco (2021) monetary policy shock measure.

framework is used in applied microeconomics to decompose the effects of a policy innovation into three separate determinants: 1) a direct effect, or the average treatment effect of a policy innovation on the outcome variable, 2) a composition effect, or a bias introduced by non-random assignment of the treatment, and 3) an indirect effect of the policy innovation altering the relationship between the outcome and control variables. Let $\boldsymbol{X}_t$ be a vector of control variables, which now includes the debt measure, and let ϵ_t^{MP} be our identified monetary policy shock series. The Oaxaca-Blinder specification is given by

$$\Delta^h y_{t+h} = \alpha^h + \underbrace{\beta^h \epsilon_t^{MP}}_{\text{direct effect}} + \underbrace{(\mathbf{X}_t - \bar{\mathbf{X}})\epsilon_t^{MP}\mathbf{\Gamma}^h}_{\text{indirect effect}} + \underbrace{(\mathbf{X}_t - \bar{\mathbf{X}})\mathbf{\Theta}^h}_{\text{composition effect}} + \omega_{t+h}, \tag{23}$$

Adapting this decomposition to the present setting, the Oaxaca-Blinder local projections setup can be used to decompose the impulse response of macroeconomic time series into analogous channels. The indirect effect we estimate will include the cumulative interaction between private ownership of government debt and the transmission of monetary policy shocks. In this setting, we return to using the Romer and Romer (2004) measure of identified monetary policy shocks and include as controls twelve lags of each of the following: the log of industrial production, the log of the consumer price index, the log of the producer price index, and the Federal funds rate.

Under the Oaxaca-Blinder decomposition, the cumulative impulse response of a monetary policy shock a time t on the outcome variable out to horizon h is a function of the state at time t, which includes the levels of each control variable. As we are interested in the average treatment effect of stabilization policy conditional on the level of debt, we estimate impulse responses where $\mathbf{x}_t = \bar{\mathbf{x}}$ for each control variable except for our debt measure.

$$IRF(\mathbf{X}_t) = \beta^h + (\mathbf{X}_t - \bar{\mathbf{X}})\mathbf{\Gamma}^h.$$

As we are concerned only with the impact of variation in the debt measure on the cumulative impulse response function, we consider the case where $\mathbf{X}_t = \bar{\mathbf{X}}$ for each control variable except for the debt measure, which we set equal to one, representing the sample-mean-debt case, or one, representing the case where the debt measure is elevated by one standard deviation relative to the sample mean.

Figure 28 replicates Figure 22 using the Oaxaca-Blinder specification.[16] The figure demonstrates that the main results of the paper are supported. When the cumulative interaction is significant, we see that the response of industrial production shows a dampening of approximately 0.3pp out to two years relative to the mean case when the debt measure is elevated by one standard deviation. Additionally, the unemployment rate rises by approximately 0.1pp less in the high-debt case than in the mean-debt case out

[16]Note that we do not reproduce the linear case as a linear Oaxaca-Blinder specification coincides with the original linear local projections specification.

to three years, although there is a period within one year for which the interaction is significantly more contractionary.

Figure 28. Cumulative Interactions in the Oaxaca-Blinder Model

Notes: The cumulative interaction between monetary policy shocks and the debt measure after a one standard deviation increase in the Romer and Romer (2004) monetary policy shock measure.

Fiscal Policy and Wealth Inequality

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Abstract

I study the dynamics of the household wealth distribution in response to changes in government spending in the U.S. I find that increases in government spending raise the net worth of all groups except for the top 1%. Decomposing the responses of wealth into broad asset and liability classes, I find that responses are largely driven by an appreciation in the price of real estate. These results are consistent with a mild and temporary compression of the household wealth distribution.

JEL Codes: D14, D31, E44, E62
Keywords: Fiscal Policy, Household Heterogeneity, Wealth Inequality

7.1 Introduction

As epitomized by Thomas Piketty's 2014 opus, *Capital in the Twenty-First Century*, debates over the distribution of income and wealth have reemerged from the decades of relative dormancy. A growing recognition that rising income and wealth inequality threaten economic performance and political stability warrants a thorough investigation into their causes. In this paper, I direct my attention to the role of fiscal policy over the business cycle in shaping trends in wealth inequality.

I find that increases in government spending raise the net worth of the bottom 99% of households by wealth, largely driven by an appreciation in the price of real estate. Furthermore, for the bottom 50% of households, the gain in real estate values comes without a corresponding increase in mortgage debt, suggesting increases in home equity and deleveraging. Additionally, I study the evolution of wealth inequality in response to government spending shocks and find a mild and temporary compression of the household wealth distribution.

I study fiscal policy for two reasons. First, active fiscal policy has become a key focus of the Biden administration beginning with the American Rescue Plan Act of 2021, designed to combat the Covid-19 recession and continuing with the "Build Back Better" agenda culminating in the Inflation Reduction Act in 2022. Second, a substantial literature finds that government taxation and spending systems create substantial differences in the pre- and post-tax distributions of household income (Benhabib, Bisin and Zhu, 2011). Using cross-country evidence, Krueger et al. (2010) find that government transfers are effective in compressing the level of household earnings inequality at the bottom of the earnings distribution, while taxes compress the earnings distribution from the top. In an estimated heterogeneous agents new Keynesian model, Bayer, Born and Luetticke (2020) find that business-cycle frequency shocks can explain roughly half of the increase in wealth inequality from 1980 to 2015, and that increases in the structural budget deficit reduce wealth inequality by compressing the liquidity premium. Kaymak and Poschke

(2016) argue that since the 1960s, the U.S. tax system has become less progressive and that increasing transfers to less wealthy households have discouraged their saving and wealth accumulation, amplifying wealth concentration.

The channels by which changes in government spending can affect the distribution of wealth are many. First, if a change in spending causes an increase in household incomes biased towards households at certain points of the wealth distribution, increased saving may result in asset accumulation for these groups or reductions in outstanding liabilities. This effect is amplified if increased government spending reduces the unemployment rate, as unemployment risk is concentrated among low-income households. Further, if increased government spending produces a response of asset prices, portfolio heterogeneity may drive changes in the distribution of wealth. I find that a 1pp increase in government spending is associated with a nearly 8% increase in the S&P 500 index, and a 1.5% increase in the Case-Shiller house price index. This suggests that households higher on the wealth distribution, who load their asset portfolios heavily on corporate equities will gain more than households that rely on home equity.

7.1.1 Related Literature

Wealth inequality can amplify the effects of aggregate shocks, whether or not households with low net worth exhibit hand-to-mouth consumption behavior (Krueger, Mitman and Perri, 2016).

The search for the causes of wealth inequality became more pressing in light of the computational advances that allowed for solutions to macroeconomic models with heterogeneous agents. As revealed by Krusell and Smith (1998), idiosyncratic earnings shocks are insufficient to generate the dispersion of wealth observable in the U.S., with particular difficulty matching the staggering wealth of the most wealthy households and the number of households with virtually no wealth.

A number of studies explore the mechanisms responsible for generating the degree of wealth dispersion observed in the U.S. One natural cause of widening wealth inequality is the heterogeneity of asset returns across the wealth distribution. This is true both due to heterogeneity in the types of assets held and in returns within narrow asset classes (Fagereng et al., 2016, 2020). Hubmer, Krusell and Smith (2021) consider a model incorporating return heterogeneity with an idiosyncratic component with a variance increasing in wealth, and are able to match the U.S. wealth distribution. Others document that earnings losses during a recession are more severe for households with low pre-recession incomes (Guvenen, Ozkan and Song, 2014). This suggests that the earnings process for low-income households is qualitatively different from that of the high-income households. Additionally, the welfare losses of significant macroeconomic downturns are concentrated among low-wealth households (Krueger, Mitman and Perri, 2016*b*). As wealth provides a means of smoothing consumption in downturns, less wealthy households are forced to cut consumption.

My empirical methods draw on the large literature estimating the dynamic effects of government spending shocks on macroeconomic variables.[1] I share the identification scheme of Auerbach and Gorodnichenko (2012) by controlling for forecasts of government spending and key macroeconomic variables to isolate the effects of unexpected changes in government spending.

The remainder of the paper is structured as follows. Section 7.2 provides an overview of the portfolio heterogeneity documented by the DFA dataset and its implications. Section 7.3 documents the procedure I use to estimate the dynamic effects of fiscal policy on household wealth. Section 7.4 presents my main results, as well as decompositions by asset an liability classes, and section 7.5 concludes.

7.2 Data

I study the distribution of wealth in the United States through the Distributional Financial Accounts (DFAs) (Batty et al., 2019), a dataset tracking the net worth of U.S. households

[1] See section 4 of Ramey (2016) for a survey of the literature.

at a quarterly frequency. An advantage of this dataset is that it provides decompositions of net worth into broad asset and liability classes, which allows me to study fiscal policy-induced changes in wealth at a deeper level of the household balance sheet. The DFAs are developed by reconciling the triennial Survey of Consumer Finances (SCF) with quarterly flow-of-funds data from the Z.1 Financial Accounts of the United States, both prepared by the Federal Reserve system. As a result, the DFAs match key moments of the SCF while also allowing a glimpse of higher-frequency dynamics. The DFAs divide the household wealth distribution into four quantile bins; the bottom 50%, the 50^{th}-90^{th} percentiles ("next 40%"), the 90^{th}-99^{th} percentiles ("next 9%"), and the top 1%.

These data sets reveal a striking concentration of wealth in the U.S. Between 1989 and 2008, the bottom 50% of households have commanded just shy of 2.7% of wealth while the top 1% have held over 27%. The DFAs also allow a glimpse into portfolio heterogeneity. The bottom 50% of households hold roughly a quarter of their asset portfolios in financial assets, with real estate and consumer durables taking 51% and 20%. The top 1%, by contrast, hold over 80% of their asset portfolios in financial assets, specifically corporate equities, taking 28% and equity in non-corporate business, taking 22%. Non-financial assets, which comprise a disproportionate share of the assets held by the bottom 50%, appreciate more slowly than the financial assets held by the top 1% in greater proportions, whose asset prices inherit risk premia from a heightened exposure to aggregate market risk.

Figure 29 plots a decomposition of the balance sheets of each household quantile group by wealth over time. The net worth of the bottom 50% of households fluctuates without a discernible trend, falling near zero in the wake of the Global Financial Crisis, while each other quantile group exhibits net worth trending upward. Although all groups experience deep losses during the crisis, the top 1% of households collectively suffered a loss of just over 21% of their net worth between 2007:Q3 and the trough at 2009:Q1, while the bottom 50% saw over 81% of their net worth erased between 2007:Q1 and the trough, which occurred much later in 2010:Q2. The wealth of the bottom 50% only passed its pre-crisis peak in 2019:Q2, while the top 1% regained their lost wealth by 2012:Q1. Considering unconditional trend growth over the 1989-2021 sample, the top 1% experienced gains in net worth of 4.3% per annum, while the bottom 50% experienced gains of just under 1.3% per annum, consistent with deep portfolio heterogeneity and potentially heterogeneity in returns.

As noted, data availability poses a major challenge to the systematic study of wealth in the U.S., a shortcoming partially remedied by the triennial cross-sectional SCF conducted by the Federal Reserve Board. However, the low frequency of the SCF presents a difficulty in studying movements in wealth in the short run in response to policy changes. Batty et al. (2019) document the procedure used to construct the DFA dataset, which combined the SCF with quarterly aggregate household wealth data provided by the Financial Accounts of the United States. The authors construct measures of wealth for each household quantile group adhering closely to the structure of table B.101.h of the Financial Accounts. The authors employ the temporal disaggregation method proposed by Chow and Lin (1971), by reconciling triennial SCF observations with related quarterly Financial Accounts data.[2]

7.3 Methods

7.3.1 Local Projections

In order to study the dynamics of the wealth distribution in response to government spending shocks, I employ the method of local projections (Jordà, 2005). My choice of estimation methods is motivated by (Montiel Olea and Plagborg-Møller, 2021), who find that local projections perform well in comparison vector-autoregressions when data are persistent and when forecast horizons are long. Indeed, these conditions are met in the

[2]The method consists of assuming that low-frequency observations provided by the SCF are drawn from a latent high-frequency series, and forecasting the "missing" observations by using relevant high-frequency regressors.

current setting as wealth distributions are observed to be persistent. Furthermore, due to my limited sample length, local projections provide the advantage of requiring fewer lags to accurately map out impulse responses at long horizons.

My baseline LP specification is the system of equations for each horizon $h = 0 \dots H$ and each household quantile group indexed by i, given by

$$\Delta^h y_{i,t+h} = \alpha^{i,h} + \beta^{i,h} G_t + \boldsymbol{\delta}^{i,h} \boldsymbol{X}_{i,t} + e^i_{t+h} \tag{24}$$

where y^i_t is the log of real net worth of group i and G_t is the log of real federal, state, and local government purchases, $\boldsymbol{X}_{i,t}$ are controls, including the log of real GDP, the log of real federal government tax receipts, and the log of the one-quarter-ahead forecast of real government expenditures at time $t-1$ as measured by the Survey of Professional Forecasters. In my baseline specification I include four lags of all control variables. The impulse response function for group i is given by the series $\{\beta^{i,h}\}^H_{h=0}$. Though the forecast errors of a standard LP system are likely to be serially correlated, the lag-augmented local projection specification allows for valid inference with standard Eicker-Huber-White standard errors (Montiel Olea and Plagborg-Møller, 2021). I consider the four household quantile groups provided by the DFAs and described above.

The level of government spending is, of course, determined endogenously in response to macroeconomic conditions. This is a standard identification problem common to empirical macroeconomic studies (Nakamura and Steinsson, 2018). As a result, estimates from equation 24 derived by OLS will be biased and inconsistent due to the contemporaneous correlation between ΔG_t and e_{t+h}.

7.3.2 Identification

A number of methods have been proposed to identify structural shocks to government spending. Romer and Romer (2010) rely on narrative records including presidential and congressional speeches to determine the underlying rationale for changes to U.S. taxes. Mertens and Ravn (2013) use this narrative approach to identify the mapping between reduced form and structural tax changes in a proxy VAR. Owyang, Ramey and Zubairy (2013) and Ramey and Zubairy (2018) use similar narrative methods that catalog news concerning changes in military spending. Blanchard and Perotti (2002) rely on a VAR with timing restrictions, imposing the assumption that government spending is predetermined within a quarter. A commonly-cited pitfall of timing restrictions is that government spending is frequently anticipated several quarters in advance of actual changes in expenditures. Mountford and Uhlig (2009) use sign restrictions in a VAR model to distinguish government spending and revenue shocks from more generic business-cycle shocks. In the present setting, I follow Auerbach and Gorodnichenko (2012), who explicitly control for survey-based expectations of government spending in their VAR system. Doing so ensures that the parameter estimates on the government spending measure are orthogonal to changes that can be anticipated.

As a point of reference, I estimate equation (24) using a set of monthly macroeconomic variables commonly studied as outcomes in the fiscal policy literature. Figure 30 presents impulse responses of these variables to a government spending shock. Outcome variables are measured as a percent of their year-0 level computed as the log change multiplied by 100. A one percentage point increase in real government expenditures is associated with a roughly 0.5pp increase in real GDP that lasts for one year before losing statistical significance. Personal consumption expenditures rise by 0.5pp out to six quarters, before falling over the medium term. Private investment shows no statistically significant change on impact, subsequently falling significantly after three years.

I also consider impulse responses of four asset price indices in figure 31. I find that the S&P 500 stock price index rises by over 5pp out to six quarters in response to a government spending shock, before falling after three years. The CPI for consumer durables shows no statistically detectable change in response to the shock, while the Case-Shiller house price index smoothly rises by 1pp out to six quarters, before falling back to the mean. The Bloomberg-Barclays Aggregate bond price index also falls by 3pp out to ten quarters, consistent with rising bond yields.

7.4 Results

Turning to my main results, figure 32 presents impulse responses of real net worth for each quantile group in response to the expansionary government spending shock. I find that in response to a 1pp increase in real government expenditures, net worth rises for all groups except for the top 1%. For the bottom 50%, the increase peaks at 4pp out to five quarters, before returning to the mean. The next 40% and next 9% experience gains on the order of 1pp and 2pp, respectively, though the gains for these groups are notably more persistent.

To explain these results, I decompose the net worth responses of each quantile group into broad asset and liability classes. Figure 33 presents the responses of the real value of real estate holdings of each group. The real estate values of the bottom 50% temporarily increase by 1pp, before returning to the mean after eight quarters. The next 40% and next 9% experience gains of roughly 2pp each, peaking after eight and six quarters, respectively. By contrast, the value of real estate for the top 1% appears to fall shortly after impact by 3pp, before returning to the mean after two years. This is despite the roughly 1pp increase in the Case-Shiller index, suggesting heterogeneity in the types of real estate owned by each group.

Figure 34 presents impulse responses of the real value of corporate equities and mutual fund shares held by each group. On impact, no group experiences a statistically detectable response for this asset class, although the evidence is suggestive of gains of nearly 5pp for the next 40% and next 9% within six quarters. These muted gains are again in spite of the substantial gain in asset prices as measured by the S&P 500 index.

Turning now to the liabilities side of household balance sheets, figure 35 presents the impulse responses of the real value of mortgage debt owed by each quantile group. For the bottom 50%, real mortgage debt appears to briefly decrease by up to 1pp, suggesting that these households are deleveraging in response to increased incomes. This is despite the fact that the real estate portfolio of this group appears to increase within two years, suggesting that the real estate response is driven by capital gains on housing. The next 40% and next 9%, by contrast, see an increase in the real value of mortgage debt after the first year, also seeing gains in the value of their real estate, pointing to leveraged purchases of real estate. The bottom 1% experience a persistent decline in mortgage debt of 2pp.

Finally, figure 36 presents the impulse responses of real consumer credit owed by each quantile group. The bottom 50% of households respond to the government spending shock by reducing their reliance on consumer credit by approximately 1.7pp. As noted above, this evidence is suggestive of these households using the windfall income gain to reduce their debt burdens. For the next 40% and next 9%, there is suggestive evidence of an approximately 1pp reduction in consumer credit occurring after two years. The top 1% exhibit no statistically distinguishable change in consumer credit use, though this group notably relies much less on consumer credit than any other group on average.

At first glance there appears to be an inconsistency between the marginal statistical and economic significance of the impulse responses for assets and liabilities of the bottom 50% of households and the large and statistically significant response of net worth of that group. Key to resolving this inconsistency is the leverage ratio of these households. Recall that the average leverage ratio of the bottom 50% is just over 3. Consider then that the impulse response of net worth can by decomposed as

$$\frac{\Delta nw_t}{nw_t} = \left(\frac{a_t}{nw_t}\right)\frac{\Delta a_t}{a_t} - \left(\frac{a_t}{nw_t} - 1\right)\frac{\Delta l_t}{l_t},$$

where a_t/nw_t is the average leverage ratio of the household group. This decomposition makes clear that high leverage amplifies the effects of changes in the value of either assets or liabilities on the response of net worth.

I also study whether government spending shocks affect the overall distribution of wealth among the groups of households studied. To do so, I run the system of equations (24) jointly for each household group, constraining the impulse responses to sum to zero. Results are presented in figure 37. I find that a 1pp shock to government spending induces a temporary increase in the share of wealth held by the bottom 50% by 0.05, peaking in quarter five before returning to the mean within two years. The next 9% also show an increase of 0.05%, though this response is persistent out to three years. By contrast, the next 40% show a temporary reduction of 0.05% out to one year that quickly returns to the mean, and the top 1% fall behind by the same amount persistently. These results are consistent with a temporary and mild compression of the wealth distribution.

7.5 Conclusion

A growing perception among the U.S. public is that government policy plays a role in shaping the distributions of household wealth. I document that changes in government spending play a mild role in the determination of wealth inequality. I find that increases in government spending raise the net worth of all groups of households except for the top 1%, largely driven by real estate holdings. For the bottom 50% of households, the rise in real estate holdings is not associated with an increase in mortgage debt, I conclude that these households are simultaneously paying down their mortgage debts and enjoying capital gains on housing. Additionally, I document that the wealth distribution faces a mild and temporary compression in response to government spending shocks, with the top 1% and 50^{th}-90^{th} percentile groups of households losing ground relative to the bottom 50% and 90^{th}-99^{th} percentile groups. These findings suggest that temporary changes in government spending offer little relief to advocates of a more equitable distribution of wealth, as opposed to changes in tax regimes and social safety nets studied elsewhere in the literature on wealth inequality.

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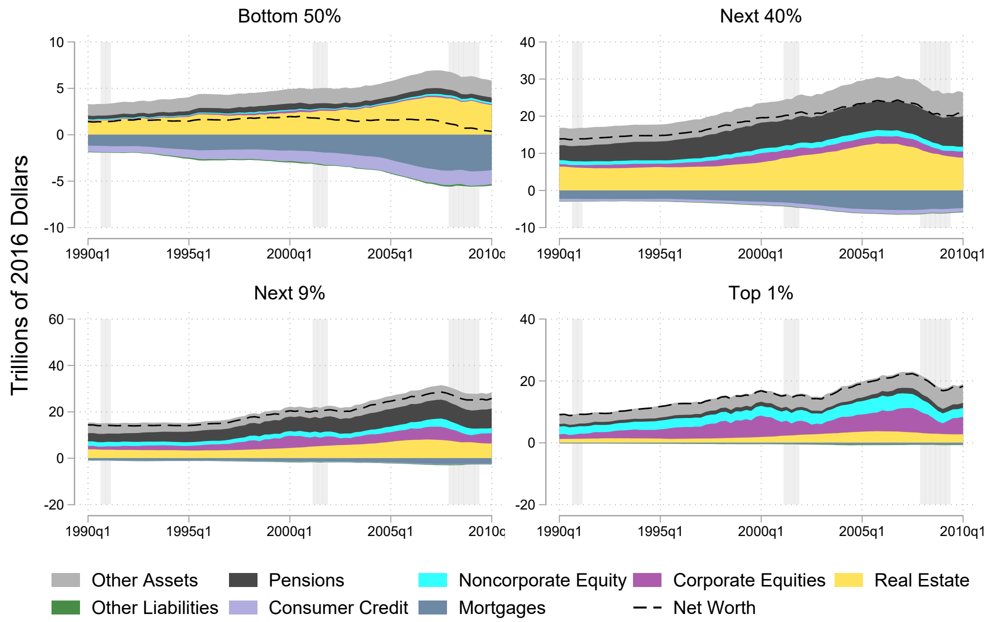

Figure 29. Balance Sheet Decompositions

Notes: Balance sheet decomposition for households by wealth in the U.S. Shaded region indicates NBER recession.

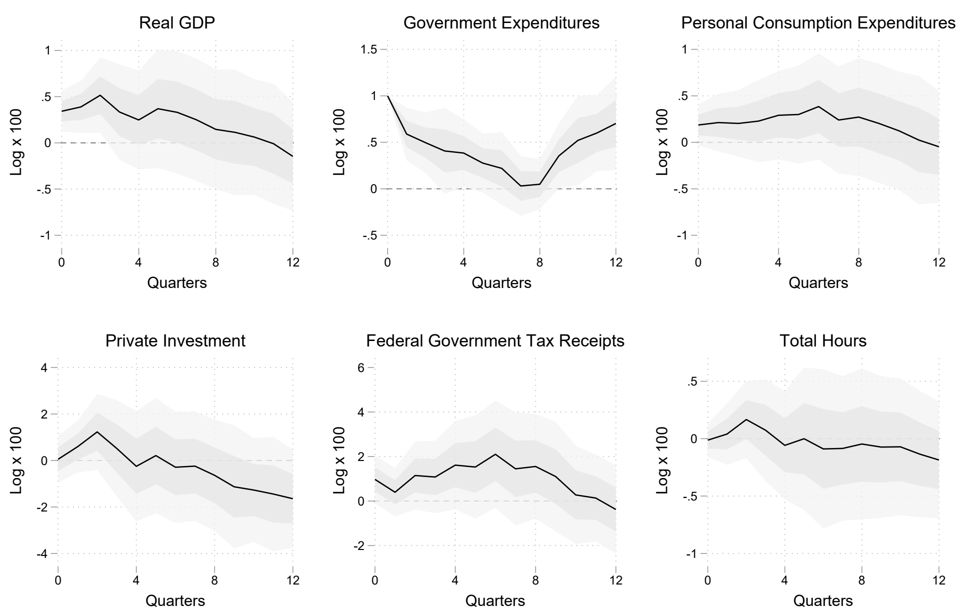

Figure 30. Macroeconomic Variables

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.

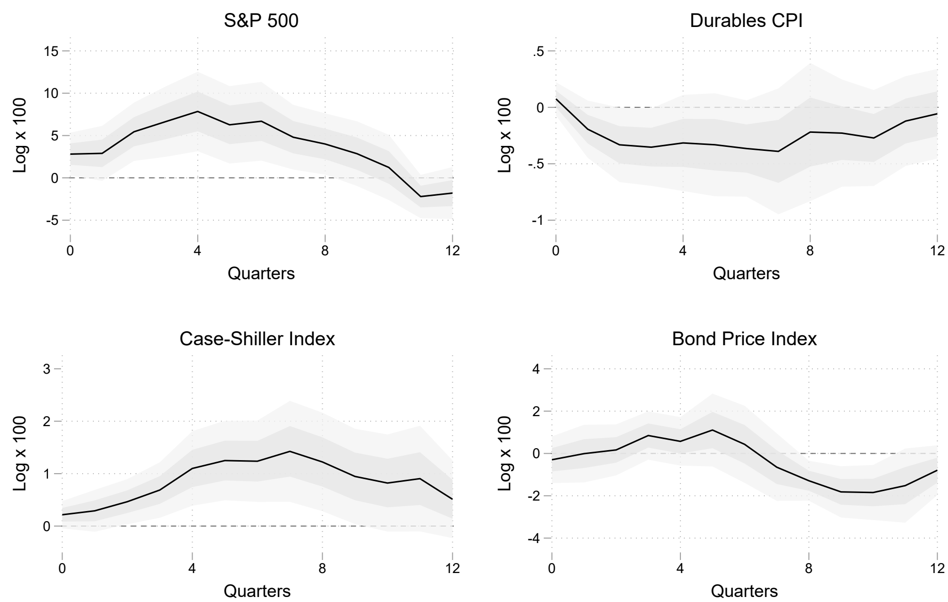

Figure 31. Asset Prices

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.

Figure 32. Net Worth

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.

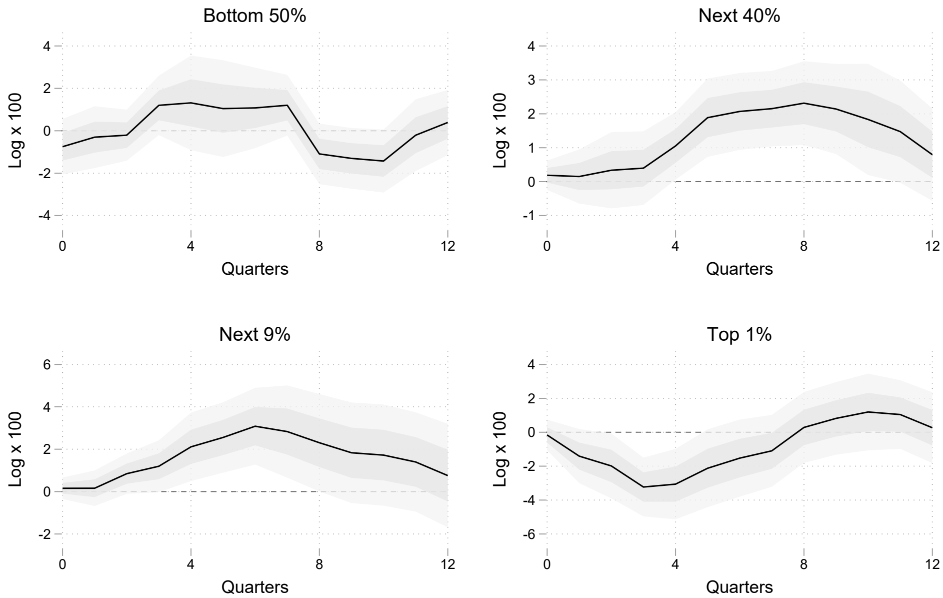

Figure 33. Real Estate

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.

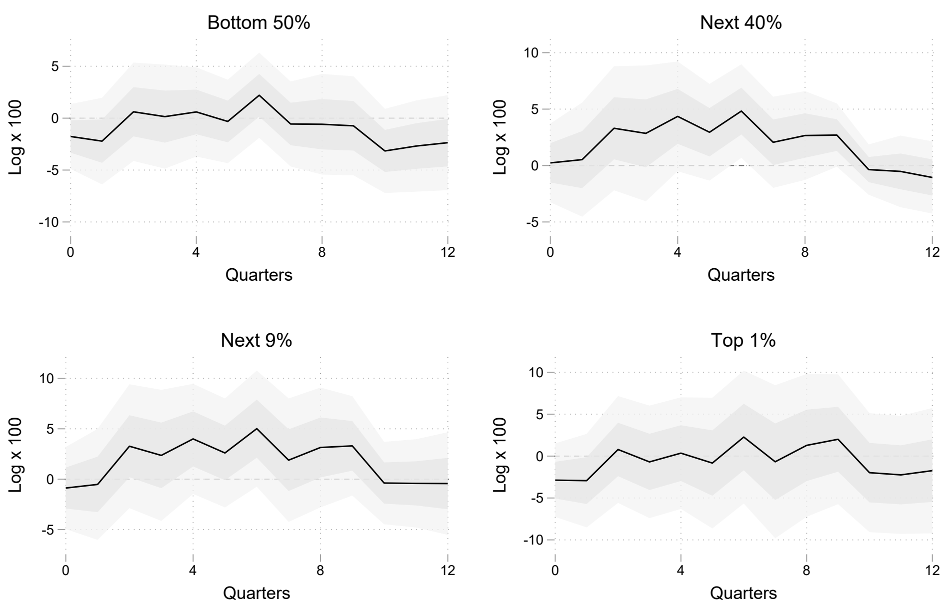

Figure 34. Corporate Equities

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.

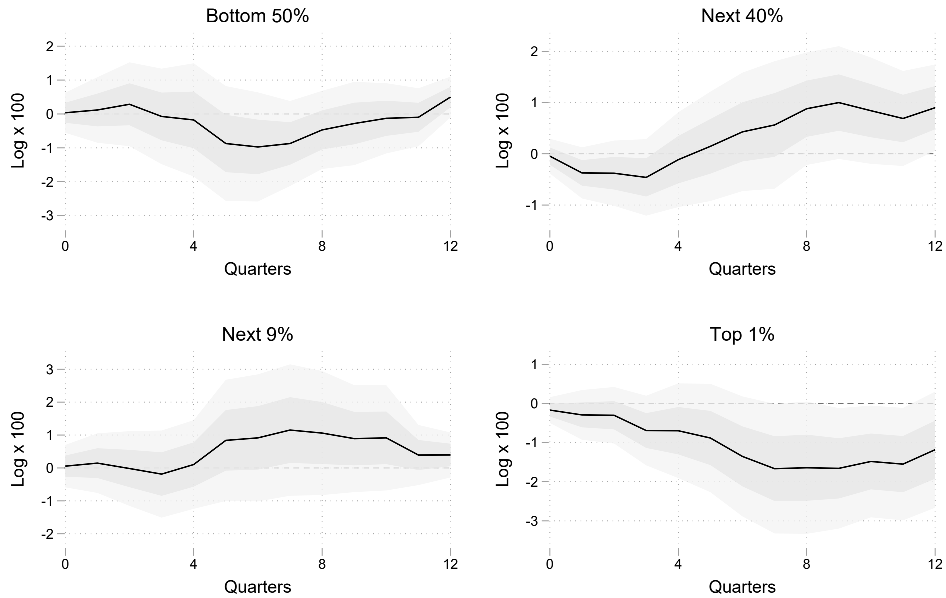

Figure 35. Home Mortgages

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.

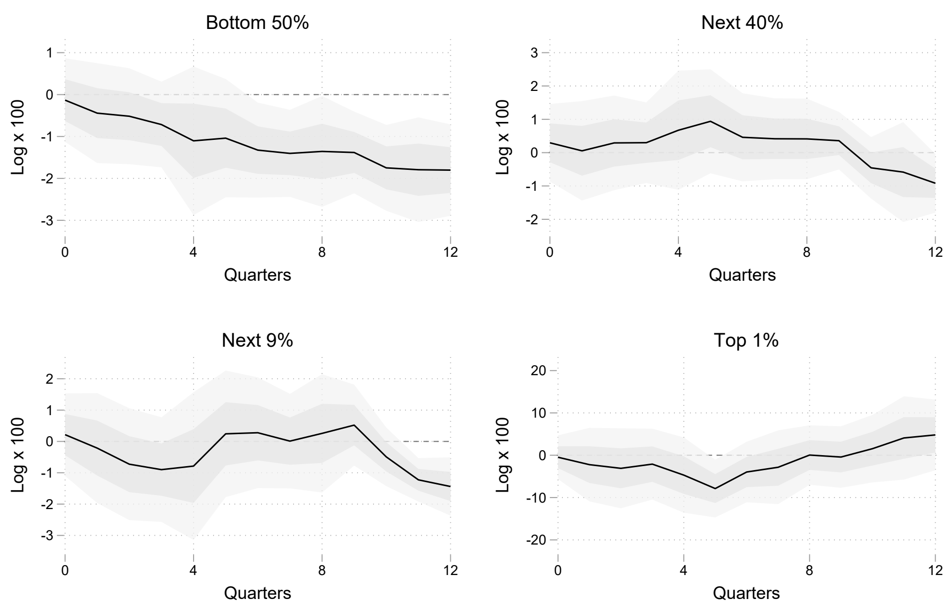

Figure 36. Consumer Credit

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.

Figure 37. Net Worth Shares

Notes: Impulse responses to a 1 pp surprise increase in real government spending. Presented with one- and two- standard error confidence bands. See text.