Monetary Policy and Wealth Inequality over the Great Recession in the UK. An Empirical Analysis*

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Abstract

We use detailed micro information at household level from the Wealth and Assets Survey to construct measures of wealth inequality from 2006 to 2018 at the monthly frequency. We investigate the dynamic relationship between monetary policy and the evolution of wealth inequality measures. Our findings suggest that expansionary monetary policy shocks lead to an increase in wealth inequality and contributed significantly to its fluctuations. This effect is heterogenous across the wealth distribution with the monetary shock affecting the median household relative to the 10th and 20th percentile by a larger amount than the right tail. Our results suggest that the shock is transmitted through changes in net property and financial wealth.

Keywords: Inequality, Wealth, FAVAR, Monetary Policy Shocks
JEL No. D31, E21, E44, E52

1 Introduction

In the aftermath of the Great Recession a number of countries face increasing income and wealth inequality. During the Great Recession, wealthy households experienced earnings and financial losses while automatic stabilisation policies were set off to support low income families. However, a decade after the global financial crisis this trend has been reversed and losses have been more than recovered. Across the 28 OECD countries, the Gini coefficient for disposable income has increased from 0.30 in 2006-7 to 0.32 in 2016-17 and 10 percent of households hold 52 percent of total wealth in 2015 (Balestra and Tonkin (2018)).

According to data compiled by Alvaredo *et al.* (2018), wealth inequality in the UK as expressed by the share of top 10 percent was in a downward trend until the end of

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1990s, when it reached its historical lower value. In the first half of 2000s wealth inequality remained mostly unchanged. During the Global Financial Crisis the ratio fell substantially while it recovered strongly in 2011-15 with average annual growth of 4 percent (Balestra and Tonkin (2018)). This recovery coincided with monetary policy easing by the Bank of England and the launch of the Quantitative Easing (QE) programme under which it purchased £375 billion of financial assets from 2009 to 2012.

In this paper we investigate the impact of monetary shocks on wealth inequality in the UK. Using the available waves in the Wealth and Asset Survey (WAS), we construct wealth inequality measures at the monthly frequency from July 2006 to March 2018. A factor augmented VAR (FAVAR) with external instrument identification is then used to generate the response of measures of the distribution of wealth.

This analysis suggests three main results. First, expansionary monetary policy shocks increase measures of inequality such as the ratio of wealth around the 80th and 90th percentile relative to wealth around the 20th and 10th percentile and the Gini coefficient. Second, the monetary shocks benefit households near the median of the distribution with their wealth rising relative to households towards the left tail. In contrast, the increase in the wealth of households around the 80th and 90th percentile relative to the median is smaller in size. Counterfactual experiments suggest that housing and financial wealth plays a crucial role in increasing wealth towards the middle and the right tail of the distribution. Net property wealth constitutes the largest proportion of wealth at the median of the distribution and forms a large component of the total around the 80th percentile. Expansionary policy shocks push up house prices which have an impact on this component and increase wealth relative to households on the left tail. Evidence for this assertion comes from the fact that the effects of monetary policy on these measures of wealth inequality become substantially smaller once the property wealth component is removed from the inequality measures. Financial wealth plays a larger role for households near the median and right tail and boosts their wealth relative to the left tail and the median, respectively. Without this component, this increase in relative wealth is reversed. Finally, the effect of monetary policy on physical wealth, the largest component of wealth for the least wealthy households, acts in the opposite direction and reduces the degree of the rise in inequality after the policy shock.

Our analysis builds on the literature on inequality and monetary policy. Monetary policy has heterogeneous effects on households' income and wealth through direct and indirect channels of transmission. An expansionary conventional or unconventional monetary policy directly affects interest payments and the value of financial assets respectively. The portfolio composition and maturity of assets and liabilities are crucial for heterogeneous responses to monetary policy shocks[1] (see Auclert (2017)). Indirectly, a monetary expansion is expected to boost investment, employment and overall economic activity through the macroeconomic channel (e.g. Coibion *et al.* (2017), Mumtaz and Theophilopoulou (2017), Ampudia *et al.* (2018)). Studies on the Euro Area such as Lenza and Slacalek (2018) and Bunn *et al.* (2018) find this to be dominant in reducing income inequality but do not find any significant effects on wealth. There are further indirect ways through which monetary policy impacts wealth: It alters house prices and benefits home owners and mortgagors (Cloyne and Surico (2016), Adam and Tzamourani (2016)). This may have an equalizing effect if these two groups cover a large part of population and if housing wealth is the largest component in poor households' portfolio (Casiraghi *et al.* (2018)). However, the rise of property prices can generate new types of inequalities between home and non home owners, mainly young earners with no parental gifts, who find increasingly difficult to enter the housing market (Piketty *et al.* (2018)).

Large scale assets purchase programmes lower gilt yields affecting large bond holders such as private pension funds. Pension fund schemes (especially Defined Benefit schemes) may experience disproportionate increase in their liabilities to the value of their assets leading to higher deficits. Lower gilt yields put also downward pressure on the return on annuities which implies lower pension income for their policy holders. As Bunn *et al.* (2018) note, the impact of monetary policy on pension wealth is very complex and depends on a number of factors: portfolio and investment decisions of the fund, generosity of future real cash flows, longevity etc. Studies which take into consideration pension wealth are constrained to make simplifying assumptions about future cash flows and focus only on measured pension wealth.[2]

The inflation induced by loose monetary policy harms fixed rate savings and debt securities holders, favouring mainly fixed rate borrowers. Doepke and Schneider (2006) find that rich households are adversely affected as they are the principal holders of long maturity interest bearing assets while Erosa and Ventura (2002) find that poor households are mostly affected as they hold most of their wealth in the form of cash.

In summary, the impact of monetary policy on household wealth is complex from a theoretical perspective as it affects wealth through the various transmission channels discussed above. The contribution of our paper is to provide empirical evidence on this relationship

[1] If, for example, liabilities consist of short term or variable rate debt, a lower policy rate will benefit these type of debt issuers, while debt holders with maturing assets will face reinvestment risk, debt holders with variable rates and savers in current account deposits will be negatively affected. On the other hand, savers in time deposits or bond holders with long term maturities in fixed rates will not be directly affected.

[2] While lower discount rates raise the value of financial assets and a household may decide to sell in order to increase current consumption at the expense of future consumption, this is not the case for pension funds. If the value of pension pots increases, households cannot directly use future pension cash flows to finance current consumption.

using a data-driven approach. To our knowledge this is one of the first attempts to examine the dynamic relationship between monetary policy shocks and wealth inequality measures in the UK.[3]Most studies using wealth surveys are constrained by a limited number of waves and low frequency data. The methodology in these studies is a two-step approach: First, the impact of a monetary policy shock on aggregate variables is estimated and then a number of assumptions concerning household's portfolio decisions, asset prices and returns are used to simulate the estimated impact on households' balance sheet (see Bunn *et al.* (2018) and Casiraghi *et al.* (2018)). By using a FAVAR, the dynamic relationship between the monetary policy shock and a large number of macroeconomic, financial variables and measures of wealth inequality is modelled in one step. This is advantageous as the approach does not require assumptions regarding the channels of transmission of the shock. In addition, standard innovation accounting can be used to estimate the importance of policy shocks.

In an independent but subsequent contribution Evgenidis and Fasianos (2020), also examine the effect of monetary policy on wealth inequality measures in the UK.[4]However, their study only considers net housing and financial wealth. We show in our analysis that additional wealth components such as pension and physical wealth are also important for understanding the transmission of policy shocks to the wealth distribution.

The rest of the paper is structured as follows: Section 2 describes the construction of the wealth inequality measures. Section 3 describes the estimation of the empirical model and the identification scheme. Section 4 presents the main results and section 5 concludes.

2 Data

In this section we describe the construction of wealth inequality measures as derived from the WAS.

2.1 Wealth Inequality Measures

The wealth inequality measures are calculated using the Wealth and Assets Survey, a longitudinal survey launched by the Office for National Statistics (ONS) in 2006. It gathers information about households' levels of assets, savings and debt, savings for retirement and factors which affect their financial planning. At present the WAS consists of five waves and one round, with each wave covering two years and the last wave pertaining to the period

[3]Inui et al. (2017) present responses of inequality measures related to financial assets for Japan but do not consider total household wealth in their study.

[4]We thank an anonymous referee for making us aware of this study. The October 2019 working paper version of the current study can be downloaded from the following link.

2014-16. Round 6 of the WAS marks the move of the survey to financial years covering the period April 2016 to March 2018. ONS aims at a response from on average 20,000 households per wave and the response rate has been around 50-55 percent in all waves.

Total wealth in the WAS is the sum of private pension wealth, net financial wealth, net property wealth and physical wealth.[5] In 2016 WAS estimates total wealth to be 12.73 billion GBP of which 42 percent consists of private pension wealth and 35 percent of property wealth. Private pension wealth considers any future current income from private pension schemes on which individuals or their spouses retain rights. Basic state pension is excluded. The two main private pension schemes are Defined Contribution (DC) and Defined Benefits (DB). DC pension wealth includes occupational and personal pensions while DB is expected income to be received from DB schemes based, for example, on final salary. Financial wealth is the value of formal and informal financial assets held by the household, net of any financial liabilities. It comprises savings and current accounts, ISAs, national saving certificates and bonds, gilts, shares, insurance products, employee shares and options, unit and investment trusts and children's assets. Physical wealth sums the value of contents in all properties of a household. These include all valuable items such as collectables, vehicles, art work, antiques etc. It is calculated at household level. Finally, property wealth is respondents' net valuation of any property owned in the UK or abroad net of any outstanding loans or mortgages.

Note that while the WAS is the only data source which allows for the construction of UK wealth inequality measures at a frequency relevant for monetary policy, it does come with some caveats. Like most income and wealth survey studies, WAS suffers from low response rates and under-reporting in higher percentiles. In the WAS this problem is dealt by oversampling wealthier households. Using information from national income tax records, WAS flagged areas where at least one person had total wealth above a certain threshold. In this way wealthy households had a much higher probability to be selected for interview. Another problem that wealth surveys face is undervaluation of assets. Wealthy households may under-report financial assets for tax purposes or because of time lags between the response and the maturity, high price volatility of some financial assets, possession of intangible assets, etc. where its precise value is difficult to be estimated. Crossley *et al.* (2016) reports that a high percentage of households who owned business assets failed to provide a valuation of such assets giving incomplete responses. In an effort to produce more precise estimates, WAS removed business assets from the estimation of total wealth. This, however may undervalue total wealth in top percentiles.

[5]We use the terms 'total wealth' and 'net wealth', interchangeably in the paper to refer to the sum of pension wealth, net financial wealth, net property wealth and physical wealth.

For our benchmark measures of wealth inequality we use quantile ratios. We define $\bar{P}_{80}$ as average wealth for households that lie between the 75th and 85th percentile of total wealth, $\bar{P}_{20}$ as average wealth for households that lie between the 15th and 25th percentile of total wealth and $\bar{P}_{50}$ as average wealth for households that lie between the 45th and 55th percentile of total wealth. Our benchmark inequality measure is defined as $\frac{\bar{P}_{80}}{\bar{P}_{20}}$. This ratio compares the wealth of households around the top 20 percent of the distribution to wealth of households near the bottom 20 percent. The $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ ratios demonstrate how the wealthier and poorer percentiles move relative to the median. We also show results based on lower and higher percentiles to capture the response of the tails of the distribution. That is, we use the ratio $\frac{\bar{P}_{90}}{\bar{P}_{10}}$ where $\bar{P}_{90}$ is the average wealth for households between the 85th and 95th percentile while $\bar{P}_{10}$ denotes mean wealth between the 5th and 15th percentile.

We also provide estimates based on the Gini coefficient in the robustness analysis. While the Gini is a more general measure, it does not provide information regarding the location of households along the distribution that are most affected by inequality. As this information is crucial in understanding the transmission of policy shocks to inequality, the percentile ratios are our preferred measure.[6]

The wealth data used to construct these inequality measures is obtained from waves 1 to 5 and round 6 of the survey. In total, our sample covers the period from July 2006 to March 2018. Following Cloyne and Surico (2016) and Mumtaz and Theophilopoulou (2017), we group households by their date of interview. The WAS sampling structure involves an initial draw of an annual sample of addresses grouped into primary sampling units (PSUs). These PSUs are then assigned to months at random. As described in the WAS Wave 1 user guide, this assignment is carried out ensuring that PSUs allocated to a month are evenly spread across the original sample and have an equal chance of being allocated to each month. In the second stage, from each PSU, addresses are sampled and assigned each month to the ONS interviewer panel. By selecting households that are interviewed each month, we obtain a sample of about 800 households per month. We then construct the percentiles of total wealth using survey weights.[7]

In the technical appendix, we show that, in terms of characteristics such as region, age, housing tenure and employment status, the coverage of the survey does not fluctuate substantially month to month. In addition, the completion outcome of the survey is fairly stable over the sample period with no large changes month to month. This provides evidence to support the view that monthly changes in the constructed wealth inequality

[6] OECD (2013) show that the Gini coefficient may be sensitive to outliers in the wealth distribution. In the technical appendix, we show that this result extends to the Gini coefficient constructed using WAS data – the level and time profile of the Gini changes substantially if the top and the bottom percentiles of the wealth distribution are trimmed.

[7] All analysis of survey data in the paper uses survey weights to construct aggregates.

measures do not reflect fluctuations in the coverage of the survey.

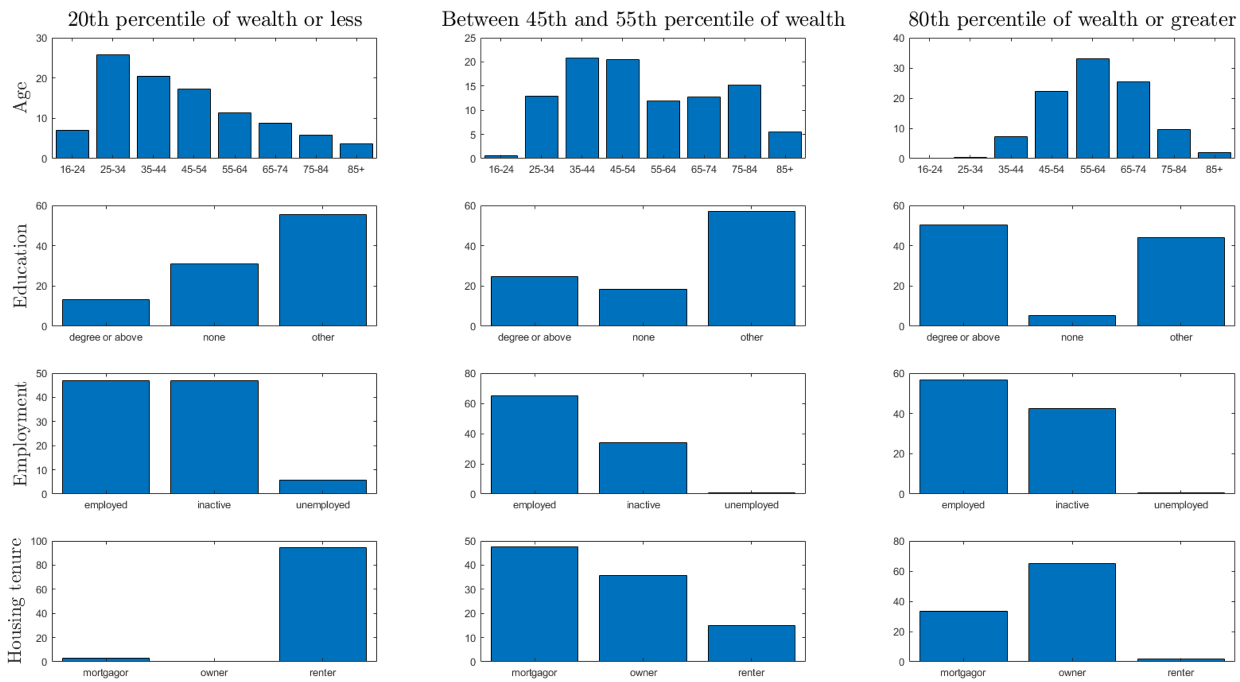

Figure 1: Characteristics by level of wealth from Wave 5 of the WAS survey. The y-axis shows the percentage of households in each category. Age, education and employment relate to the reference person in the household or their partner.

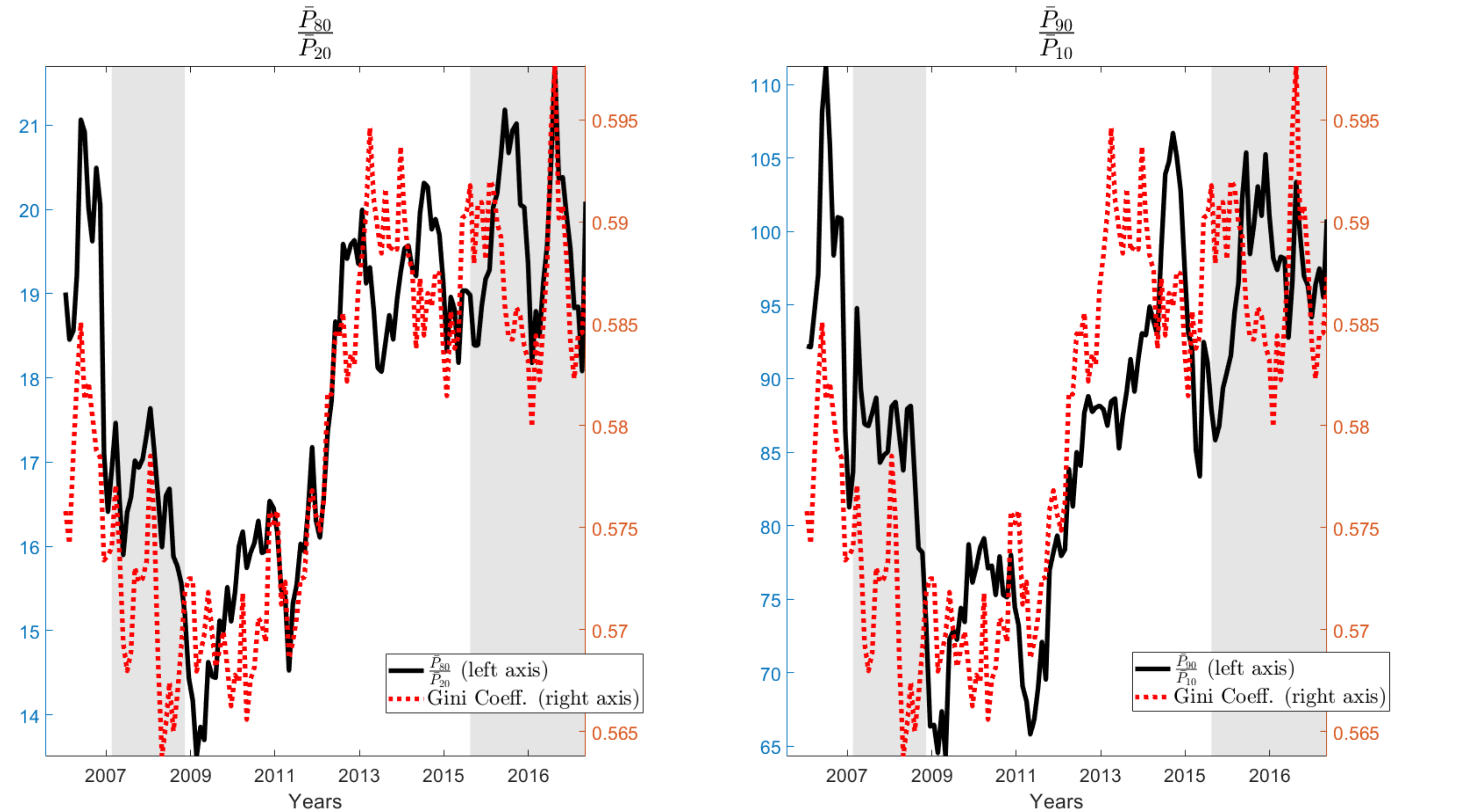

Figure 2: Gini coefficient (right axis) and the $\frac{\bar{P}_{80}}{\bar{P}_{20}}, \frac{\bar{P}_{90}}{\bar{P}_{10}}$ ratios (left axis). Both series are smoothed using a 6 month moving average in the figure.

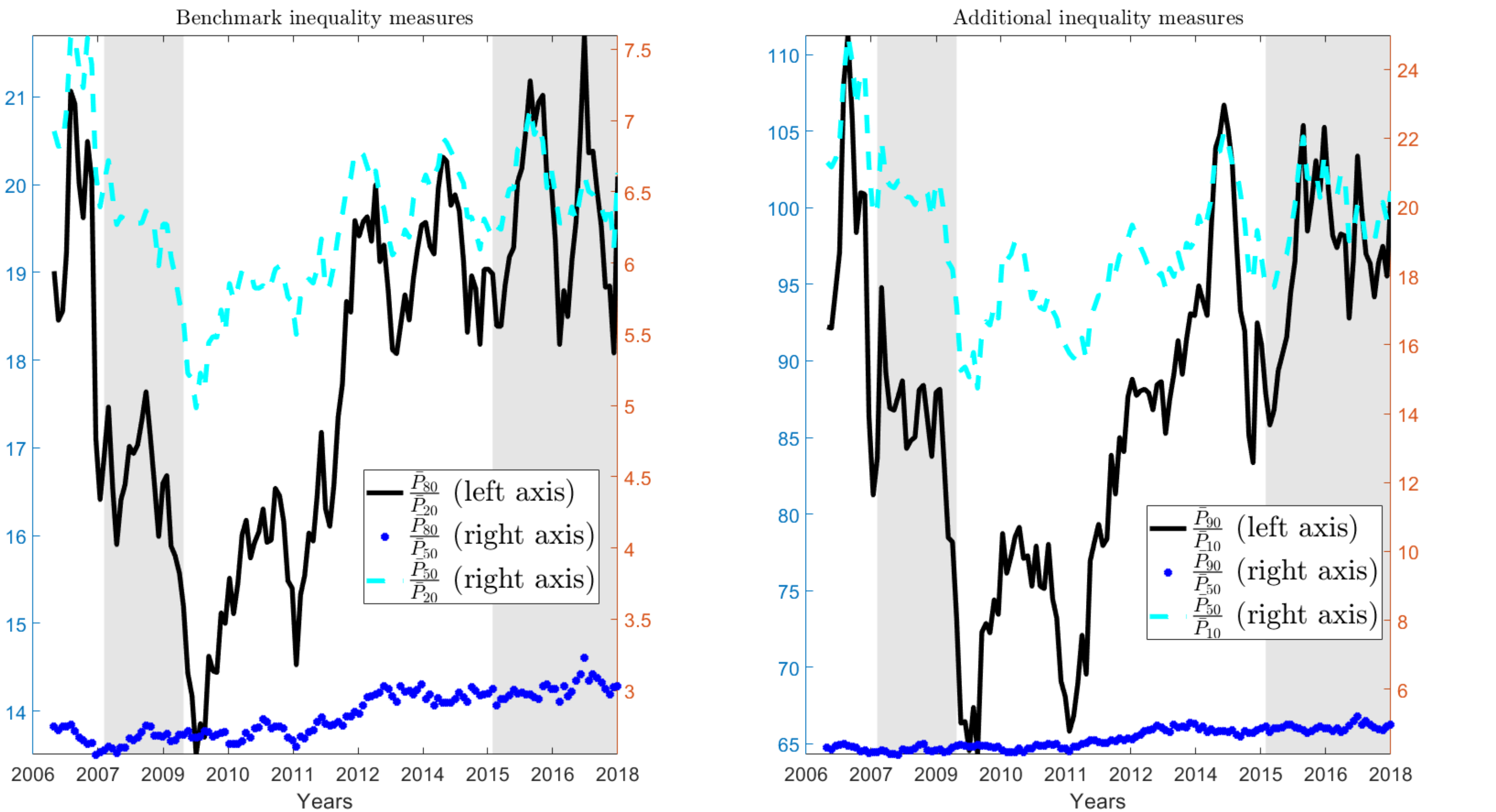

Figure 3: Left panel: $\frac{\bar{P}_{80}}{\bar{P}_{20}}$ (left axis) and $\frac{\bar{P}_{80}}{\bar{P}_{50}}$, $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ (right axis). Right panel: $\frac{\bar{P}_{90}}{\bar{P}_{10}}$ (left axis) and $\frac{\bar{P}_{90}}{\bar{P}_{10}}$, $\frac{\bar{P}_{50}}{\bar{P}_{10}}$ (right axis). The measures are smoothed using a 6 month moving average in this figure.

Figure 1 provides information regarding the characteristics of households that lie on or above the 80th wealth percentile, near the median or have wealth less than or equal to the 20th percentile. The top panel of the figure shows that wealthier households consist of older individuals, with a large proportion in the 55-74 age range. In contrast, the bulk of less wealthy households have individuals below 55 years of age. Individuals towards the middle and the right of the distribution are more likely to have a degree qualification and less likely to be unemployed compared to those at the left tail of the distribution. Finally, it is clear from the last row of the figure that households on the left tail are more likely to be renters. About 90 percent of households below the 20th percentile rent. In contrast, over 80 percent of households near the median own their house either outright or through a mortgage. The proportion of owners or mortgagors rises to 97 percent for households above the 80th percentile of wealth.

The evolution of the benchmark measure of total wealth inequality can be seen in the left panel of Figure 2. We smooth the measure using a 6 month moving average in order to highlight low frequency and business cycle fluctuations.[8] For the purposes of comparison, we also present the Gini coefficient. The percentile based measures and the Gini coefficient display a correlation of about 0.7 over the sample period and tend to move together fairly closely. Wealth inequality was declining during the pre-2007 period with the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$ ratio falling to just above 17. The onset of the financial crisis coincided with a short-lived increase in the measures. However, after 2008, the inequality declined sharply with the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$ ratio almost half of its initial value. The remaining period is characterised by a largely sustained increase in the inequality measures with both the Gini coefficient and the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$ ratio moving towards their pre-2007 levels. The right panel shows that while the $\frac{\bar{P}_{90}}{\bar{P}_{10}}$ measure is more volatile, it evolves in a manner that is similar to the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$. Over 2007-2009, the measure declined from 110 to below 70 highlighting the drastic effect of the financial crisis. In the post-crisis period, the measure has trended upwards.

The left panel of Figure 3 compares the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$ measure with the $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ measures. It is clear from the figure that the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$ measure is tracked by the $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ measure. In contrast, the $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ ratio, remains relatively flat over the sample period. The right panel of the figure shows that a similar conclusion holds for $\frac{\bar{P}_{90}}{\bar{P}_{10}}$. This suggests that movements in these measures of total wealth inequality over this period are largely driven by changes in the wealth of households near the median relative to the left tail of the distribution.

As discussed above, there were several changes in conventional and unconventional monetary policy over this period. In the next section, we consider the effect of monetary policy shocks on measures of wealth inequality and investigate the channels of shock

[8] The raw measures are reported in the technical appendix.

transmission.

3 Empirical model

To estimate the impact of monetary policy shocks, we employ a factor augmented vector autoregression (FAVAR) as our benchmark model. This choice offers two key advantages. First, by using a large information set, it is more likely that we account for the variety of non-policy macroeconomic and financial shocks that the UK was subject to over the available sample period. Second, as discussed below, the FAVAR explicitly accounts for presence of idiosyncratic shocks and measurement error in the survey data.

The observation equation of the model is defined as:

$$\begin{pmatrix} R_t \\ X_t \end{pmatrix} = \begin{pmatrix} I & 0 \\ 0 & \Lambda \end{pmatrix} \begin{pmatrix} R_t \\ F_t \end{pmatrix} + \begin{pmatrix} 0 \\ v_t \end{pmatrix} \tag{1}$$

where R_t denotes the policy interest rate. X_t is $M \times 1$ matrix of variables for the UK covering both aggregate macroeconomic and financial data *and* measures of wealth inequality. In the benchmark model, the latter include the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$, $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ ratios. The 37 macroeconomic and financial series included in X_t are listed in the appendix. Note that the sample period is 2006M7 to 2018M3.

$\underbrace{F_t}_{K\times 1}$ denotes a set of K factors that summarise the information in X_t, Λ is a $M \times K$ matrix of factor loadings. Finally, v_t is a $M \times 1$ matrix that holds the idiosyncratic components. We assume that v_t follows an $AR\left(q\right)$ process:

$$v_{it} = \sum_{p=1}^{P} \rho_{ip} v_{it-p} + e_{it}, var(e_{it}) = r_i, R = diag\left([r_1, r_2, .., r_M]\right) \tag{2}$$

where $i = 1, 2, .., M$.

Denoting the factors $\begin{pmatrix} R_t \\ F_t \end{pmatrix}$ by the $N \times 1$ vector Y_t, the transition equation can be described as:

$$Y_t = Bx_t + u_t \tag{3}$$

where $x_t = [Y'_{t-1}, .., Y'_{t-P}, 1]'$ is $(NP+1) \times 1$ vector of regressors in each equation and B denotes the $N \times (NP+1)$ matrix of coefficients $B = [B_1, ..., B_P, c]$. The covariance matrix of the reduced form residuals u_t can be written as:

$$\Sigma = \left(Aq\right)\left(Aq\right)'$$

where A is the lower triangular Cholesky decomposition of Σ, and q is an element of the family of orthogonal matrices of size N, satisfying $q'q = I_N$.

3.1 Identification of shocks

Following Stock and Watson (2008) and Mertens and Ravn (2013), we employ an external instruments approach to identify the monetary policy shock. The structural shocks of the FAVAR model ε_t are defined as:

$$\varepsilon_t = A_0^{-1} u_t, \varepsilon_t \sim \mathcal{N}(0, I_N) \tag{4}$$

where $A_0 = Aq$. The shock of interest is the first shock ε_{1t} in the $N \times 1$ vector of shocks $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{\cdot t}]$, where $\varepsilon_{\cdot t}$ contains the remaining $N-1$ elements in ε_t. To identify the effect of ε_{1t}, we employ an instrument m_t described by the following equation:

$$m_t = \beta \varepsilon_{1t} + \sigma \tilde{v}_t, \quad \tilde{v}_t \sim \mathcal{N}(0, 1) \tag{5}$$

where $\mathbb{E}(\tilde{v}_t \varepsilon_t) = 0$. The instrument is assumed to be relevant (i.e. $\mathbb{E}(m_t \varepsilon_{1t}) = \alpha \neq 0$) and exogenous (i.e. $\mathbb{E}(m_t \varepsilon_{\cdot t}) = 0$).

In our empirical application, the instrument to identify the monetary policy shock is taken from Gerko and Rey (2017) who use high frequency data on short-sterling (SS) futures to construct a proxy for a monetary policy shock. In particular, Gerko and Rey (2017) consider changes in SS futures during a tight window around monetary policy events. They argue, that changes in SS futures around the release of the minutes of the monetary policy committee meetings contain information regarding the future stance of conventional and unconventional monetary policy and provide evidence that suggests that this measure is a strong instrument for the policy shock. As in Gerko and Rey (2017), the monetary policy instrument R_t is assumed to be the 5 year government bond yield.

The structure of the FAVAR model implies that the series in X_t are driven by aggregate shocks ε_t and idiosyncratic shocks e_{it}. When the survey-based wealth inequality series in X_t are considered, our model captures the impact of aggregate shocks *net* of the effect of idiosyncratic disturbances that might proxy measurement error or differences in characteristics specific to the particular percentile group (see Giorgi and Gambetti (2017)).[9]

[9] In the technical appendix, we show that the estimated variance of the idiosyncratic components associated with the wealth inequality measures is of a similar magnitude to that associated with macroeconomic series. We also present Monte-Carlo evidence that suggests that the impulse responses estimated by the FAVAR model are robust to an increase in measurement error in a subset of series included in X_t.

3.2 Model estimation and specification

Following Bruns (2019) and Miescu and Mumtaz (2019), the FAVAR is estimated using a Gibbs sampling algorithm that is an extension of the algorithm proposed by Caldara and Herbst (2019) for proxy VARs. Details of the algorithm and the priors are presented in the technical appendix. As discussed in Caldara and Herbst (2019), the priors for β and σ^2 play an important role as they influence the reliability of the instrument. Mertens and Ravn (2013) define the reliability statistic as the squared correlation between m_t and ε_{1t}:

$$\rho^2 = \frac{\beta^2}{\beta^2 + \sigma^2} \tag{6}$$

In our benchmark model, the priors for β and σ^2 are set to reflect the strong belief that the instruments are relevant and imply that $\rho \approx 0.5$. This prior belief is based on the evidence regarding the high relevance of the instrument presented in Gerko and Rey (2017). We show, in the sensitivity analysis below that an alternative identification scheme suggests results that are similar to benchmark.

The choice of the number of factors is a key issue with regards to specification of the model. The responses of macroeconomic variables to the monetary policy shock do not change substantially for models with three factors or more. We therefore use $K = 3$ as the benchmark. Following Bernanke *et al.* (2005), we present some robustness analysis regarding this choice below. The lag length P is set to 6 in the benchmark model as the number of time-series observations is fairly limited.

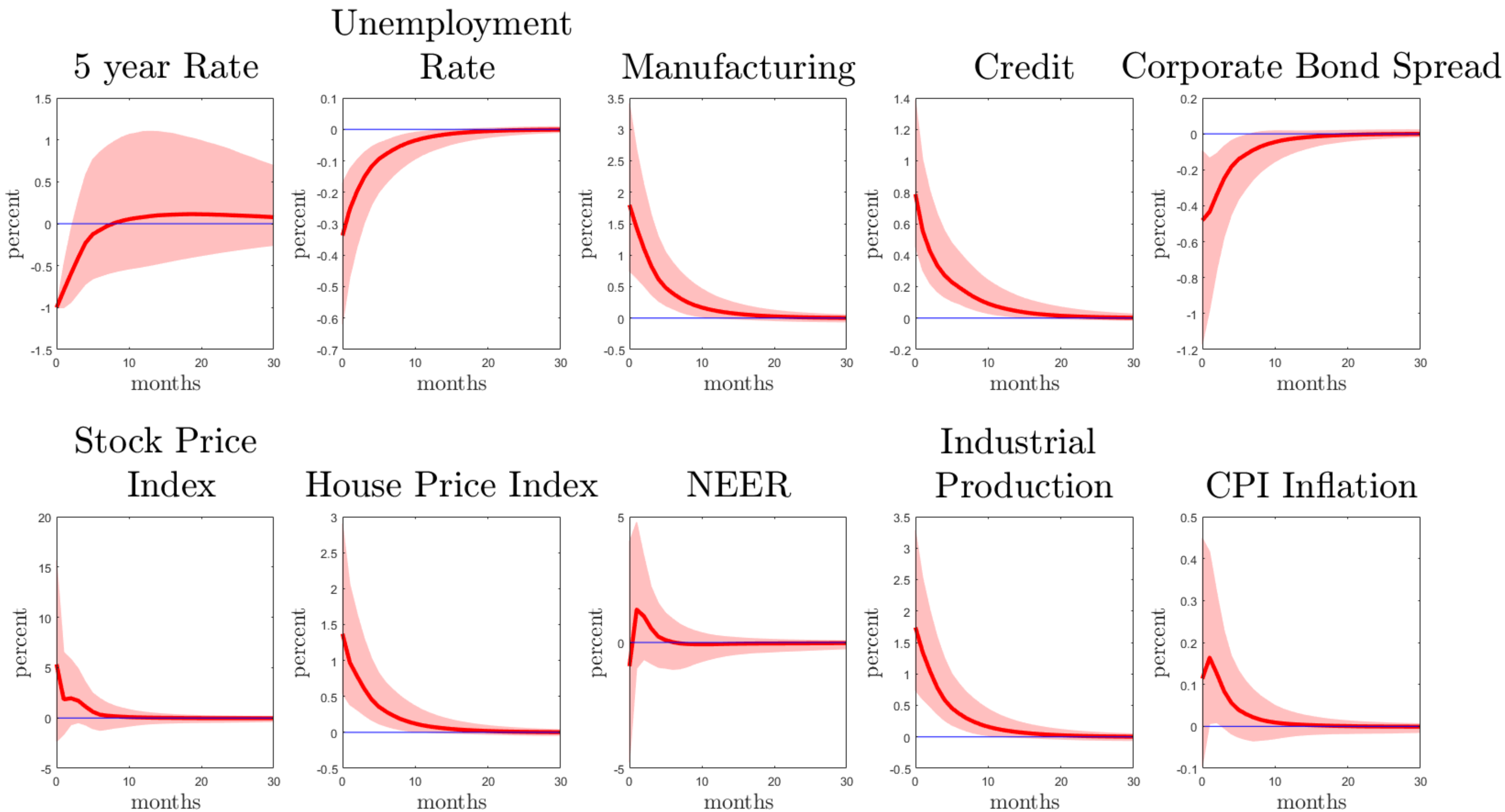

Figure 4: Impulse response of UK aggregate variables to an expansionary monetary policy shock. The shock has been scaled to reduce the UK 5-year government bond yield by 100 bp . The red line is the median estimate and the shaded area is the 68% error band.

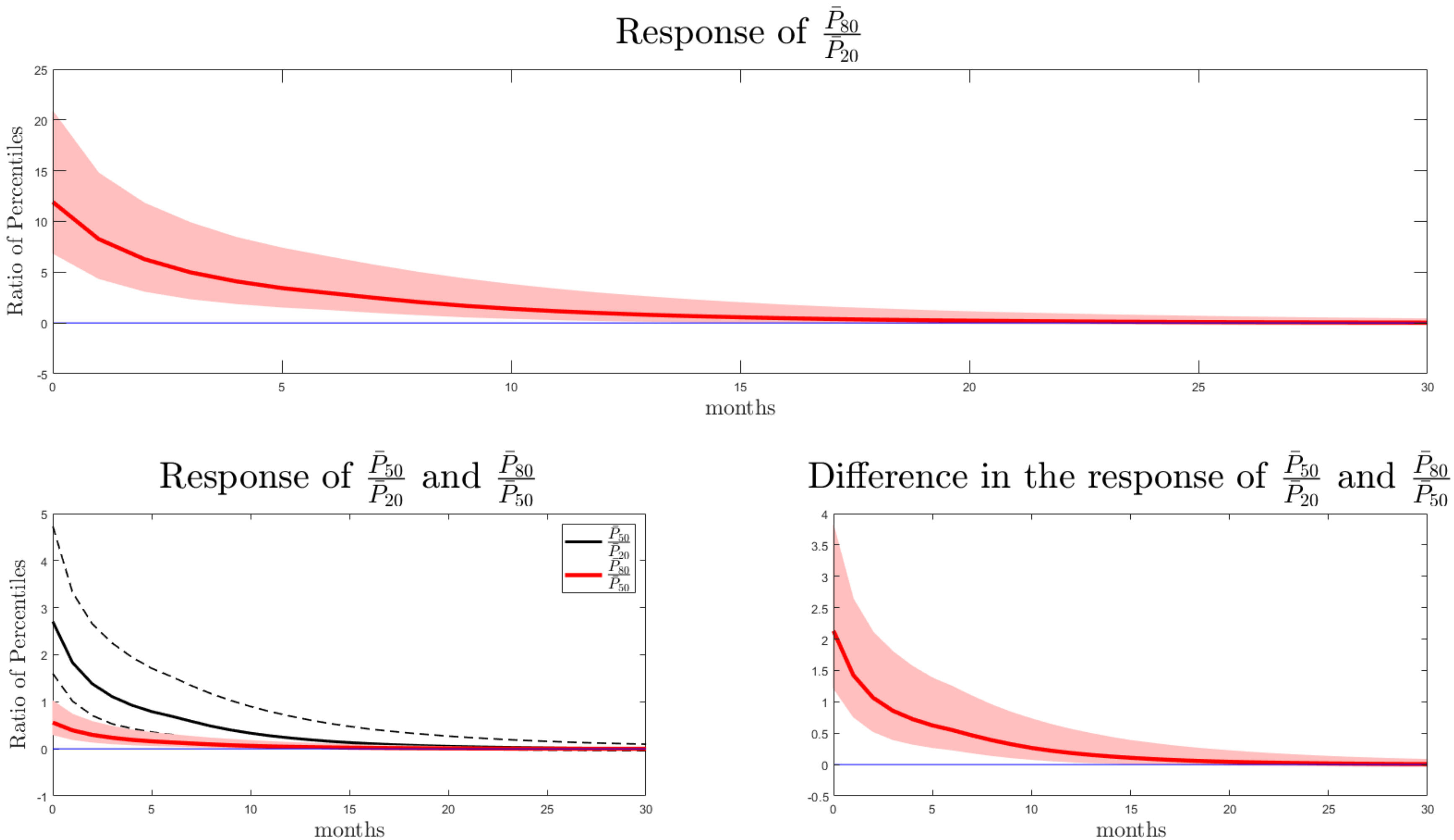

Figure 5: Response of benchmark measures of wealth inequality to an expansionary monetary policy shock.

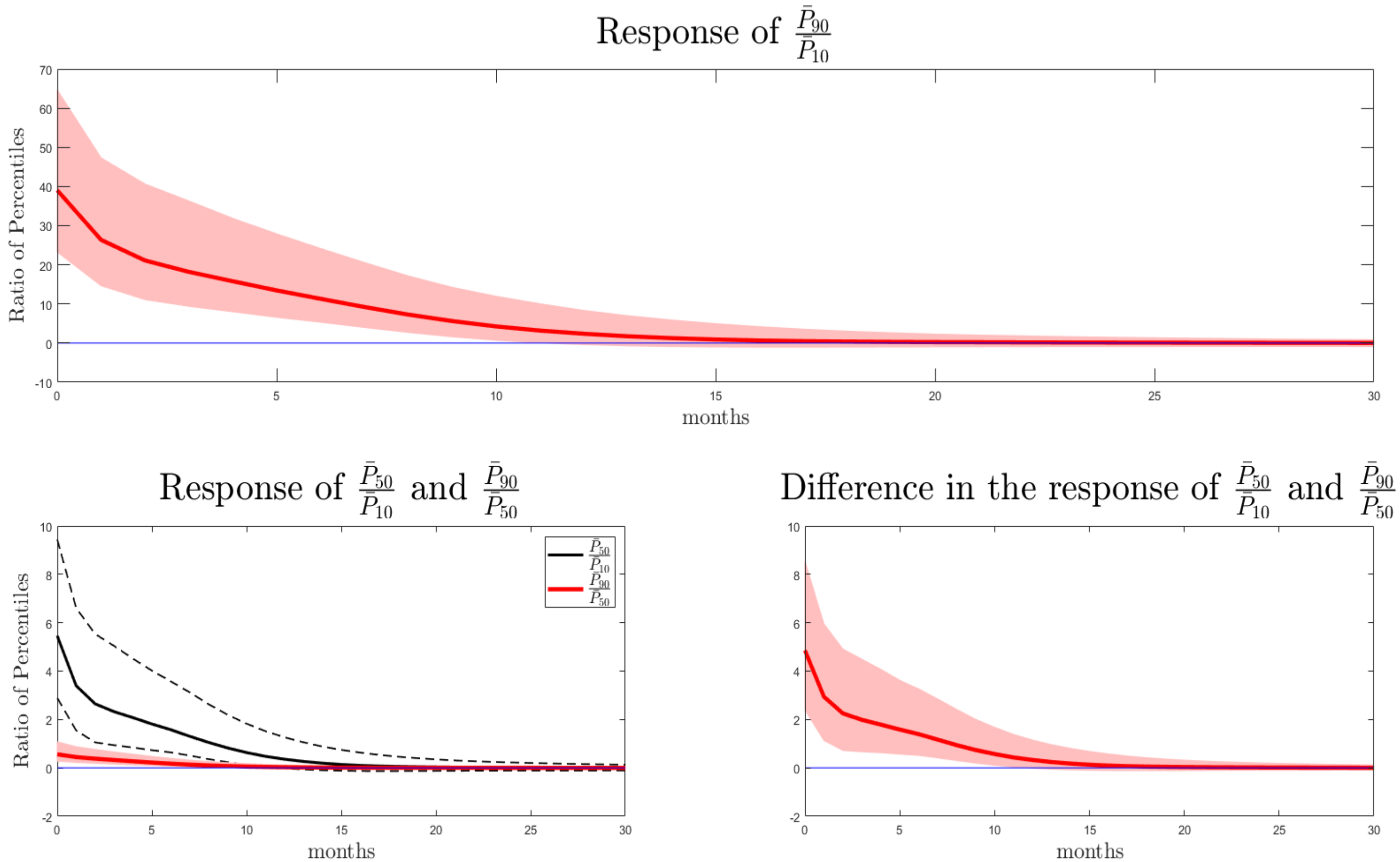

Figure 6: Response of additional measures of wealth inequality to an expansionary monetary policy shock.

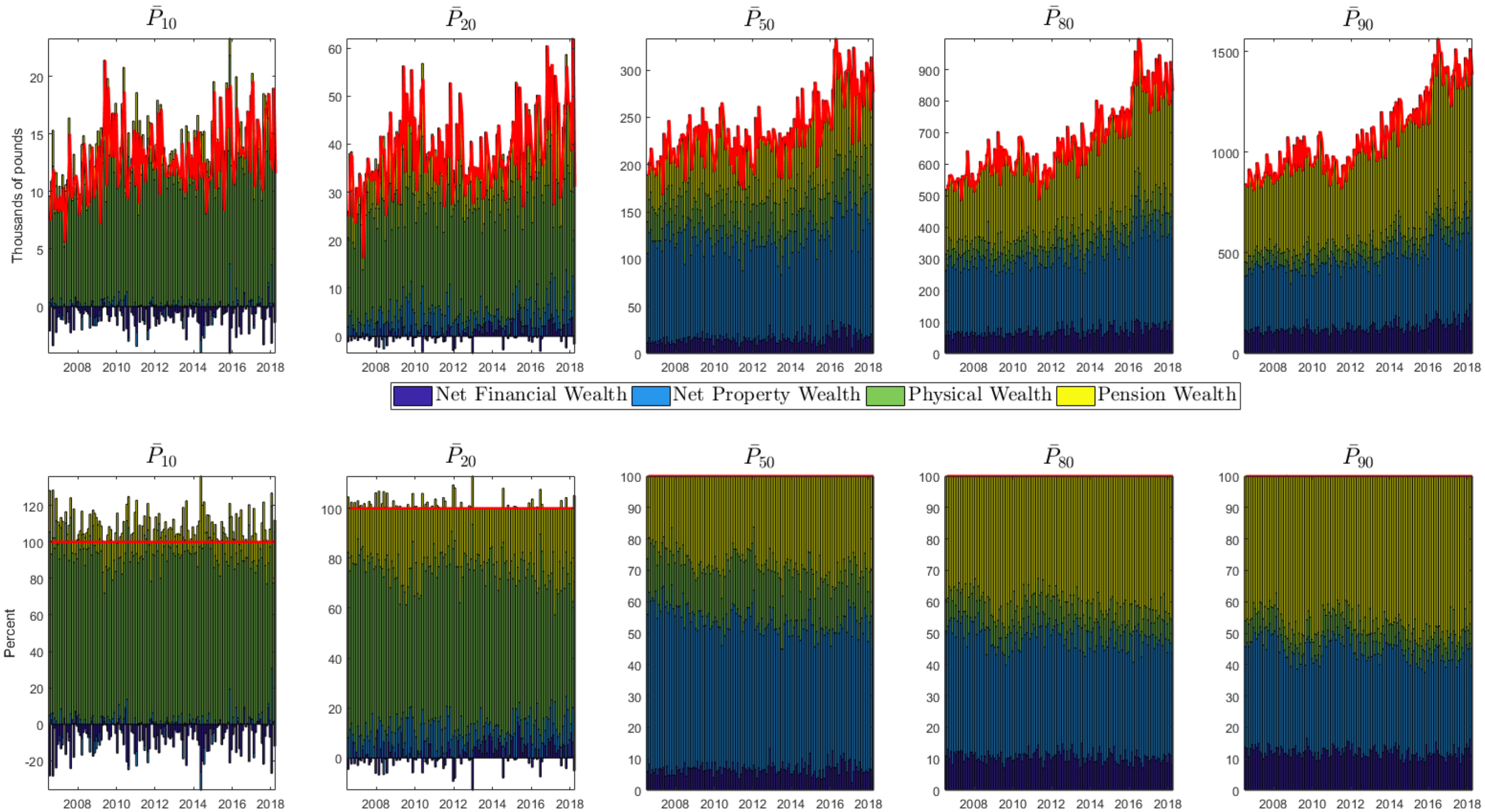

Figure 7: Decomposition of total wealth by selected percentiles. The top row presents the contributions in cash terms. The bottom row presents the contributions as a percentage of total wealth for each group. The total of the components is depicted as a red solid line.

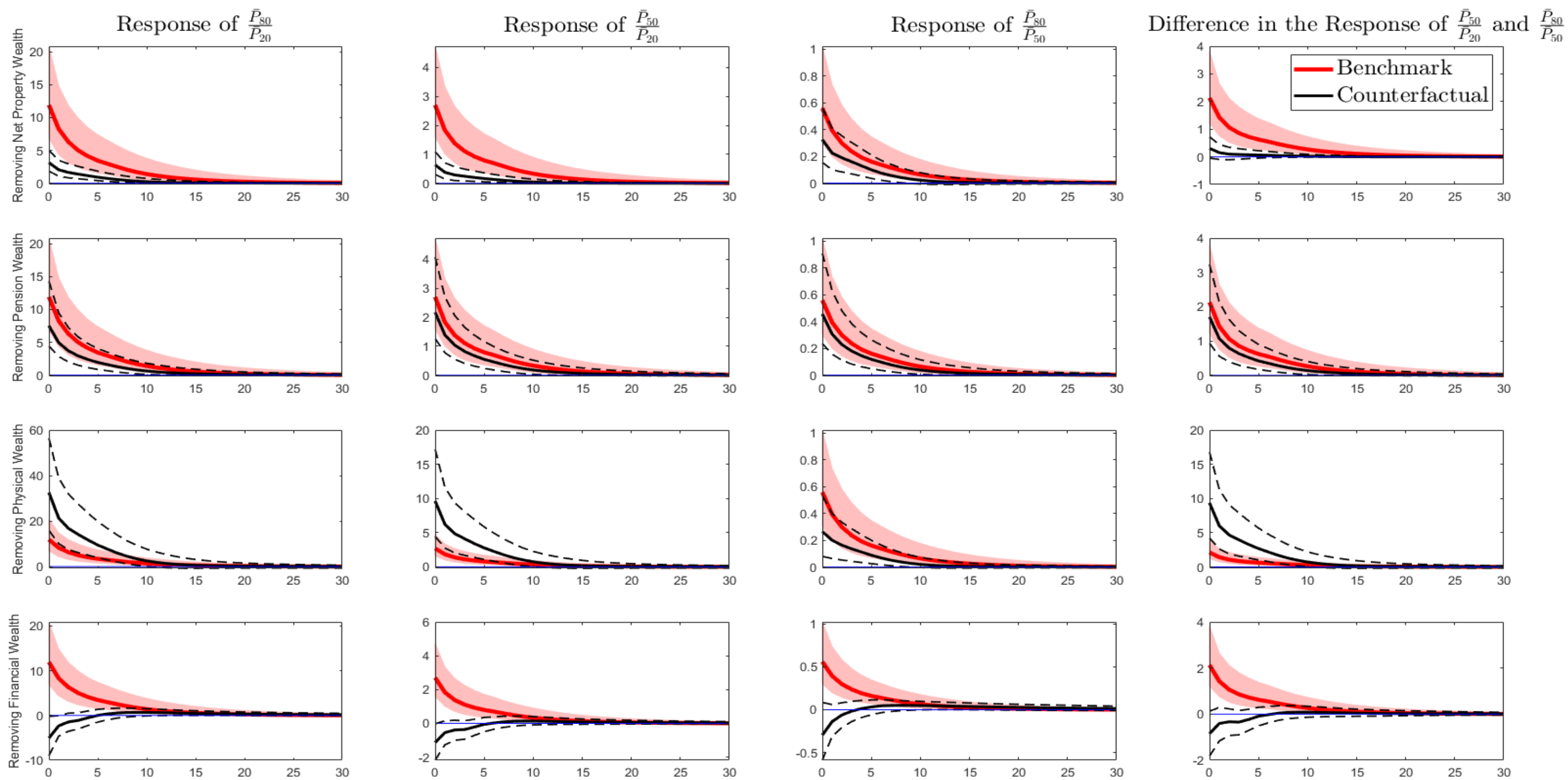

Figure 8: Comparison of benchmark results and those obtained when one form of wealth is excluded. Using benchmark inequality measures.

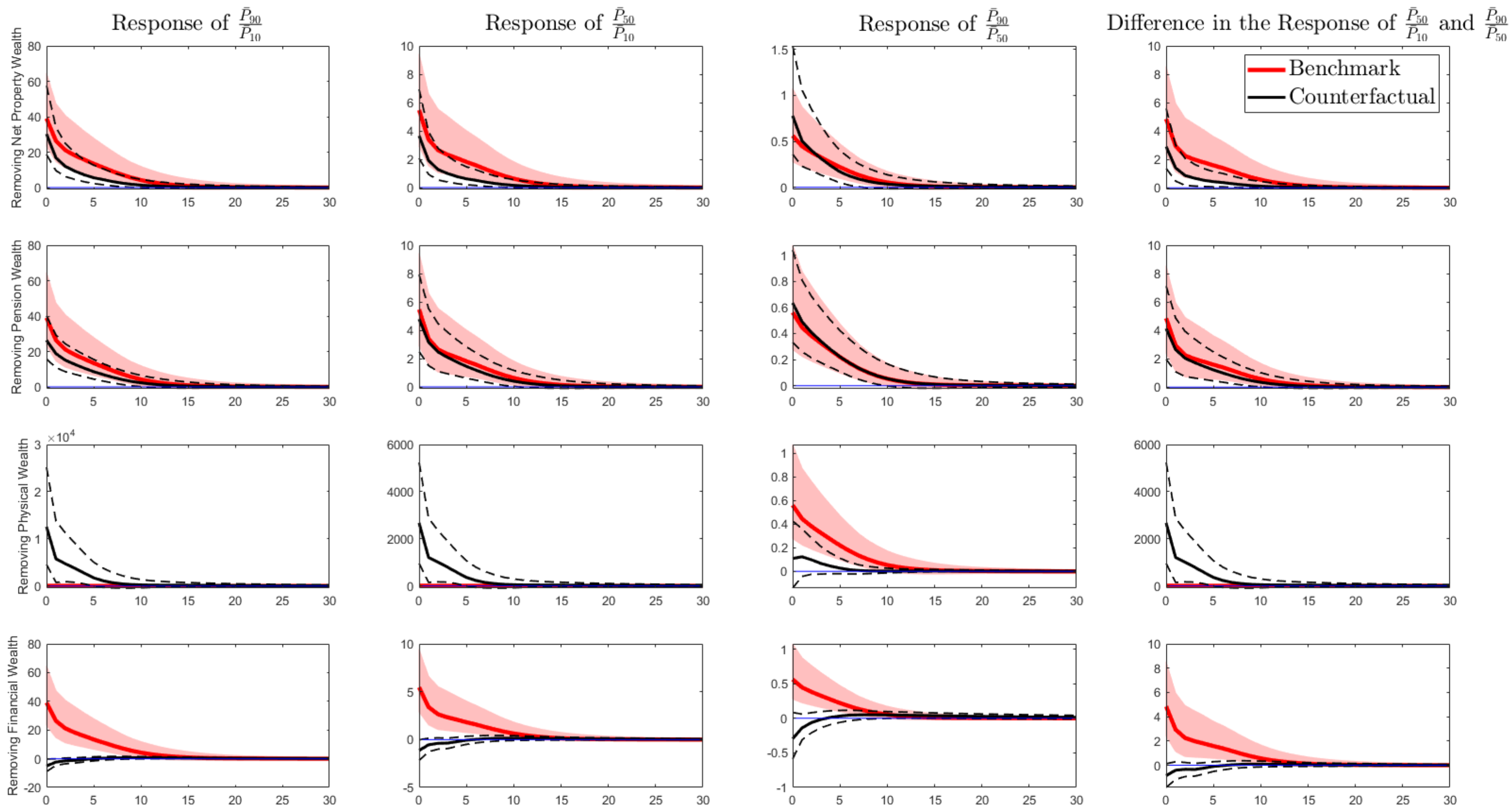

Figure 9: Comparison of benchmark results and those obtained when one form of wealth is excluded. Using additional inequality measures.

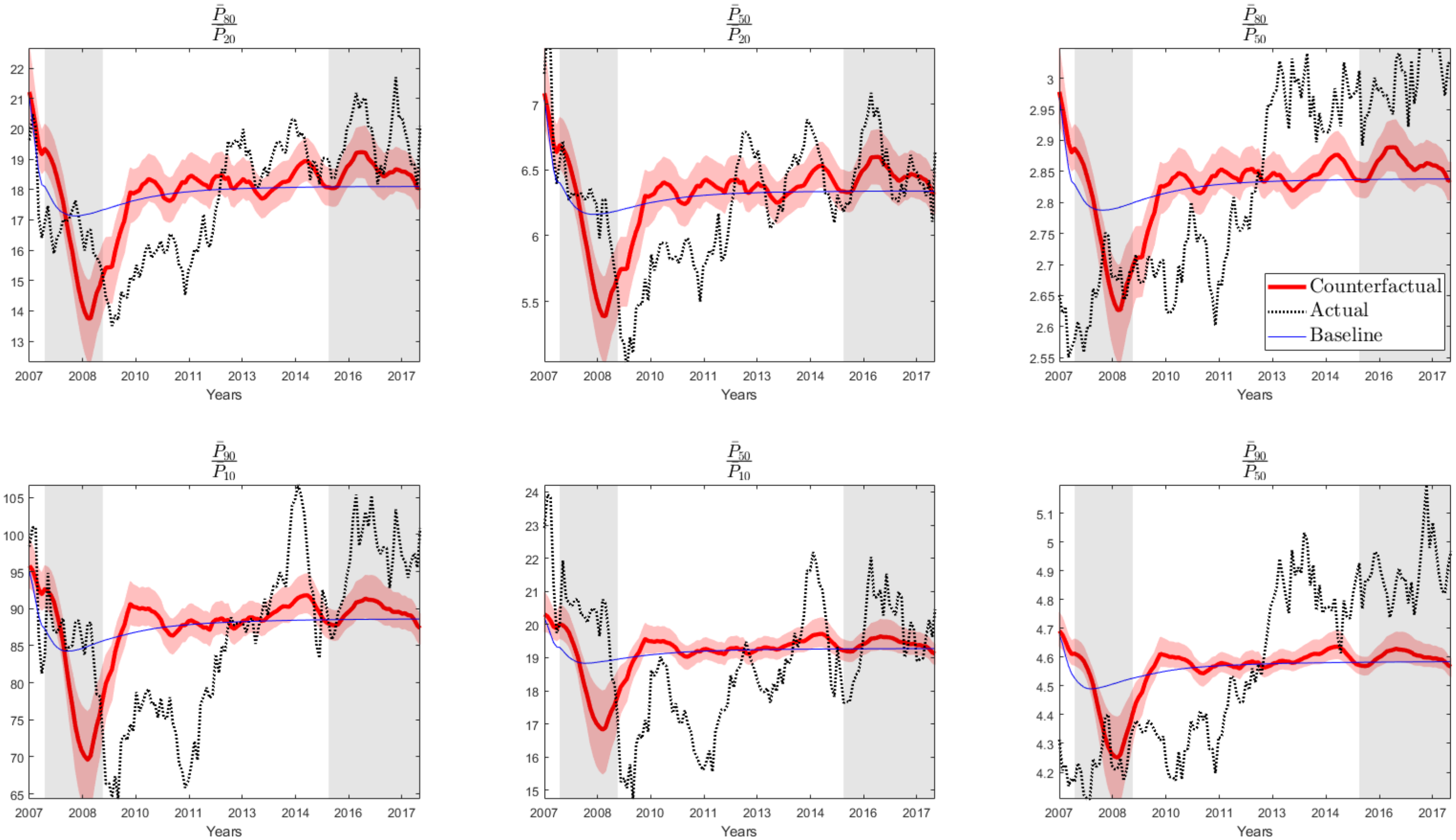

Figure 10: Counterfactual estimates of wealth inequality. The red lines and shaded area depict the counterfactual estimates (median and 68 percent error band) assuming that only the monetary policy shock is non-zero. The blue line denotes the FAVAR implied trend. The series are smoothed using a 6 month moving average.

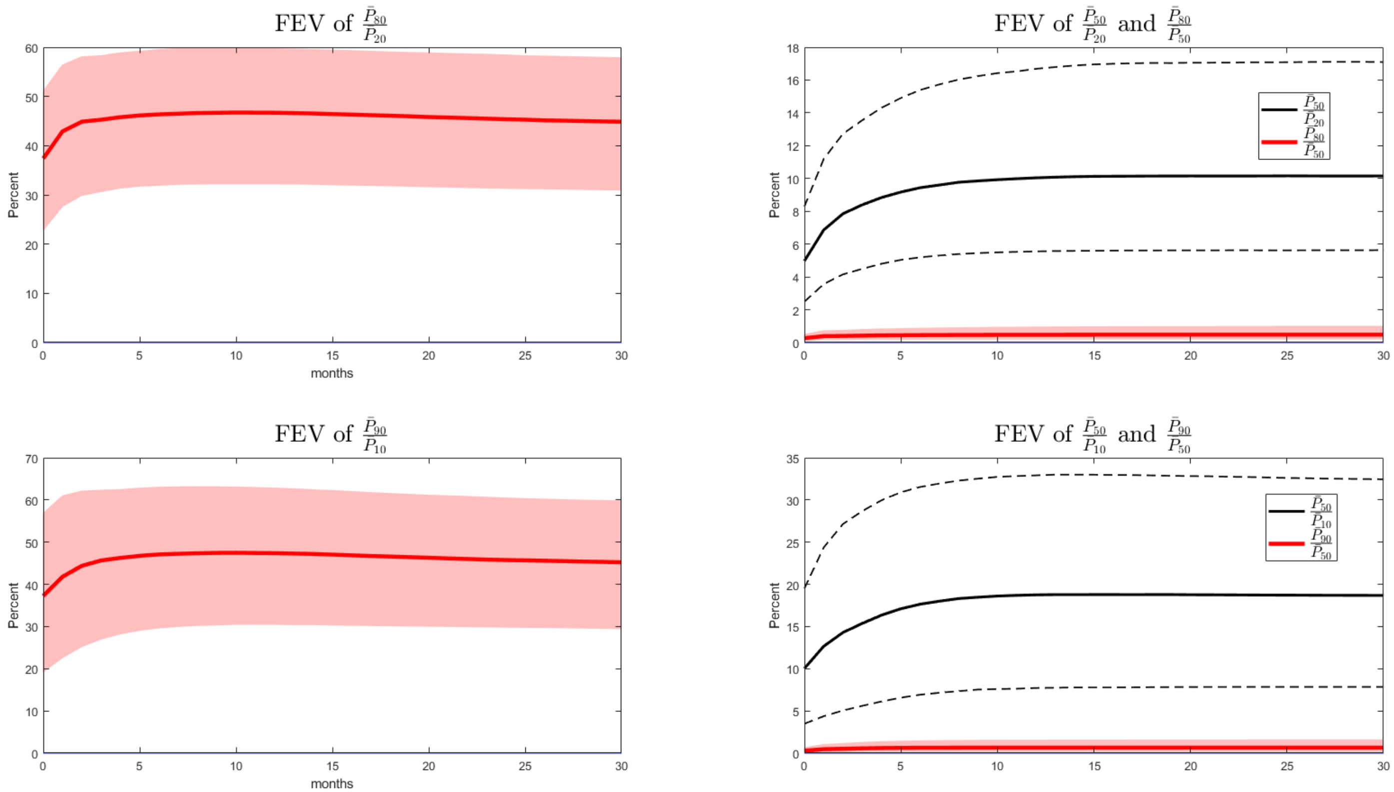

Figure 11: Contribution of the monetary policy shock to the forecast error variance (FEV) of wealth inequality measures.

4 Response to a monetary expansion

4.1 Impact on macroeconomic aggregates

Before considering the impact of the monetary shock on the wealth distribution we report its impact on economic aggregates. Figure 4 shows the response of selected aggregate macroeconomic and financial variables to a monetary policy shock scaled to reduce the five year rate by 100 basis points. The monetary expansion leads to a boost in real economic activity with an increase in manufacturing and industrial production and a decline in unemployment. CPI inflation rises after the shock. As in Gerko and Rey (2017), the shock is associated with financial easing – the corporate bond spread declines, the stock index and credit rises and the response of house prices is positive. The response of NEER indicates a depreciation on impact with a quick reversal. However, unlike Gerko and Rey (2017), we do not find a large response of the exchange rate to the shock. This possibly reflects the smaller sample used in our study. Overall, these estimates are consistent with the standard results regarding the macroeconomic impact of monetary policy shocks reported in the literature.

4.2 Impact on the distribution of wealth

We now turn to the estimated impact of this shock on the total wealth distribution. Figure 5 considers the response of the benchmark measures of total wealth inequality included in X_t, i.e. $\frac{\bar{P}_{80}}{\bar{P}_{20}}$, $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{20}}$. The top panel of the figure shows that after a monetary expansion, average wealth of households around the 80th percentile rises relative to the 20th percentile by about 12 units, with the impact persisting for 18 months. The bottom panels of the figure considers if this inequality is driven by changes above or below the median. While $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ increases after the shock, the magnitude of the response is small. In contrast, average wealth near the median rises relative to the wealth of households around the 20th percentile far more substantially. The bottom right panel shows that the difference between the two responses is different from zero in statistical terms. This suggests that wealth inequality is pulled up mainly by the increase in wealth towards the middle of the distribution relative to the 20^{th} percentile.

The response of $\bar{P}_{90}$ relative to $\bar{P}_{10}$ is much larger in magnitude, with wealth in the latter group becoming 40 times larger than the former group (see Figure 6). An examination of the response of wealth below and above the median again suggests that the response of $\frac{\bar{P}_{50}}{\bar{P}_{10}}$ is systematically larger than that of $\frac{\bar{P}_{90}}{\bar{P}_{50}}$.

4.2.1 Channels of transmission

To investigate the heterogeneous responses of wealth percentiles to the monetary policy shock we first examine the composition of wealth across the distribution. Figure 7 shows the composition of total wealth for groups $\bar{P}_{10}, \bar{P}_{20}, \bar{P}_{50}, \bar{P}_{80}$ and $\bar{P}_{90}$ in each month of the sample and displays the contributions of each component.

For group $\bar{P}_{10}$ and $\bar{P}_{20}$, physical wealth forms the largest proportion of total wealth, contributing, on average, 92 and 64 percent, respectively. Pension wealth is moderately important for these groups with an average contribution of 14 percent for $\bar{P}_{10}$ and 25 percent for $\bar{P}_{20}$. The average contribution of housing wealth for group $\bar{P}_{10}$ is negligible and estimated to be below 1 percent. This component forms 10 percent of the total wealth of group $\bar{P}_{20}$, on average over the sample. It is interesting to note that financial wealth contributes negatively for extended periods for households around the 10th percentile. On average, this component is unimportant for group $\bar{P}_{20}$, forming about 2 percent of the total. In group $\bar{P}_{50}$, the largest component is net housing wealth, averaging 50 percent as a proportion of their total. Pensions form the second largest component at 30 percent followed by physical wealth (17 percent) and net financial wealth (7 percent). The role of housing wealth remains important for group $\bar{P}_{80}$. In percentage terms it forms 39 percent of their total wealth, on average, which is almost equal to the contribution of pension wealth that stands at 41 percent. Physical and financial wealth contribute about 10 percent for this group. The contribution of pension wealth rises to around 50 percent in group $\bar{P}_{90}$ with housing wealth becoming slightly less important and forming 33 percent of the total. Net financial wealth forms 12 percent of the total with the average contribution of physical wealth estimated to relatively small (7 percent).

It is useful to note that, in terms of relative size, average housing and financial wealth is much larger towards the right tail of the wealth distribution. Relative to group $\bar{P}_{20}$, housing wealth is about 30 times larger for households near the median. Housing wealth in groups $\bar{P}_{80}$ and $\bar{P}_{90}$ is about 2 to 3 times larger than that of households around the median and 70 to 95 times larger than households around the 20th percentile. Net financial wealth for group $\bar{P}_{50}$ is about 20 times larger than $\bar{P}_{20}$. For $\bar{P}_{80}$, this component is 70 times larger than $\bar{P}_{20}$ and about twice as large as group $\bar{P}_{50}$. Net financial wealth for the $\bar{P}_{90}$ group is more than 100 times larger than group $\bar{P}_{20}$ and about 8 times larger than households near the median.

As noted in Bunn *et al.* (2018), monetary policy shocks can affect total wealth through these components. Expansionary monetary policy boosts prices of assets such as stocks and homes, thus increasing net financial and housing wealth.[10] An increase in asset prices

[10] Higher house prices may also increase future housing costs. However, given that we model short/medium

may boost the value of defined contribution pension schemes that rely on investment to create a future pension income stream. Moreover, lower interest rates can increase the present discounted value of pensions in payment and defined benefit schemes, as defined in the WAS. Finally, an increase in aggregate demand due to monetary easing may boost the nominal value of households goods and collectables that constitute physical wealth.

In order to investigate the importance of these channels, we re-estimate the benchmark FAVAR but replace $\frac{\bar{P}_{80}}{\bar{P}_{20}}$, $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ with measures that *exclude* one component of wealth. In other words, we group households in each month into the wealth intervals used to define the groups $\bar{P}_{20}, \bar{P}_{50}$ and $\bar{P}_{80}$. We then construct a 'counterfactual' measure of average wealth in each interval which excludes net housing wealth, pension wealth, physical wealth and net financial wealth, respectively. These measures are used to construct the ratios $\tilde{P}_{\frac{80}{20}}, \tilde{P}_{\frac{80}{50}}$ and $\tilde{P}_{\frac{50}{20}}$. The group $\tilde{P}_{\frac{80}{20}}$ denotes the ratio of this counterfactual wealth measure in the intervals given by the 75th to 85th percentile and 15th to 25th percentile of total wealth. $\tilde{P}_{\frac{80}{50}}$ denotes the ratio of this counterfactual wealth measure in the intervals given by the 75th to 85th percentile and 45th to 55th percentile of total wealth. Similarly, $\tilde{P}_{\frac{50}{20}}$ denotes the ratio in the intervals given by the 45th to 55th percentile and 15th to 25th percentile of total wealth.

Note that this experiment differs from the counterfactuals presented in studies such as Bunn *et al.* (2018). Bunn *et al.* (2018) compare inequality measures based on the actual wealth data in the WAS with those obtained using counterfactual estimates of wealth under the assumption that monetary policy was held fixed over the sample period. Their counterfactual scenario involves assumptions regarding the effect of monetary policy on components of wealth. In contrast, these dynamic relationships are estimated in our FAVAR model. Second, unlike Bunn *et al.* (2018), we do not make assumptions regarding the effect of monetary policy but use the composition of wealth available in the WAS to alter wealth data in each percentile group in order to infer the source of the transmission of the shock. Third, the results in Bunn *et al.* (2018) pertain to wealth data over the period 2012-2014, considered jointly. In contrast, our use of monthly data enables us to take into account changes in wealth that occur over the short and medium horizon. Given large changes in asset prices over the sample period, it is likely that such changes played an important part in driving relative changes in wealth.[11]

run dynamics in the FAVAR model, this effect may not be visible in the impulse responses. In their simulations, Bunn *et al.* (2018) show that future housing costs erode wealth gains by younger households. However, they caution that future housing costs are hard to calibrate accurately.

[11] The experiment also differs from the counterfactual impulse response analysis used in Evgenidis and Fasianos (2020) where the response of some variables is set to zero by assuming the presence of additional shocks in the empirical model that impose the zero restrictions. As these shocks do not have a structural interpretation, it is not clear what economic scenario is depicted by the counterfactuals. Our approach relies on counterfactual inequality measures is not subject to this problem.

Each row of Figure 8 compares the response of $\frac{\bar{P}_{80}}{\bar{P}_{20}}$, $\frac{\bar{P}_{80}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ obtained from the benchmark model with that of counterfactual measures $\tilde{P}_{\frac{80}{20}}$, $\tilde{P}_{\frac{50}{20}}$ and $\tilde{P}_{\frac{80}{50}}$ where one component of wealth is removed. The top row of the figure shows that once net property wealth is removed, the impact of monetary expansion on the wealth of groups $\bar{P}_{80}$ and $\bar{P}_{50}$ relative to $\bar{P}_{20}$ declines substantially. As noted above, housing wealth at the right tail of the distribution is substantial relative to the 20th percentile and forms a significant proportion of total wealth for $\bar{P}_{80}$ and $\bar{P}_{50}$. Therefore it is not surprising that policy shocks that increase house prices lead to a rise in relative wealth for these groups. These estimates support the results reported in Bunn *et al.* (2018), which suggest that, in *cash terms,* richer households benefited substantially more from the housing wealth channel.[12] Bunn *et al.* (2018) also report that the benefit from housing wealth accruing to households in the second decile, as a proportion of their net wealth, was smaller than that enjoyed by households in the seventh and eighth decile. It is also interesting to compare our results with those obtained for the Euro-Area by Lenza and Slacalek (2018). These authors find that the impact of monetary policy on wealth inequality is negligible, with inequality falling marginally. They attribute this to the fact that net housing wealth is distributed homogeneously across the wealth distribution in Euro-Area countries. Similarly, Adam and Tzamourani (2016) find that house price increases benefit non wealthy households that are home owners. These two features are not present for the UK sample. As shown in Figure 7 the distribution of housing wealth is skewed towards the median and the right tail. In addition, households below the 20th percentile of wealth are overwhelmingly renters (see Figure 1). Given these differences, it is unsurprising that benefits of house price increases accrue to groups $\bar{P}_{80}$ and $\bar{P}_{50}$, relative to group $\bar{P}_{20}$.

When pension wealth is excluded from the inequality measures, the difference between the counterfactual responses and the benchmark is much less pronounced. The left panel in the second row of the figure suggests that pensions may play a role in the increase in $\frac{\bar{P}_{80}}{\bar{P}_{20}}$ after a monetary expansion. For the remaining measures, removing pension wealth has a limited impact.

The third row of the figure shows that the impact of policy shocks on physical wealth also appear to play a major role. When physical wealth is removed, the response of $\tilde{P}_{\frac{80}{20}}$ and $\tilde{P}_{\frac{50}{20}}$ rises substantially. These estimates are consistent with the fact that physical wealth forms the largest component of total wealth for households in the left tail of the distribution. A monetary expansion may increase the value of physical wealth of the households in group $\bar{P}_{20}$ thus ameliorating the rise in relative wealth at the right tail. Once this component is

[12] Note, however, that in proportion to their own total wealth the gains are smaller for the richer groups. Our estimates provide information regarding gains relative to group $\bar{P}_{20}$.

removed, the gap between the left tail of the wealth distribution and around the median and the right tail widens substantially more than the benchmark.

Net financial wealth appears to play a major role in transmission of the shock. Without this component, the rise in relative wealth at the right tail and around the median largely disappears. This is not surprising given the fact that the monetary expansion is associated with a substantial easing of financial conditions and a rise in asset prices. As shown in Figure 7, households near the median and the right tail hold substantially more financial wealth than households at the left tail and benefit more as a consequence. Similar results are reported for the Euro area by Adam and Tzamourani (2016) who find that increases in financial asset prices largely benefit wealthier households.

In Figure 9 we consider the same counterfactual experiment using the additional inequality measures $\frac{\bar{P}_{90}}{\bar{P}_{10}}$, $\frac{\bar{P}_{90}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{10}}$. The estimated response of $\frac{\tilde{P}_{90}}{\tilde{P}_{10}}$ and $\frac{\tilde{P}_{90}}{\tilde{P}_{50}}$is smaller than benchmark in the first row of the figure showing the role of housing wealth. However, the magnitude of the decline is substantially smaller than in the case of the benchmark inequality measures shown in Figure 8. This suggests that housing plays a smaller role in the transmission of monetary policy shocks to the relative wealth of very wealthy households. This is not surprising as housing wealth as a proportion of total wealth is smaller for households around the 90th percentile. In contrast, the second row of the figure shows that pension wealth plays a larger role for the measure $\frac{\bar{P}_{90}}{\bar{P}_{10}}$. As physical wealth constitutes the bulk of the wealth of households around the 10th percentile, removing this component inflates the response of the inequality measures $\frac{\bar{P}_{90}}{\bar{P}_{10}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{10}}$ substantially (see third row of Figure 9). The last row of the figure again highlights the importance of financial wealth in transmitting the policy shock to the wealth of households around the 90th percentile. Relative to group $\bar{P}_{10}$, households near the median also benefit substantially from this channel.

In summary, this counterfactual analysis suggests that net financial wealth and net property wealth are key factors in the transmission of monetary expansions into higher wealth inequality. Property wealth benefits households near the median and near the 80th percentile relative to those on the left tail of the distribution. Financial wealth appears to be a key driver of wealth of households that lie on or above the 80th percentile. In contrast, physical wealth acts as ameliorating influence and reduces inequality by increasing the wealth of households on the left tail of the distribution.

4.3 Contribution of monetary policy shocks

To investigate the historical importance of the monetary policy shock we conduct a counterfactual experiment. For each iteration of the Gibbs sampler we simulate data for the wealth inequality measures from the FAVAR model assuming that only the identified monetary policy shock is non-zero. Figure 10 shows the data, the baseline or trend component implied by the FAVAR and the estimate of the series under the counterfactual scenario.[13] If only the policy shock was non-zero, then positive policy innovations in the early part of the sample would have driven down the inequality measures faster. This is especially the case for the $\frac{\bar{P}_{80}}{\bar{P}_{20}}$, $\frac{\bar{P}_{90}}{\bar{P}_{10}}$, $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{10}}$ measures. However, for about two years after 2009, policy innovations were, on average, estimated to be negative reflecting the response to the financial crisis. The counterfactual estimates of inequality lie above the actual data over the years 2009 to the end of 2011. A comparison of the counterfactual with the trend component indicates that a part of this movement was driven by the monetary policy innovations, especially for the $\frac{\bar{P}_{90}}{\bar{P}_{10}}$, $\frac{\bar{P}_{90}}{\bar{P}_{50}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{10}}$ measures.

In Figure 11, we show that contribution of the policy shock to the forecast error variance (FEV) of the inequality measures. The shock makes a contribution of about forty percent to the FEV of $\frac{\bar{P}_{90}}{\bar{P}_{10}}$ and $\frac{\bar{P}_{80}}{\bar{P}_{20}}$. It is interesting to note that the contribution is larger for the FEV of $\frac{\bar{P}_{50}}{\bar{P}_{10}}$ and $\frac{\bar{P}_{50}}{\bar{P}_{20}}$ when compared to the measures related to wealth above the median.

4.3.1 Robustness

Gini Coefficient In this section we show the response of the wealth Gini coefficient to monetary policy shocks. As shown in the technical appendix (see Figure 5), the level and the evolution of the Gini coefficient over time is very sensitive to assumptions regarding outliers. As a consequence, we do not use the Gini as the benchmark inequality measure. Nevertheless, the key results reported above are confirmed when we include the Gini in the benchmark FAVAR model. The top panel of Figure 12 shows the response of the Gini coefficient to an expansionary monetary policy shock. The Gini coefficient increases by about 7 percent with the response persisting for 2 years.[14] This result is in contrast to Bunn *et al.* (2018) who report a fall in the Gini coefficient in response to a policy expansion. However, Bunn *et al.* (2018) analyse the Gini coefficient calculated using wealth data for the period 2012-2014, jointly. In other words, their analysis does not take into account the possibility of higher frequency changes in the Gini. This may mean that their estimates do not account for the short and medium run impact of monetary policy through asset price fluctuations.

In the bottom panel of Figure 12, we consider the role of house prices and financial conditions in transmitting the policy shock. This counterfactual analysis is carried out by

[13] The simulated data under the counterfactual scenario include the contribution of the trend component. Therefore, the deviation of the simulated data from the trend component is the contribution of the monetary policy shock.

[14] In units of the Gini this implies an increase of about 0.04.

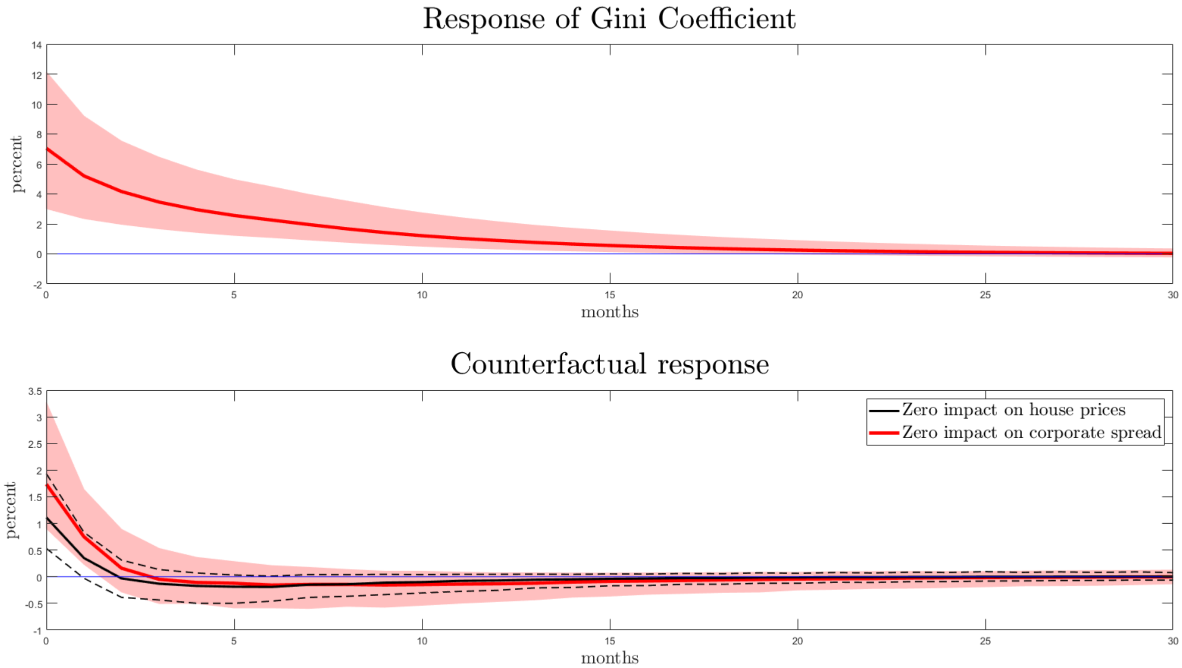

Figure 12: Response of the Gini coefficient to an expansionary monetary policy shock

solving for shocks in the transition equation of the FAVAR in order to impose the following restrictions: (i) the counterfactual response of the policy rate should equal the actual estimate and (ii) the response of house prices and corporate bond spreads, respectively, equals zero over the entire horizon. These conditions proxy the counterfactual scenario where monetary policy does not affect house prices or financial conditions, with the bond spread used as a proxy for the latter.[15]The counterfactual impulse responses of the Gini are noticeably smaller in magnitude, confirming the importance of these channels in the transmission of policy shocks.

Identification and model specification We carry out a number of further checks to test the robustness of the main results. The results of this analysis are reported in the technical appendix. First we check if using inequality measures calculated at a quarterly frequency changes the main results. Using an extending version of the FAVAR model that allows for mixed-frequency data, we find results very similar to the benchmark case (see Figure 2 in the appendix). The benchmark results are also robust with respect to the

[15]While in the case of the percentile ratios it is possible to carry out the counterfactual by removing wealth components from the data, this method does not apply to the Gini coefficient. In the former case, the selection of households in each percentile group is based on total wealth and can be kept fixed in the actual and counterfactual scenaria. In the case of the Gini coefficient, however, changing the wealth data would imply a different distribution of the households in the counterfactual case.

identification scheme. Figure 2 in the appendix shows the impulse responses from the model when the instrument proposed by Cesa-Bianchi *et al.* (2020) is used to identify the monetary policy shock. As in Gerko and Rey (2017), Cesa-Bianchi *et al.* (2020) also consider high frequency changes in Sterling futures. However, their instrument is based on changes in the future rates around MPC meetings. The figure shows that the response of the wealth inequality measures supports the benchmark results. We also consider a FAVAR model where we use a recursive identification scheme. In particular, in this alternative model, the five year rate is replaced by the shadow rate constructed by Wu and Xia (2016). Following Bernanke *et al.* (2005), the policy shock is identified via a recursive ordering under which this disturbance has no contemporaneous impact on slow moving variables (e.g. industrial production) but affects fast moving variables such as asset prices immediately. The last row of Figure 2 shows that the response of the inequality measures to a reduction in the shadow rate is positive, albeit more sluggish than the benchmark case. The bottom right panel of the figure suggests that, as with the IV identification scheme, the impact of the shock is largest below the median. A FAVAR model with the number of factors set to 7 also produce results that are similar to the benchmark case.

5 Conclusions

This paper considers the impact of monetary policy on the distribution of wealth over the last two decades. The estimated impulse responses from a FAVAR model suggest that a monetary expansion is associated with an increase in wealth inequality. The increase is largely driven by an increase in wealth at the median relative to the left tail of the distribution. An exploration of the components of total wealth indicates that the transmission of the monetary policy shock occurs via net property wealth and net financial wealth.

From a policy perspective, these results highlight the importance of the impact of monetary policy on the housing and financial markets. With Brexit instigating a downturn in house and stock prices, the impact of this shock and the monetary policy response may have strong distributional consequences. In future work, it may be useful to investigate if shifts in the wealth and/or income distribution have an impact on the aggregate UK economy and if such structural changes alter the transmission of policy shocks.

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