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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Does monetary policy affect income inequality in the euro area?*

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Abstract

This paper examines how monetary policy affects income inequality in 10 euro area countries over the period 1999–2014. We distinguish macroeconomic and financial channels through which monetary policy may have distributional effects. The macroeconomic channel is captured by wages and employment, while the financial channel by asset prices and returns. We find that expansionary monetary policy in the euro area reduces income inequality, especially in the periphery countries. The macroeconomic channel leads to these equalizing effects: monetary easing reduces income inequality by raising wages and employment. However, there is some indication that the financial channel may weaken the equalizing effect of expansionary monetary policy.

Keywords: income inequality, monetary policy, euro area

JEL Classification: D63, E50, E52

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1 Introduction

Recent decades have witnessed rising wealth and income inequality in advanced countries (Piketty, 2014; OECD, 2015) with possibly serious repercussions. Greater inequality worsens the efficiency of resource allocation, constrains aggregate demand and output growth, and depresses consumption and investment (Onaran et al., 2011; Berg et al., 2018; Madsen et al., 2018). More uneven income distribution may also lead to higher household indebtedness, fuel asset market bubbles, and increase financial instability (Coibion et al., 2014; Kumhof et al., 2015; Perugini et al., 2016).

Against this background, distributional effects of monetary policy have been of increasing concern among policy-makers (e.g., Bernanke, 2015; Draghi, 2015). The empirical literature on the impact of monetary policy on income inequality yields mixed conclusions.[1] While some studies find that contractionary monetary policy increases income inequality (Coibion et al., 2017; Mumtaz and Theophilopoulou, 2017; Furceri et al., 2018), others report the opposite (Cloyne et al., 2016; Inui et al., 2017). Some evidence shows that unconventional, accommodative monetary policy reduced income inequality in the U.S. (Montecino and Epstein, 2015), Italy (Casiraghi et al., 2018) and the euro area (Lenza and Slačálek, 2018). However, Saiki and Frost (2014) find that quantitative easing increased income inequality in Japan, while Inui et al. (2017) report insignificant effects for that country.

The evidence for the euro area remains scant: to our knowledge, two studies examine the impact of ECB's conventional (Guerello, 2018) and unconventional monetary policy on income inequality (Lenza and Slačálek, 2018). Two important issues arise in analyzing this topic. The first one concerns the identification of a euro area monetary policy shock. The second involves testing specific channels through which monetary policy impacts income inequality. This paper offers contributions on both aspects.

We investigate how expansionary monetary policy affects income inequality in 10 euro area countries over the period 1999–2014.[2] We do so by estimating a panel VARX model with an exogenous euro area monetary policy shock identified by a Proxy-SVAR

[1] See Deutsche Bundesbank (2016) and Colciago et al. (2018) for surveys of the literature.
[2] The time span of analysis ends in 2014 due to data availability on income inequality.

framework. We distinguish two distributional channels – macroeconomic and financial – through which monetary easing may have opposite effects on income inequality. Monetary expansion stimulates output, job creation, and wage growth, benefiting low- and middle-income households and reducing income inequality. At the same time, lower interest rates lead to higher asset prices and capital returns; this may increase income inequality by making rich households better off.

We capture the macroeconomic channel by wages and employment, while the financial channel by asset prices and returns. To examine these channels, we analyze PVARX impulse responses of income inequality and channel variables to an expansionary monetary policy shock. As the data on income inequality are annual while all other variables are quarterly, we apply mixed-frequency data techniques.

Our findings suggest that expansionary monetary policy in the euro area reduces income inequality. This outcome is most evident for the periphery countries. The macroeconomic channel enhances the equalizing effects: monetary expansion reduces income inequality stronger through raising wages and employment. The evidence for the financial channel is less clear. There is some indication that higher asset prices and returns due to monetary easing may weaken the equalizing effect of an expansionary monetary policy shock. Our results are robust to different model specifications and identification approaches of a monetary policy shock.

The rest of the paper is organized as follows. Section 2 discusses how monetary policy may impact income inequality based on the theoretical literature. Sections 3 and 4 present the data and methodology, respectively. Section 5 provides the empirical results, extensions, and robustness checks. Section 6 concludes.

2 Impact of monetary policy on income inequality: literature review

Based on the recent theoretical literature on distributional effects of monetary policy (Gornemann et al., 2016; Auclert, 2017; Kaplan et al., 2018; Luetticke, 2018), Ampudia et al. (2018) decompose the monetary policy transmission on inequality into direct and indirect effects. Direct effects operate through partial-equilibrium consequences of a change in a policy rate on households' incentives to save and borrow as well as their net financial income and debt, holding their employment, prices and wages fixed.

A direct effect of expansionary monetary policy on households' income may vary across households depending on their asset holdings. Lower policy rates reduce interest incomes from deposits and other interest-bearing assets. This makes high-income households worse off as a large share of their income comes from financial assets and deposit savings. Middle- and low-income households with no financial assets are not directly affected by this policy change as far as their income is concerned.[3] As a result, a cut in interest rates may reduce income inequality.

Indirect effects arise as a result of the general equilibrium responses of prices, wages, output and employment to a change in monetary policy. A cut in a policy rate triggers changes in households' spending and firms' investment, leading to an increase in output, employment and wages (Ampudia et al., 2018). Indirect effects can be heterogeneous across households depending on their income sources and earnings status. In this context, the literature distinguishes two distributional channels of monetary policy: *earnings heterogeneity* and *income composition*.

The *income composition* effect reflects heterogeneity in households' primary income sources (Gornemann et al., 2016; Coibion et al., 2017; Luetticke, 2018). Income sources include labor income (wages and salaries), capital (financial) income, business income, and transfer income. Low-income households typically rely more on transfers, whereas middle-income households rely on labor earnings, and high-income ones – on capital and business income. Expansionary monetary policy may increase income inequality by raising capital income and profits more than labor earnings as the former are concentrated among households at the top end of the income distribution.

The *earnings heterogeneity* effect implies that labor earnings along the income distribution react differently to monetary policy changes (Areosa and Areosa, 2016; Coibion et al., 2017). These earnings tend to vary across households depending on their skills

[3]Note that while savers lose from lower interest rates, households with net outstanding debt benefit from reduced interest payments (Ampudia et al., 2018). The latter does not affect the gross income of borrowers but rather their wealth and liabilities.

and productivity. A policy rate cut may raise labor earnings which benefits low- and middle-income households relatively more than high-income ones, reducing income inequality (Auclert, 2017).

This paper focuses on the indirect effects of expansionary monetary policy on income inequality and explores two channels producing these effects – macroeconomic and financial. We refer to the concepts of income composition and earnings heterogeneity to describe the mechanisms behind these channels. Figure 1 illustrates our framework.

Figure 1: **Monetary policy impact on income inequality: transmission channels**

Expansionary monetary policy shock (↓ policy rate) →

Direct effects (partial-equilibrium):
↓ interest-bearing income ⇒ ↓ income inequality

Indirect effects (general-equilibrium):
Macroeconomic channel: ↑ Y, I, employment, wages ⇒ ↓ income inequality
Financial channel: ↑ asset prices ⇒ ↑ capital returns ⇒ ↑ income inequality

The macroeconomic channel arises from the general equilibrium effects of monetary policy on output, labor demand, and income (see e.g., Cloyne et al., 2016; Auclert, 2017; Kaplan et al., 2018; Sterk and Tenreyro, 2018). A decrease in an interest rate reduces real debt and costs of financing which stimulates consumption of durables, aggregate demand, and productive investment. Higher goods prices and lower capital costs encourage firms to increase production and employment and put upward pressure on wages. This benefits the working and middle classes which rely on labor earnings as their main income source. Households at the top end of the income distribution are affected less as their total income is less sensitive to wage changes (Gornemann et al., 2016; Coibion et al., 2017). As a result, monetary easing raises labor earnings and lowers income inequality. This has been found by studies on distributional effects of conventional (Coibion et al., 2017; Mumtaz and Theophilopoulou, 2017) and unconventional monetary policy (Casiraghi et al., 2018; Lenza and Slačálek, 2018).

However, expansionary monetary policy may also lead to higher income inequality, as was found by Cloyne et al. (2016) and Inui et al. (2017). Inui et al. (2017) infer that this could be due to labor market rigidities and nominal wage stickiness, which lead to a structural dispersion of wages across workers and result in rising earnings inequality. A different explanation is given by Dolado et al. (2018) who develop a Two Agents New Keynesian (TANK) model with capital-skill complementarity and find that an unexpected monetary easing increases labor earnings inequality by raising wages for high-skilled workers more than for low-skilled ones. Thus, the distributional impact of macroeconomic channel may depend on labor market conditions and households heterogeneity along various dimensions.

The financial channel may add to the indirect effects of monetary policy on income inequality. On the one hand, rising asset prices due to monetary easing increase the net worth of firms issuing equity or owning stocks and reduce the costs of financing capital, which encourages firms to invest (Mishkin, 2001). This boosts economic activity and reduces income disparities if firms raise employment and wages in all sectors. On the other hand, assets prices – in particular, equity – may escalate inequality. Higher equity prices result in larger capital gains on financial intermediaries' and firms' balance sheets; thanks to higher profits they can increase bonuses and dividend payments (Brunnermeier and Sannikov, 2012; O'Farrell et al., 2016). This benefits high-income households as they hold most financial assets. Thus, an increase in capital income of the rich could raise income inequality. This result is documented for the effects of quantitative easing in Japan (Saiki and Frost, 2014), the U.K. (Mumtaz and Theophilopoulou, 2017) and the U.S. (Montecino and Epstein, 2015)

To sum up, monetary expansion may reduce income inequality indirectly by stimulating economic activity (macroeconomic channel). This equalizing effect may be counteracted by the financial channel via an increase in capital incomes. We test these conjectures by analyzing the distributional effects of expansionary monetary policy in the euro area.

3 Data

Our analysis focuses on 10 euro area economies over 1999Q1–2014Q4. Countries include Austria, Belgium, France, Finland, Germany, Greece, Italy, the Netherlands, Portugal, and Spain.[4] The data before 1999Q1 are not analyzed due to the presence of a structural break: monetary policy reaction functions and structural characteristics of countries before 1999 are different from those after they became EMU members.

The literature on distributional effects of monetary policy faces challenges related to measuring inequality. Conventionally, income inequality measures are constructed from household surveys which provide comprehensive data on households' income composition over a long period. Surveys have been used by several studies on the impact of monetary policy on income inequality (e.g., Coibion et al. (2017) for the U.S.; Mumtaz and Theophilopoulou (2017) for the U.K.; Inui et al. (2017) for Japan; and Casiraghi et al. (2018) for Italy). For EMU countries household surveys are available mainly at an annual frequency and often only for a few years. Granular data on income and wealth distribution in the EU are collected by the Household Finance and Consumption Survey (henceforth HFCS), consisting of two waves so far. Lenza and Slačálek (2018) use it to evaluate the impact of quantitative easing on the income distribution in the four largest euro area countries. This database offers only two time observations, making it unsuitable for a dynamic analysis. Guerello (2018) follows a different approach by computing income dispersion based on qualitative answers from the monthly Consumer Survey of the European Commission to a question concerning a change of a households financial situation over the last 3 months. This measure may reflect subjective perceptions of households which may not accurately capture the income distribution.

To deal with the data issues, we use annual income inequality measures and apply a mixed-frequency technique to convert them into quarterly observations (see Section 4 for details). We proxy income inequality with the Gini coefficient from the Standardized World Income Inequality Database (henceforth SWIID) (Solt, 2016). The SWIID is the most comprehensive database and allows cross-country comparison as it standardizes income (De Haan and Sturm, 2017).[5] The Gini coefficient measures the extent to

[4]Ireland and Luxembourg are excluded due to data limitations. We do not include the 'new' EMU countries as they adopted the euro much later.

[5]One criticism of the SWIID is that it uses many distinct sources and applies multiple-imputation methods to fill in missing values. This raises concerns about reliability of the imputed data, especially

which an income distribution among individuals differs from a perfectly even distribution and ranges from 0 (perfect equality) to 100 (perfect inequality). We take the Gini of equivalized household market (pre-tax, pre-transfer) income, i.e. income before redistribution via fiscal policy. The advantage of using the Gini coefficient compared to measures based on household surveys is that the former represents the entire income distribution while surveys tend to under-sample the tails of it, especially top incomes (Ruiz and Woloszko, 2015).[6] As an extension, we will use gross labor earnings inequality that excludes incomes from capital and transfers (see section 5.3.).

We also include quarterly macroeconomic, monetary, and financial variables.[7] We use the aggregate euro area (EA) data to identify EA monetary policy shocks and country-level data to examine the effects of these shocks on income inequality across EA countries. Aggregate EA variables include real GDP, headline HICP, and additional covariates for alternative identification schemes (real effect exchange rate). We employ the shadow rate for EA from Krippner (2015) as a proxy for monetary policy stance, in order to capture unconventional measures adopted by the ECB during the period of effective lower bound on a policy rate. Country-level variables include real GDP, headline HICP, wages (gross hourly earnings), and stock prices. All macroeconomic, financial, and income inequality variables are transformed into log-levels in estimations, while the shadow rate is used as it is.

3.1 Historical trends in income composition and inequality

Figure 2 displays the scatter plot of the average Gini coefficients of income inequality in 10 EA countries and corresponding means of GDP per capita, capturing the level of economic development. Means are computed for the whole sample period 1999–

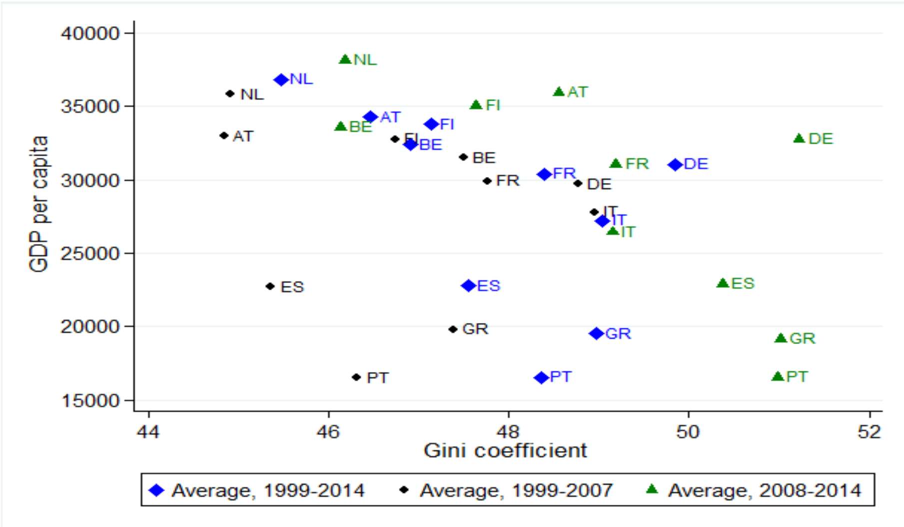
for countries which provide fewer actual observations (Jenkins, 2015; Solt, 2016). Despite this drawback, the SWIID is largely consistent with the actual surveys on which it is based (Galbraith et al., 2015). In addition, in our sample of EA countries the percentage of imputed missing values was only 5-10%.

[6]We are aware that the Gini coefficient has also drawbacks. It may exhibit low variability and it puts the same weight to income differences close to the median as at the tails of the income distribution (Atkinson, 1970). Other measures of inequality may be more appropriate, such as the share of income of the lowest/highest quintile or the 90/10 percentile ratio. These measures, however, are available for EA countries from the EU-SILC database from 2003 and are based on disposable income, i.e. after redistribution. For these reasons we choose to work with the Gini coefficients.

[7]See Table A.1 in Appendix for details on data construction and sources.

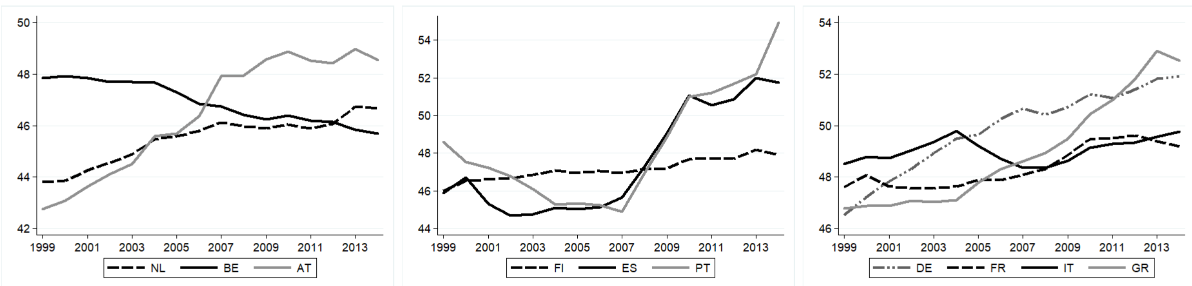
2014 as well as for pre-crisis (1999–2007) and post-crisis (2008–2014) periods. There is substantial heterogeneity in inequality levels across the euro area. Most of the core economies are characterized by lower Gini coefficients compared to the periphery ones, in line with the Kuznets curve theory. The least unequal in gross incomes are the Netherlands, Austria, and Belgium, which are also the richest among EA countries in terms of their GDP per capita. The largest income disparities are observed in Southern Europe and Germany. The latter is a surprising fact suggesting that German gross incomes have been very unequal, even before the GFC.

Figure 2: **Income inequality and GDP per capita in EA countries**



Notes: Own calculations. GDP per capita is in euros, chain linked volumes (2010) from Eurostat. Gini market is from SWIID.

Figure 3: **Development of income inequality in EA economies, 1999–2014**



Notes: Own calculations based on SWIID. Countries are grouped into three categories, shown in separate graphs, based on their average Gini coefficient over 1999–2014, namely: i) low income inequality (Austria, Belgium, the Netherlands); ii) median income inequality (Finland, Portugal, Spain); and iii) high income inequality (France, Germany, Greece, Italy).

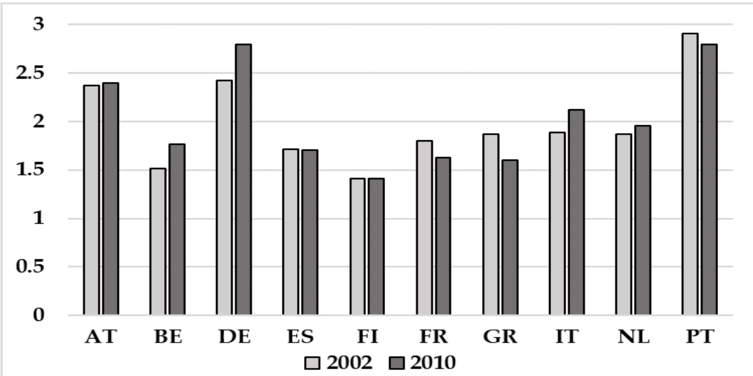
Income inequality in the euro area has been on the rise in recent decades, as illustrated in Figure 3. Gini coefficients increased over 1999–2014 in most countries with a substantial rise observed in Austria, Germany, Greece, Portugal, and Spain. The exception is Belgium where income inequality declined somewhat. There was an upward shift in income inequality after 2007, particularly evident in Southern European countries. This could be related to the GFC and the subsequent sovereign debt crisis in the euro area, which caused a recession and worsened economic situation of households.

Figure 4: **Growth rates of Gini coefficients, wages, and stock prices in EA countries**

1999–2014 1999–2007 2007–2014

Notes: Own calculations. The graphs illustrate growth rates (in %) of Gini coefficients, wages, and stock prices between 1999 and 2014; 1999 and 2007; 2007 and 2014, respectively. The left vertical axis shows the percentage growth rate of Gini coefficients, while the right vertical axis the percentage growth rate of wages and stock prices.

Figure 5: **Wage skill premiums in EA countries in 2002 and 2010**



Notes: Own calculation based on The World Indicators of Skills for Employment database, OECD.

Next, we compare changes in income inequality within countries to changes in wages and stock prices in the same periods (Figure 4). Large increases in Gini coefficients between 1999 and 2014 coincided with the asset prices boom observed in most EA countries before the crisis. The stock market crash in the following years did not reverse the inequality growth trend. Wages have been rising throughout the whole sample period, except in Greece and Portugal where wages dropped after 2010. At the same time, the wage skill premium (defined as the ratio between mean hourly earnings of high-skilled and low-skilled workers) has increased noticeably only in Germany and slightly in Belgium and the Netherlands between 2002 and 2010 (Figure 5).[8]

[8]The rising wage skill premium due to a skill-based technological change is considered to be one of

Changes in wages and stock prices have different implications for income inequality depending on the distribution of incomes across the population. Using the data from the HFCS (wave 1) we compute income shares as % of gross total, labor, financial, and transfer incomes for different quintiles of the income distribution in EA countries (see Figure A.1 in Appendix). The graph shows that in most countries over half of total and labor income is concentrated among households at the top 20% of the income distribution. This is especially evident in Southern Europe. Up to 90% of income from financial investments benefits the upper tail of the income distribution. In the euro area, financial assets are concentrated among high-income households (Denk and Cazenave-Lacroutz, 2015; Adam and Tzamourani, 2016). In particular, a high percentage of households in the top 10-20% holds equity shares (see Figure A.2).[9] Transfer income is concentrated among the bottom 40% of households.

Based on these stylized facts we infer that expansionary monetary policy in the euro area may benefit low- and middle-income households by raising labor earnings and high-income households by boosting asset prices and returns. The total effect of monetary policy would depend on the relative strength of different channels.

4 Methodology

4.1 Dealing with mixed frequency data

Before turning to the empirical analysis, we address a mixed frequency data problem: Gini coeffficients are sampled annually, while macroeconomic, financial, and monetary variables are quarterly. To solve this problem, we follow an approach that uses a state-space representation of a VAR model, where a low-frequency variable is treated as a high-frequency one with missing observations. To estimate missing observations, the Kalman filter is applied (Harvey and Pierse, 1984). According to Bai et al. (2013), the Kalman filter produces accurate forecasts and is an optimal filter if the state-space

the main factors behind growing income inequality in recent decades (Jaumotte et al., 2013; Dolado et al., 2018). Due to the lack of high frequency longitudinal data on earnings by skills level for EA countries, we cannot incorporate this aspect in the current analysis.

[9] Denk and Cazenave-Lacroutz (2015) find that two-thirds of all stocks in the euro area are owned by the top 20%, while less than 10% of households in the bottom of the income distribution invest in stocks.

model is correctly specified and parameters are known. The Kalman filtering approach is similar to mixed frequency VAR (MF-VAR) models when missing data occur at regular frequency (Eraker et al., 2015). Unlike MF-VAR based on Bayesian inference, it can be estimated by maximum likelihood.[10]

The country-level VAR model used for the Kalman filter is defined as:

$$Y_t = C + \sum_{j=1}^{p} A_j Y_{t-j} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \Sigma_\varepsilon) \tag{1}$$

where Y_t is a matrix of endogenous variables, $Y_t = [X_t, Z_t]$. X_t is a matrix of observed quarterly data for country-level GDP, HICP, wages, and stock prices. Z_t denotes unobserved quarterly data for Gini coefficients; it is a vector of annual series treated as quarterly series with missing observations. Z_t is constructed as follows: it is observed every fourth quarter of a year ($t_q = 4, 8, 12, ..., T_q$), to which we assign the annual value of a Gini coefficient; in remaining three quarters of a year ($t_q = 1, 2, 3, 5, 6, 7, .., T_{q-1}$) values are missing. All variables are included in VAR in log-levels with one lag.

The order of variables is irrelevant in this exercise as we are interested in imputing missing observations and not in identifying shocks. In fact, changing the order of variables does not alter the imputed values. Following notations of Eraker et al. (2015), the VAR model specified in equation (1) can be rewritten in a state-space form as:

$$\begin{bmatrix} X_t \\ Z_t \end{bmatrix} = \begin{bmatrix} C_x \\ C_z \end{bmatrix} + \begin{bmatrix} A_{xx} & A_{xz} \\ A_{zx} & A_{zz} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Z_{t-1} \end{bmatrix} + \begin{bmatrix} u_t \\ v_t \end{bmatrix} \tag{2}$$

If Z_t is observed, the observation equation is specified as

$$Y_t^{obs} = \begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} \begin{bmatrix} X_t \\ Z_t \end{bmatrix}. \tag{3}$$

If Z_t is not observed, the observation equation changes to

$$Y_t^{obs} = \begin{bmatrix} I & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} X_t \\ Z_t \end{bmatrix}. \tag{4}$$

[10] An alternative approach uses MIxed DAta Sampling (MIDAS) models, extended for VAR systems by Ghysels (2016), where a low-frequency variable is regressed onto high-frequency ones using parsimonious distributed lags. This technique cannot be applied for a large set of variables due to a significant computational burden (Foroni and Marcellino, 2013). Moreover, it focuses on forecasting a coarsely observed variable and discards lots of information contained in high frequency data.

Given that the missing data occur at regular frequencies (annual and quarterly), the observation equation shifts between (3) and (4) systematically. Using this algortihm, we run the Kalman filter for each country and interpolate unobserved quarterly values of the Gini coefficient in Z_t based on the observations of X_t.[11]

4.2 PVARX model

When analyzing the monetary policy transmission in the euro area we take into account that EA countries do not conduct independent monetary policies. A common monetary policy for all eurozone members is implemented by the ECB. It is therefore designed to respond to EA-wide economic indicators rather than to individual countries' dynamics. This has two implications for our study. First, a common EA monetary policy shock is identified using aggregate euro area variables. Second, the identified shock is included in an empirical analysis as exogenous.

A suitable econometric approach entails estimating a PVARX model for a panel of 10 euro area countries.[12] The baseline PVARX has the following reduced form:

$$Y_t = \sum_{j=1}^{p} C_j Y_{t-j} + \sum_{j=1}^{g} D_j X_{t-j} + e_t, \quad e_t \sim \mathcal{N}(0, \Sigma_e) \tag{5}$$

where Y_t is a matrix of endogenous country-specific variables. X_t is an exogenous monetary policy shock identified from the euro area Proxy-SVAR model (see section 4.3.); p is a lag length for endogenous variables, g for exogenous variables. The endogenous variables are included with a first lag while the exogenous monetary policy shock is included contemporaneously and with first two lags as in the literature on narrative monetary policy shocks.[13] The endogenous variables are included in log-levels to avoid the loss of information.[14]

In order to estimate the PVARX model we follow the approach proposed by Pesaran and Smith (1995), which offers a standard technique to estimate panel VAR models in

[11] We use a Matlab toolbox by Casals et al. (2016) for state-space estimation of econometric models.

[12] We also estimate country VARX models to account for country heterogeneity (see section 5.4.).

[13] As a robustness check, we experiment with different lag length of endogenous/exogenous variables.

[14] According to Sims (1980), even if variables are non-stationary, a VAR model in log-levels will produce consistent estimates. As a robustness check, we re-estimated PVARX models with all endogenous variables, except for Gini coefficients, included in first differences. This did not affect our outcomes.

a non-Bayesian way. As shown by these authors, in a standard maximum likelihood framework this estimation method yields consistent estimates. Confidence intervals for impulse responses based on the PVARX model are constructed by the bootstrapping method which helps to reduce sampling errors caused by the generated data.

4.3 Monetary policy shocks

4.3.1 Benchmark identification

In the benchmark model we identify EA monetary policy shocks via the application of Proxy-SVAR (see e.g., Mertens and Ravn, 2013; Gertler and Karadi, 2015; Stock and Watson, 2018) where we use monetary policy surprises from Jarocinski and Karadi (2018) as a proxy.[15] This method does not require a perfect correlation between the proxy and the latent structural shocks and is robust to potential measurement errors. Below, we briefly describe this methodology. Consider a SVAR model as follows:

$$A_0 Y_t^{EA} = \sum_{i=1}^{q} B_i Y_{t-i}^{EA} + \varepsilon_t^{EA} \tag{6}$$

where q is the lag length, Y_t^{EA} is a vector of endogenous variables consisting of euro area GDP, HICP and a shadow interest rate: $Y_t^{EA} = [i_t^{EA},\ GDP_t^{EA},\ HICP_t^{EA}]'$. B_i is a 3×3 matrix of parameters capturing lagged relationships between endogenous variables, A_0 is a 3×3 matrix of parameters capturing contemporaneous relationships between endogenous variables, and ε_t^{EA} is a 3×1 vector of structural shocks with Gaussian distribution of mean 0 and identity covariance matrix.[16]

The reduced-form representation implied by the structural model (6) is:

$$Y_t^{EA} = \sum_{i=1}^{q} F_i Y_{t-i}^{EA} + B_0 \varepsilon_t^{EA}, \tag{7}$$

where $B_0 = A_0^{-1}$, $F_i = B_0 B_i$ and $u_t^{EA} = B_0 \varepsilon_t^{EA}$.

Our aim is to identify monetary policy shocks. To illustrate the procedure, we rewrite the relationship between the reduced-form innovations and the structural shocks as follows:

[15] In Jarocinski and Karadi (2018) monetary policy surprises are on a monthly frequency; we obtain a quarterly measure by averaging. We thank Marek Jarocinski and Peter Karadi for sharing the data.

[16] Deterministic terms are omitted from equation (6) for notational brevity.

$$u_{i,t}^{EA} = \eta u_{z,t}^{EA} + \Phi_1 \varepsilon_{i,t}^{EA} \tag{8}$$

$$u_{z,t}^{EA} = \xi u_{i,t}^{EA} + \Phi_2 \varepsilon_{z,t}^{EA} \tag{9}$$

where $u_{i,t}^{EA}$ and $\varepsilon_{i,t}^{EA}$ are a reduced-form innovation and a structural shock of the interest rate, respectively; $u_{z,t}^{EA}$ and $\varepsilon_{z,t}^{EA}$ represent reduced-form innovations and structural shocks of all other variables in the model. The estimation procedure is the following. First, we use monetary policy surprises as a proxy for $u_{i,t}^{EA}$ to estimate ξ in (9). Next, we use $(u_{z,t}^{EA} - \hat{\xi} u_{i,t}^{EA})$ as an instrument for $u_{z,t}^{EA}$ to estimate η in (8) and Φ_1. This results in the identification of $\varepsilon_{i,t}^{EA}$ with a variance of 1, which is the monetary policy shock in our analysis. Conditional on the values of η, ξ, and Φ_1 the first column of B_0 is calculated and the impulse responses to a monetary policy shock are obtained as:

$$B_0^{1st\_column} = \begin{bmatrix} \mathbf{I} + \eta(\mathbf{I} - \eta\xi)^{-1}\xi \\ (\mathbf{I} - \eta\xi)^{-1}\xi \end{bmatrix} \Phi_1. \tag{10}$$

4.3.2 Alternative identifications

In addition to the benchmark model with Proxy-SVAR identification, we consider two alternative identifications of monetary policy shocks: (i) by using sign restrictions and (ii) by estimating a Taylor rule for the euro area.

First, following Faust (1998), Canova and Nicolo (2002), Uhlig (2005), and Rubio-Ramirez et al. (2010), we use sign restrictions for identification of B_0 in equation (7). Particularly, we are interested in identifying a monetary policy shock and do so by assuming that monetary expansion leads to an increase in output and prices. Table 1 shows the sign restrictions we use for a positive demand shock, a positive supply shock, and a negative monetary shock, based on the literature.

Table 1: **Short-run responses to demand, supply and monetary policy shocks**

	Demand	Supply	Monetary policy
GDP	+	+	+
Price	+	-	+
Interest rate	+	-	-

Note: The table lists signs of reactions of endogenous variables (in the first columns) to a positive demand shock, a positive supply shock, and a negative monetary policy shock, respectively (in the first row).

Regarding the second alternative approach, we consider a Taylor-rule-based monetary policy (see Taylor, 1993; Clarida et al., 1998) in which an interest rate responds to a measure of economic activity – output growth in this case – and inflation in EA:[17]

$$i_t^{EA} = \rho i_{t-1}^{EA} + \beta_1 \pi_t^{EA} + \beta_2 y_t^{EA} + \varepsilon_{i,t}^{EA} \tag{11}$$

where y_t^{EA} is output growth, π_t^{EA} is inflation, i_t^{EA} is a short-term interest rate proxied by the shadow rate for the euro area. We estimate the contemporaneous Taylor-rule equation (11) by two-stages least squares where we include first two lags of interest rate, inflation, and output growth as instruments.[18] The residuals of the equation (11) are then considered as a measure of monetary policy shocks.

5 Empirical analysis

5.1 Euro area monetary policy shocks

We start by estimating Proxy-SVAR for the EA over 1999Q1–2014Q4 to identify a structural monetary policy shock. All the variables except for interest rate are included in log-levels. Figure A.3 in Appendix shows the impulse responses of EA output, prices, and a shadow rate to one standard deviation (14 basis points) negative monetary policy shock. Median responses are reported along with the 16th and 84th percentiles. The responses are consistent with theory and previous empirical evidence: a one standard deviation easing of monetary policy implies a peak increase of euro area GDP and prices of about 0.42 and 0.24 percent, respectively. These results suggest that a monetary policy shock is well identified. In addition, correlations between the principal components of monetary policy surprises and latent monetary policy shocks are about 0.5, indicating the relevance of policy surprises for identification of the shocks.

Figure A.4 plots the identified monetary policy shocks from Proxy-SVAR and from alternative approaches. As it can be seen, their dynamics are very similar. Table A.2 shows that the correlations between the shocks are high. The choice of using the Proxy-SVAR-based shocks as the benchmark is motivated by the advantages of Proxy-SVAR compared to other approaches: it does not require to impose prior beliefs on the sign

[17] An advantage of using output growth rather than output gap as a measure of economic activity is that it does not require an estimate of potential output which is challenging (Orphanides et al., 2000).

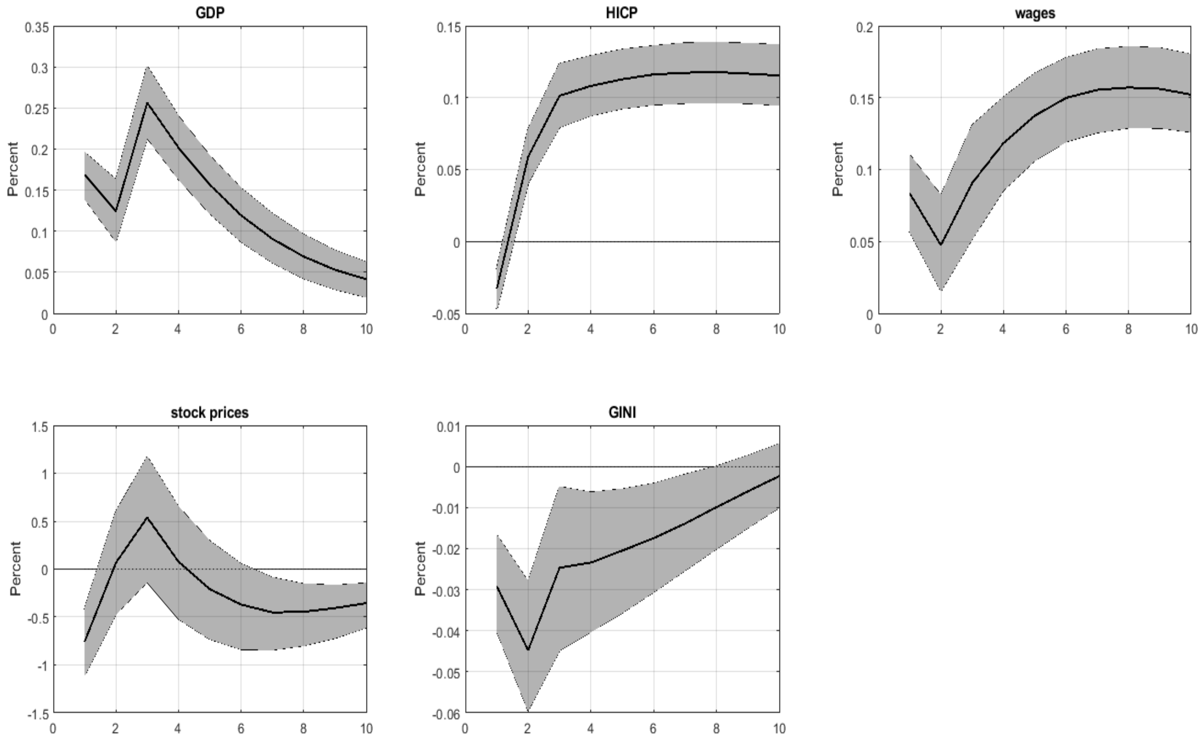
[18] Our results hold when we consider instead a forward-looking Taylor rule in which an interest rate responds to expected inflation (one and two quarters ahead), capturing the price stability objective of the ECB. Adding to the equation expected output growth does not change our outcomes either.

of responses or to specify a certain form of a monetary policy rule. Nevertheless, as we show below, using alternative measures leads to similar findings.

5.2 Baseline model

As a baseline, we estimate a PVARX model for 10 euro area countries over the period 1999Q1-2014Q4. Real GDP, HICP, wages, stock prices and Gini coefficients (all in log-levels) are included as endogenous variables and EA monetary policy shock is included as an exogenous variable. The impulse responses to a one standard deviation negative monetary policy shock are shown in Figure 6.

Figure 6: **Responses to an expansionary monetary policy shock, baseline PVARX**



Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and the Gini coefficient to one st.dev. negative monetary policy shock. The vertical axis shows the response in percent. The solid lines are median responses and the shaded areas represent 16th and 84th percentiles.

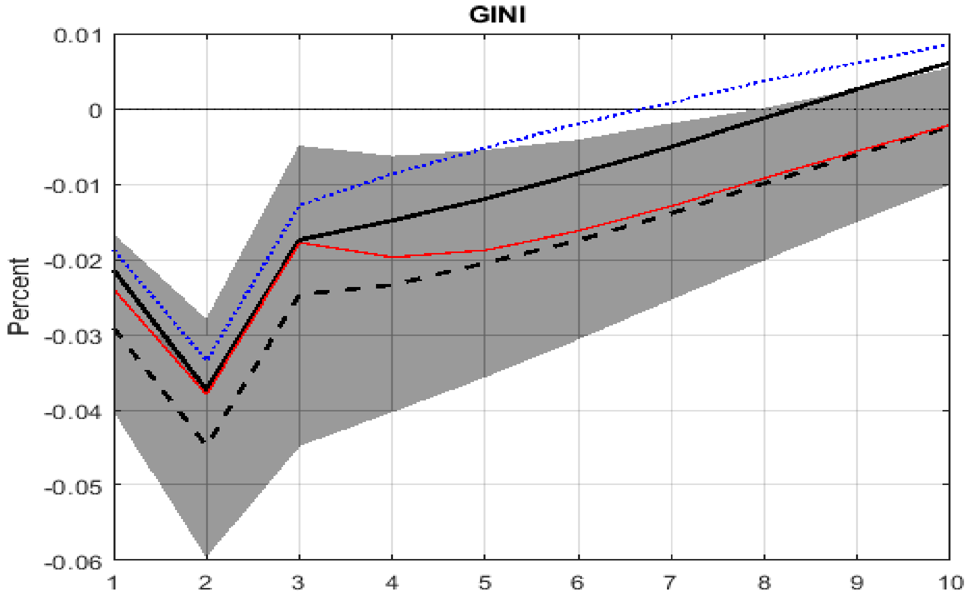
The responses of macroeconomic variables to monetary easing are in line with theory and empirical evidence: a one standard deviation negative monetary policy shock implies in our sample a peak increase of output and prices by 0.26 and 0.13 percent, respectively. GDP rises strongly immediately after the shock; this positive effect gradually dies out after 10 quarters. The opposite dynamics is observed for HICP – the increase in prices after an expansionary monetary shock is persistent and endures over a medium-run horizon.

Monetary policy has a significant effect on income inequality: a one standard deviation negative monetary policy shock (14 basis points) reduces the log of Gini coefficient by about -0.045 percent at the trough, two quarters after the shock. This response remains negative and significant for two years after the shock and diminishes in magnitude over time. In economic terms, the impact of a monetary policy shock is small. Based on the estimated responses, a one unit (100 basis points) negative monetary policy shock is estimated to decrease the log of Gini coefficient by -0.32 percent, which is equivalent to a reduction of Gini by -1.01 in original units (with the average Gini coefficient across the sample of 47.81 or 3.87 in log-level). To put numbers into perspective, the average change in the Gini coefficient for our sample of countries between 1999 and 2014 amounted to 9.1% or 4.35 in original units. Wages rise after the shock by 0.15 percent at the peak. This effect is persistent and long-lasting. Stock prices drop immediately after a shock and then increase in the third quarter by 0.5 percent.

These findings suggest that monetary policy significantly affects income inequality in the euro area. What would the effect of an expansionary monetary policy shock on income inequality have been if wages and stock prices had not reacted to the shock? That is, how do macroeconomic and financial channels contribute to the distributional effects of monetary policy? To answer this question, following the approach of Giuliodori (2005), we consider three counterfactual scenarios in which these channels do not enter the monetary policy transmission. First, we exclude the financial channel from the model. Second, we exclude the macroeconomic channel. Third, we exclude both channels.[19] Figure 7 shows the responses of the Gini coefficient to a negative monetary policy shock under counterfactual and baseline scenarios. The difference between the responses can be interpreted as an evidence of a propagating contribution of these channels in the monetary policy transmission to income inequality.

[19] Alternatively, we include wages and stock prices as exogenous variables assuming that they do not react to a monetary policy shock or other variables in the model. The results of this approach are similar to the one when these variables are excluded.

Figure 7: **Responses of Gini coefficient to an expansionary monetary policy shock, different model scenarios**



Notes: The figure plots median responses of the Gini coefficient to one st.dev. negative monetary policy shock in four model scenarios: i) the dashed black line – with wages and stock prices (baseline), the shaded area represents 16th and 84th percentiles; ii) the solid black line – without channels; iii) the solid red line – with wages; and iv) the dotted blue line – with stock prices.

The baseline model produces a stronger reduction in the Gini coefficient as compared to the model without both channels or with one channel (macro or financial). The contribution of the macroeconomic channel is supported by a significant and persistent increase in wages after an expansionary monetary shock. The contribution of the financial channel is less clear. There is some indication that higher stock prices weaken the response of the Gini coefficient to monetary easing, suggesting the disequalizing effect.

We test robustness of our baseline results to different identifications of a monetary policy shock, choices of lags, and the use of local projections.[20] First, we include in a PVARX model a monetary policy shock identified from SVAR with sign restrictions. The responses to a negative monetary shock are comparable to the baseline results (see Figure A.5 in Appendix), although output increases are weaker while stock prices drop over the entire horizon. The response of the Gini coefficient is similar to the baseline.[21]

[20]The results of all sensitivity checks are available on request.

[21]We also try other specification in SVAR. Following Mojon and Peersman (2003) we add an exogenous block of three variables: world commodity price index, U.S. real GDP, and U.S. shadow rate from Krippner (2015) as a proxy for a short-term interest rate. These variables may influence EA macroeconomic indicators and interest rates. We also include as an endogenous variable EA real effective exchange rate. The responses based on this identification are similar to the ones without these variables.

Second, we use a monetary policy shock identified via a Taylor-rule equation. The responses from PVARX to this shock are comparable to the results with the benchmark and sign restrictions shocks, albeit less significant and smaller in magnitude (see Figure A.6 in Appendix). The main finding holds for all identifications – monetary easing reduces income inequality and this effect is enhanced by the macroeconomic channel.

Third, we experiment with the lag length by including in the PVARX model endogenous variables with first two lags or an exogenous monetary policy shock with first 1-4 lags. The main findings are not affected by these changes.

Fourth, following previous studies (Coibion et al., 2017; Furceri et al., 2018) we use linear local projections of Jordá (2005) to produce impulse responses. Local projections are robust to lag-length misspecification and do not require imposing a specific order on the relationships between variables. These responses are comparable to those based on the PVARX model and imply a significant decrease in the Gini coefficient after a negative monetary shock.

We are aware that our PVARX inference could be affected by the multi-step nature of the estimation procedure and, in particular, by the fact that quarterly values of Gini coefficients are interpolated. To check whether this transformation of income inequality from annual to quarterly influences the results, we estimate PVARX with annual data where the data interpolation is not used. All the variables are included as yearly averages while annual monetary policy shocks are calculated as a sum of quarterly values. Note that this shrinks the time series dimension from 64 to 16 observations; thus, the results should be interpreted with caution. The impulse responses from yearly PVARX (Figure A.7 in Appendix) are comparable to those from a quarterly model and do not alter our conclusions.[22]

In the aftermath of the GFC, since October 2008 the ECB started implementing unconventional monetary policy measures as conventional ones became less effective (Pattipeilohy et al., 2013; Szczerbowicz, 2015). We estimate PVARX over the period 1999Q1-2008Q3 to examine whether distributional effects and transmission of mone-

[22] Alternative to the mixed-frequency data interpolation, we also tried a simple univariate cubic interpolation of Gini coefficients. The results of this exercise were similar to the baseline ones.

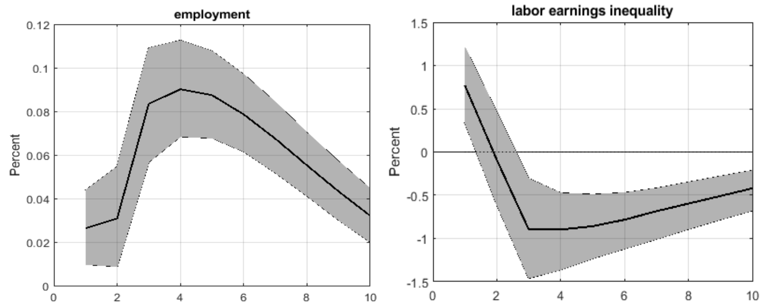
tary policy changed after the crisis. Figure A.8 in Appendix shows the impulse responses. They are comparable to the baseline ones. Income inequality decreases after an expansionary monetary shock; this effect is more persistent before 2008Q4, in line with findings of Furceri et al. (2018). Stock prices drop after a negative monetary shock over the entire horizon. This could be related to the fact that the stock prices boom in the euro area coincided with restrictive monetary policy of the ECB from December 2005 until the crisis. Our result is consistent with Galí and Gambetti (2015) who find for the U.S. that stock prices increase persistently in response to exogenous monetary tightening (implying, vice versa, that monetary easing could reduce stock prices).

5.3 Macroeconomic and financial channels: extension

This section extends the analysis by considering additional macroeconomic and financial factors. The baseline findings suggest that expansionary monetary policy via the macroeconomic (wage) channel reduces income inequality in euro area countries. Higher wages make employed households better off by raising their labor earnings. Monetary policy can also have redistributive effects by stimulating employment. This benefits households at the bottom of the income distribution as their earnings are mainly affected by being employed or by changing the number of hours worked (Heathcote et al., 2010). To test this conjecture we add employment (a share of employed in active population) to the PVARX model. The estimated impulse responses point to a significant role of this factor: employment increases strongly after a negative monetary policy shock and this effect remains positive for over 10 quarters (see Figure 8).

The Gini coefficient of gross income inequality captures all income sources. As a result, the effect of monetary policy on total income distribution could be mitigated by factors that influence other types of income. To account for this, we estimate PVARX with gross labor earnings inequality. It is measured by the Theil index (see Table A.1. in Appendix for a description) and converted into quarterly observations by a mixed-frequency data technique (see section 4.1). This index excludes income dispersion arising from other income sources than wages such as capital incomes and transfers. We

Figure 8: **Responses of employment and labor earnings inequality to an expansionary monetary policy shock**



Notes: The figure plots responses of employment and the Theil index of gross labor earnings inequality to one st.dev. negative monetary policy shock. The solid lines are median responses and the shaded areas represent 16th and 84th percentiles. The vertical axis shows the response in percent.

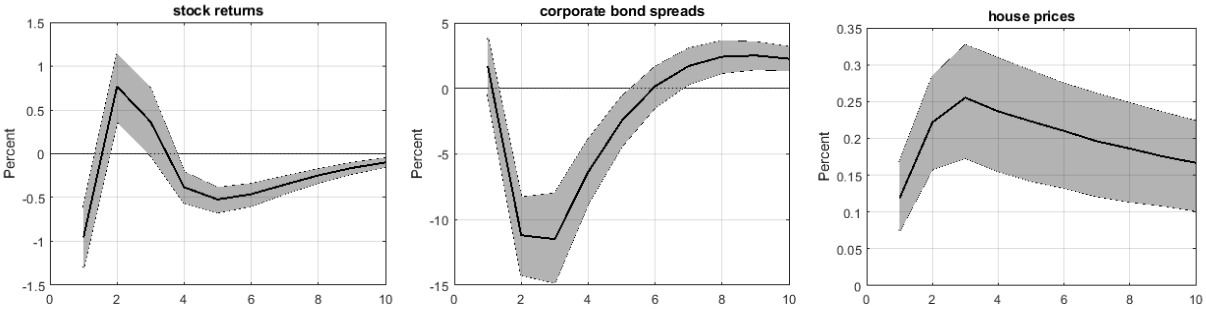
include in the model wages and employment to capture the macroeconomic channel and exclude stock prices as they are not directly related to labor earnings. The graph on the right in Figure 8 displays the response of the Theil index to a negative monetary policy shock. The Theil index increases immediately after a shock but reduces sharply afterwards; the response remains below zero for 10 quarters. This finding suggests that expansive monetary policy reduces labor earnings inequality, contributing to the decrease in total income inequality in the euro area.[23]

Next, we zoom in on the financial channel. We capture the financial channel with two alternative proxies: stock returns and corporate bond spreads. Stock returns are measured as log first differences of stock prices, while corporate bond spreads as a difference between 5-year corporate bond yield and 5-year government bond yield.[24] Bond spreads have a considerable predictive power for economic activity (Gilchrist et al., 2009; Faust et al., 2013; Xu and de Haan, 2018) and are often used as indicators of abnormal returns in financial markets (Krylova, 2016). Monetary easing reduces bond spreads, leading to higher risk tolerance and a search for yield among investors. This results in excess returns on risky assets and higher capital incomes for asset owners who are primarily at the top end of the income distribution.

[23]It would be also interesting to explore the responses of top incomes which capture changes in the income distribution at the top end. Unfortunately, the data on top incomes for euro area countries are limited. The World Inequality Database (henceforth WID) has data on 1% and 10% top income shares for 3 countries in our sample, while the World Bank World Development Indicators report top 10% income shares from 2004 onwards, which is too short for our analysis.

[24]The choice of 5-year maturity is dictated by data availability on bond yields. For Greece, corporate bond yield data was not available.

Figure 9: **Responses of stock returns, corporate bond spreads, and house prices to an expansionary monetary policy shock**



Notes: The figure plots impulse responses of stock returns, bond spreads, and house prices to one st.dev. negative monetary policy shock. The solid lines are median responses and the shaded areas represent 16th and 84th percentiles. The vertical axis shows the response in percent.

The impulse responses of stock returns are larger in magnitude and more significant than the responses of stock prices (see Figure 9). Stock returns drop in the first quarter after a negative monetary policy shock and then rise sharply by 0.75 percentage points for two quarters. In response to monetary easing, bond spreads decrease by about -12 basis points at the trough; the effect remains negative for one and a half year after the shock. This result is in line with the 'financial accelerator' mechanism of Bernanke et al. (1999). The inclusion of these financial variables weakens the inequality-reducing effect of monetary easing, suggesting the disequalizing role of the financial channel.

Additionally, we capture the financial channel with house prices (in log levels). Although changes in house prices are mainly associated with a change in wealth inequality (see e.g., Adam and Tzamourani, 2016; O'Farrell et al., 2016), they may also influence income inequality. Expansive monetary policy drives up house prices, increasing the value of real estate. This raises rental incomes of property owners and buy-to-let investors as well as profits in the real estate commercial sector (Gallin, 2008; Baptista et al., 2016), where incomes are typically already high and concentrated among households at the top of the income distribution. As a result, this may widen the income gap. Figure 9 (graph on the right) shows that house prices rise after an expansionary monetary shock; this response remains positive for more than 10 quarters. The inclusion of house prices mitigates the inequality-reducing effect of monetary easing.[25]

[25] Ideally, we would also examine the effects of monetary policy on wealth inequality through house prices. However, the longitudinal data on wealth distribution for EA countries are not available (the WID has data only for France). This remains for future research.

5.4 Country heterogeneity

In the PVARX analysis EA countries are included as a homogeneous group. Thus, a panel model estimates average responses across all analyzed countries. This section goes beyond this average effect and explores country heterogeneity.

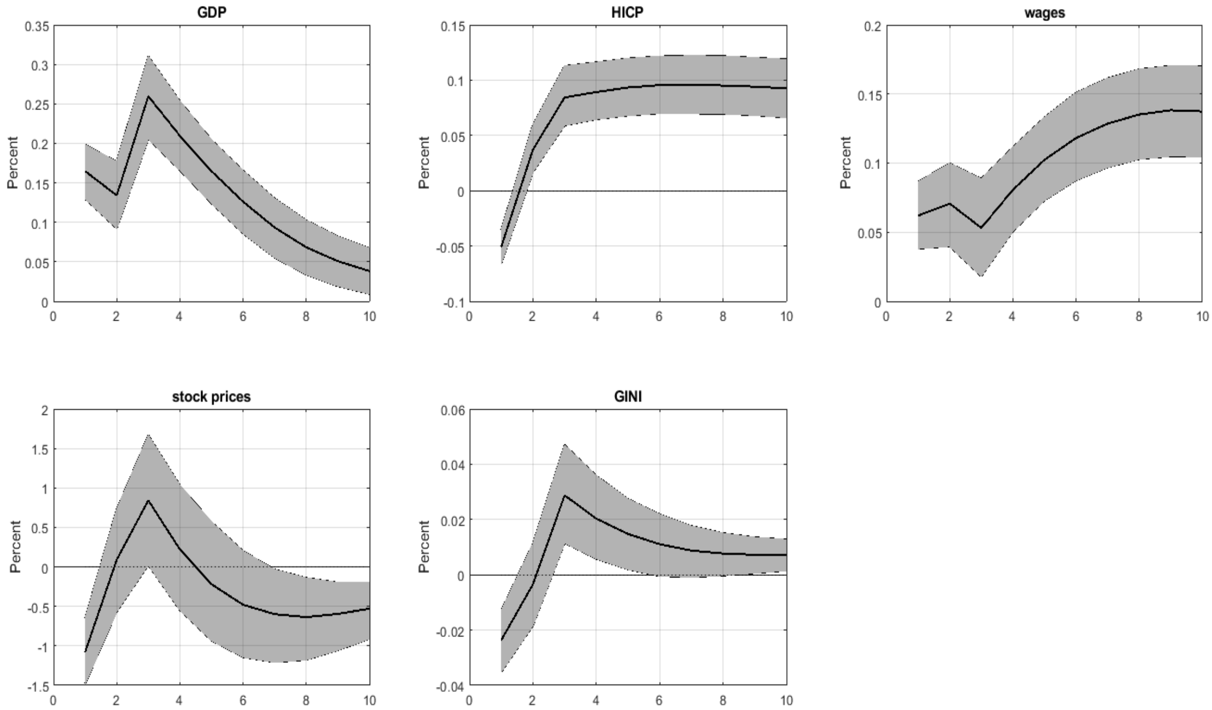
First, we examine two country groups – the core (Austria, Belgium, France, Finland, Germany, the Netherlands) and the periphery (Greece, Italy, Portugal, Spain). The stylized facts in section 3.2. suggest that core EA countries have lower Gini coefficients (on average) than the periphery. It is plausible that these country groups are also influenced differently by monetary policy shocks. We estimate the baseline PVARX for each group and calculate impulse responses (see Figures 10-11).

While output and prices respond similarly to a negative monetary policy shock in both groups, there are differences in responses of income inequality and distributional channels. In the core group the Gini coefficient falls immediately after the shock and then increases; the effect remains above zero for over two years. In the periphery the response of the Gini coefficient is negative and larger in magnitude – after an expansive monetary policy shock income inequality falls by -0.1 percent and the response stays below zero for over 10 quarters. Wages increase stronger in the periphery than in the core, while stock prices do not react in the periphery but increase in the core.

The findings suggest that the periphery countries benefit more than the core ones from the distributional effects of loose monetary policy in the EA. The macroeconomic channel is also stronger in the periphery. This could be due to high reliance of low and middle class in those countries on wages as a primary income source. In the core group monetary expansion may have undesirable distributional effects since it can increase income inequality by boosting asset prices. Controlling for additional macroeconomic and financial factors does not change these conclusions.

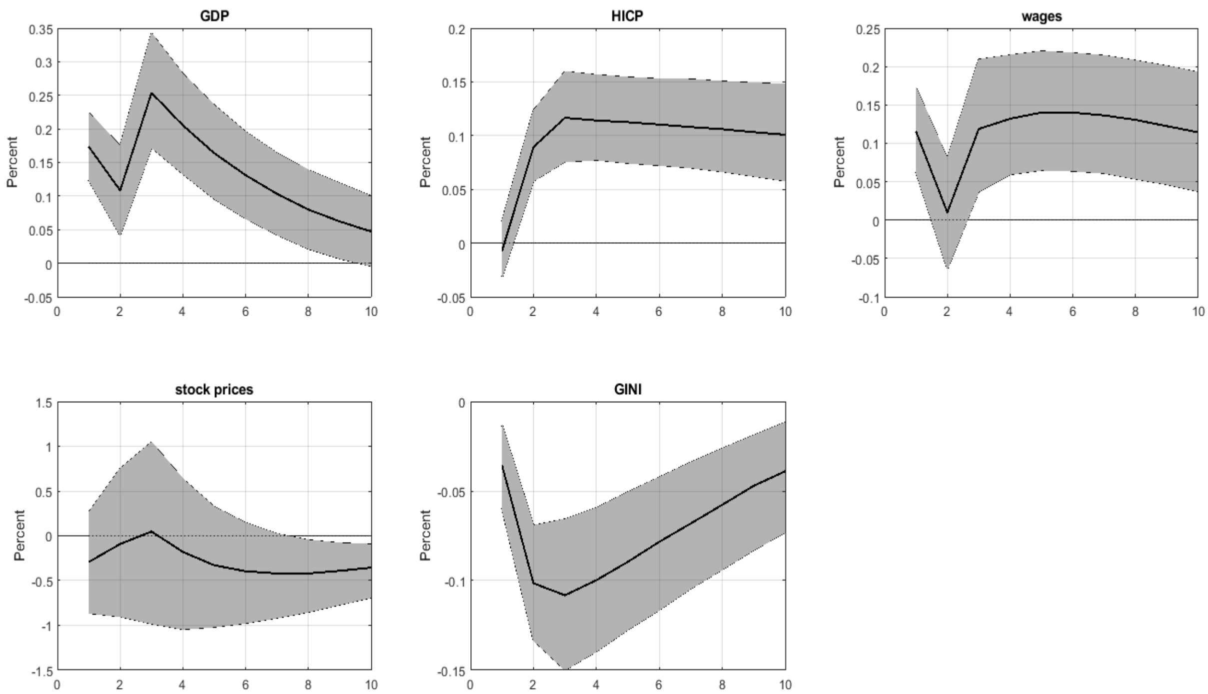
Next, we consider country heterogeneity with respect to income level. We calculate median GDP per capita for our sample and for each country over 1999-2014. Based on these statistics we distinguish three country groups: high-income (countries with the median GDP per capita above the sample median: Austria, Belgium, Finland, the

Figure 10: **Responses to an expansionary monetary policy shock (core)**



Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and the Gini coefficient to one st.dev. negative monetary policy shock for the core countries. The vertical axis shows the response in percent. The solid lines are median responses and the shaded areas represent 16th and 84th percentiles.

Figure 11: **Responses to an expansionary monetary policy shock (periphery)**



Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and the Gini coefficient to one st.dev. negative monetary policy shock for the periphery countries. The vertical axis shows the response in percent. The solid lines are median responses and the shaded areas represent 16th and 84th percentiles.

Netherlands), mid-income (median GDP per capita around the sample median: Germany, France) and low-income (median GDP per capita below the sample median: Greece, Italy, Portugal, Spain). Low-income countries coincide with the periphery ones, for which the responses are shown in Figure 11. The responses for high- and mid-income groups are displayed in Figures A.9-A.10 in Appendix.

The findings for the high-income group are similar to the ones for the core group. The Gini coefficient drops in the first quarter after a shock; afterwards the response turns positive and remains above zero. In response to monetary easing the Gini coefficient in the mid-income group falls and the effect remains negative after 10 quarters.

Finally, we estimate VARX for individual countries using a baseline specification (results available on request). For most countries the impulse responses are in line with the panel results and indicate that monetary easing reduces income inequality. This effect dissipates within a year after the shock, except for Italy and Greece where the responses of the Gini coefficient remain negative for two years. The responses of income inequality are insignificant in two countries (Germany and the Netherlands).

6 Conclusion

This paper analyzes the effects of expansionary monetary policy on income inequality in 10 euro area countries over the period 1999–2014. We examine macroeconomic and financial channels through which monetary policy shocks can have distributional effects. The macroeconomic channel is captured by wages and employment, while the financial channel by asset prices and returns.

Our findings suggest that monetary easing reduces income inequality in the panel of euro area countries. This effect is particularly evident in the periphery economies. The responses of the Gini coefficient to an expansionary monetary policy shock are small in magnitude and significant in the short-run up to two years. Our results are consistent with (Guerello, 2018) who also finds that accommodative monetary policy in the euro area reduced income inequality.

The macroeconomic channel enhances redistributive effects of monetary policy. Wages and employment increase in response to a negative monetary shock, contributing to the inequality-reducing impact of monetary easing. The evidence for the financial channel is less clear. There is some indication that higher asset prices and returns due to monetary easing may weaken the equalizing effect of monetary expansion. Our conclusions are in line with Lenza and Slačálek (2018) who find that quantitative easing in the EA compressed the income distribution by boosting wages and employment, while the increase in financial income had a negligible effect on income inequality.

Our results indicate that the impact of monetary policy on income inequality is mainly propagated through the general equilibrium effects on economic activity, labor earnings, and employment. Changes in asset prices affect only a small fraction of households at the upper end of the income distribution, which has a negligible impact on the whole income distribution. Moreover, the financial channel is more likely to have wealth rather than income effects through changes in the value of assets and liabilities in households' balance sheets.

Note that our study considered distributional effects of monetary policy in the short run. Monetary policy is argued to be neutral in the long run and hence could have a limited long-term influence on real variables, including income and wealth distribution (Draghi, 2015; Bunn et al., 2018). Nevertheless, it would be interesting to explore the long-run evolution of income inequality after a change in monetary policy stance using a different empirical approach and a well-specified theoretical model.

This paper adds to our understanding of factors driving income inequality. It shows that monetary policy may have distributional effects in the euro area although their economic size is small. In this respect, other policies and economic forces could be considered responsible for the observed rise in income and wealth inequality in recent years, such as fiscal austerity measures, technological change, globalization, and a decline in a labor share, among others. The analysis of these factors and their interaction with monetary policy could be an interesting topic for future work.

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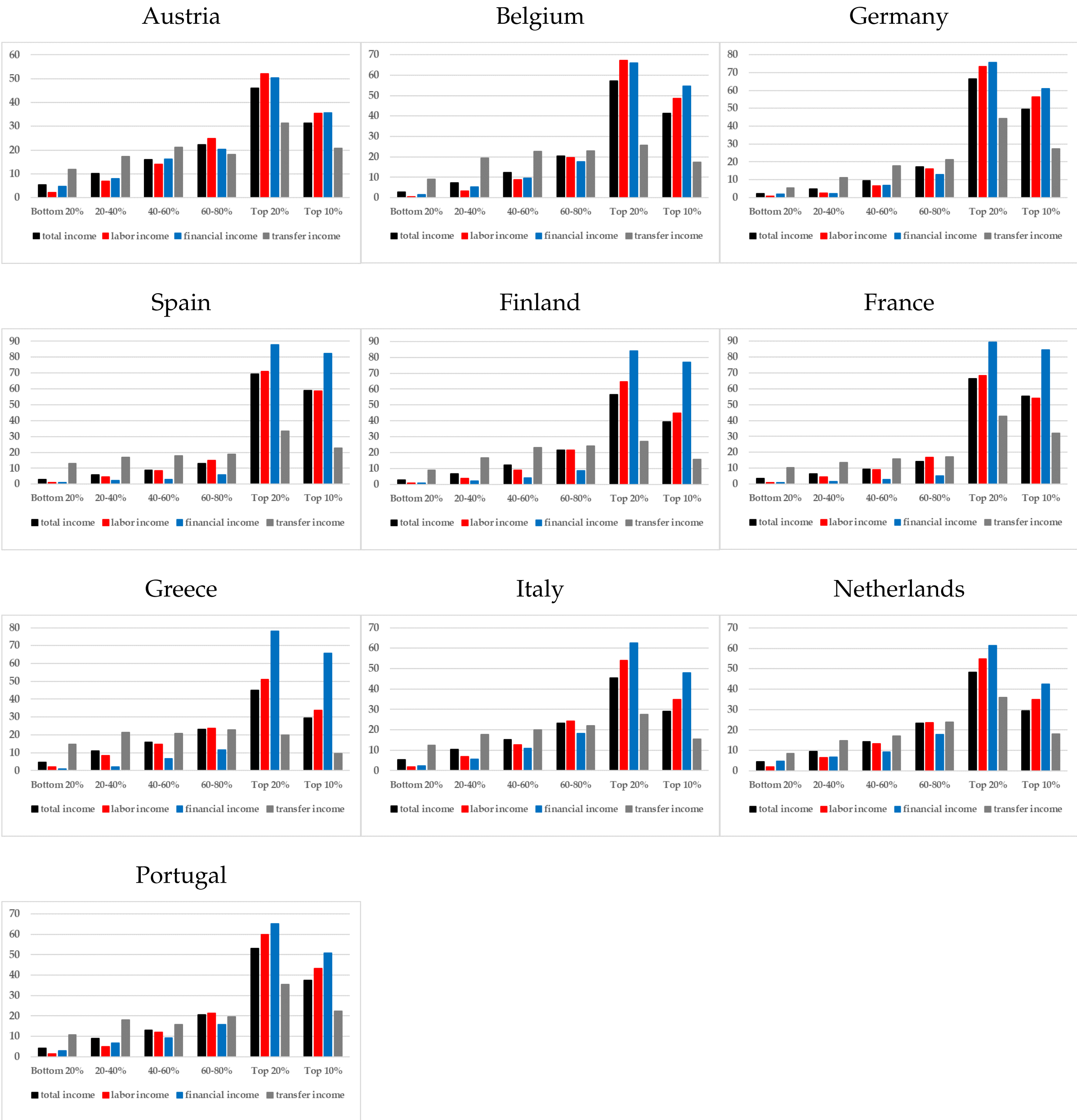
Appendix

Table A.1: **Data description and sources**

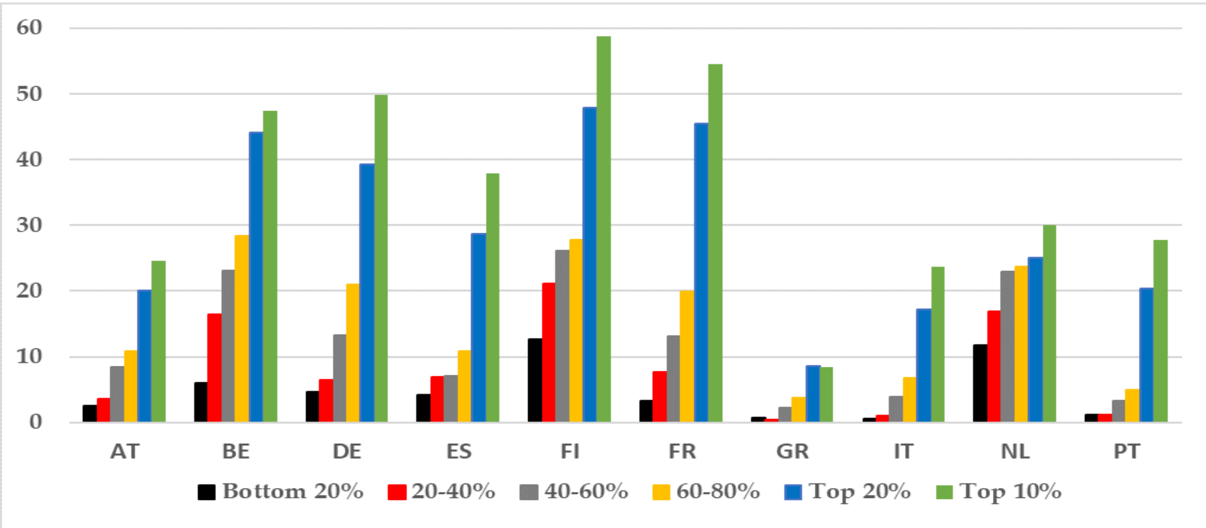
Variable	Description	Data sources
	Euro area variables	
Real GDP^{EA}	Seasonally and calendar adj., chain linked volumes (2010), mln euro; adjusted to EA composition	Eurostat
HICP^{EA}	HICP^{EA} (2005=100), adjusted to EA composition	Eurostat
Monetary policy rate	Shadow interest rate for the euro area	Krippner (2015)
REER	Real effective exchange rate (index, 2010=100)	Eurostat
	Country-level variables	
Real GDP	Seasonally and calendar adj., chain linked volumes (2010), mln euro	Eurostat
HICP	HICP (2005=100)	Eurostat
Wages	Gross hourly earnings (index, 2010=100)	OECD.Stat
Employment	Share of employed in total active population (15-64 age group)	Eurostat
Stock prices	Share prices index (2010=100)	OECD.Stat
Bond spread	Difference between 5-year corporate bond yield and 5-year government bond yield	Bloomberg, Datastream
House prices	Residential property price index	BIS
Income inequality	Gini coefficient of gross income inequality (pre-tax, pre-transfer). Measured as the area between the Lorenz curve and the equality diagonal. The Lorenz curve plots cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest. Gini coefficients are constructed from several sources, with data of Luxembourg Income Study (LIS) used as standard. The final series are standardized on the LIS household-adult-equivalent income data.	Solt (2016)
Labor earnings inequality	Gross wage inequality, defined as a dispersion of wages (person equivalent) in manufacturing. Measured by between-group components of Theil's T statistic calculated across industries, based on the UNIDO Industrial Statistics. UNIDO's measures are based on 2 or 3 digit code of the International Standard Industrial Classification.	UTIP, Galbraith and Kum (2002)

Figure A.1: **Income shares across the income distribution in EA countries**



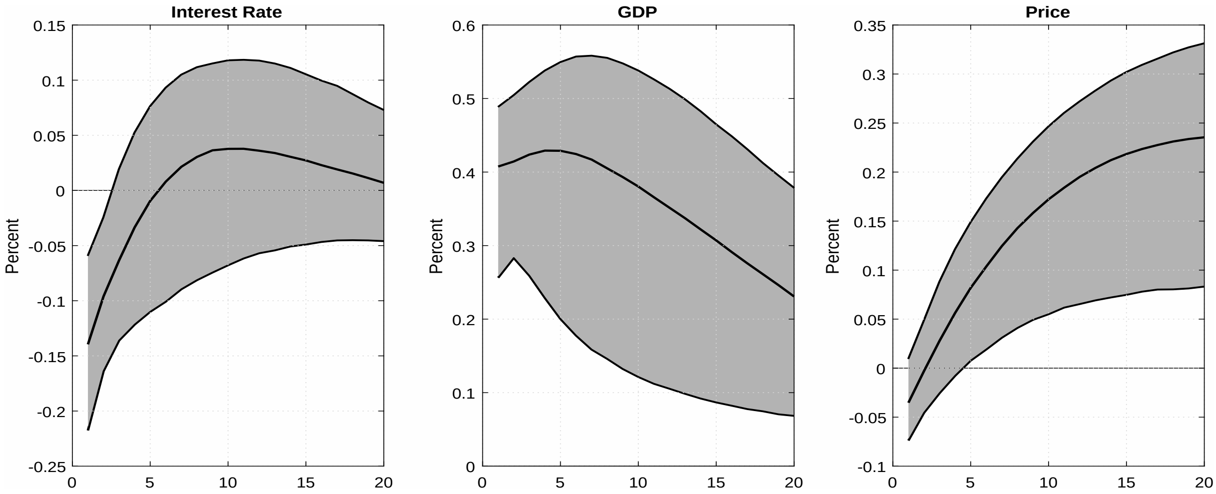
Notes: Own calculations based on Household Finance and Consumption Survey (HFCS), wave 1. The graphs illustrate shares (in % of total per country) of gross total income, labor, financial, and transfer incomes across the income distribution. Income quintiles are based on annual household gross income. Labor income includes employee income, self-employment income, and income from private business other than self-employment. Financial income is income from financial investments, such as interest and dividends. Transfer income includes pensions, regular social transfers, and unemployment benefits.

Figure A.2: **Percentage of households holding stocks (directly and indirectly) across the income distribution in EA countries**



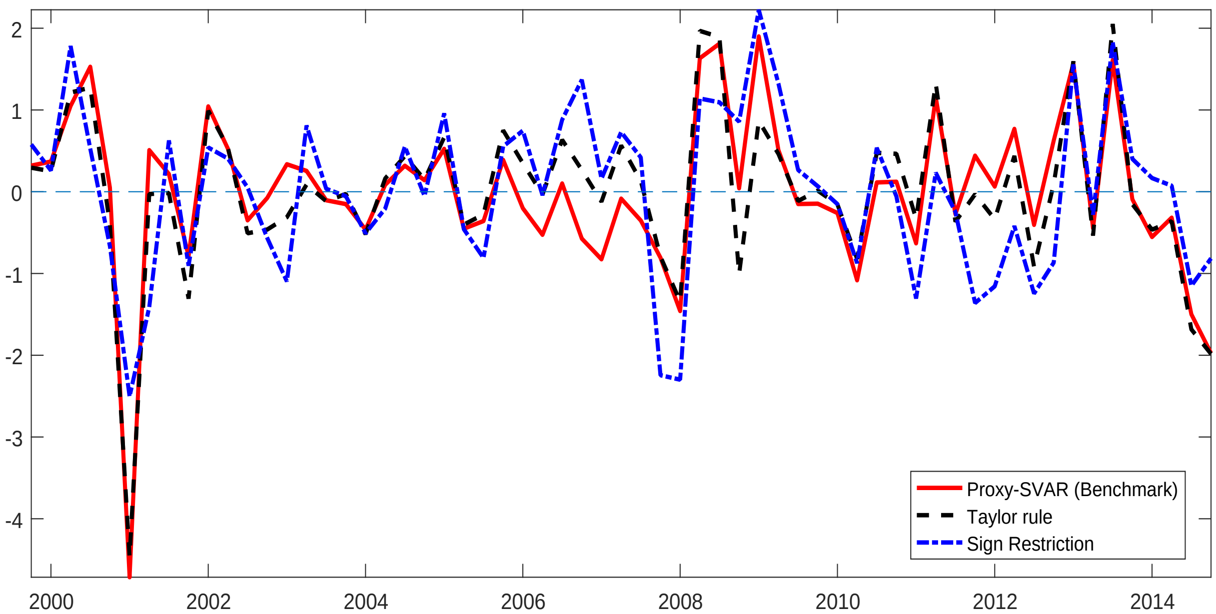
Notes: Own calculations based on Household Finance and Consumption Survey (HFCS), wave 1. The graph illustrates the percentage of households holding stocks directly (through owning publicly traded stocks) and/or indirectly (through owning mutual funds which predominantly invest in stocks). Income quintiles are based on annual household gross income.

Figure A.3: **Responses of euro area variables to an expansionary monetary policy shock**



Notes: The figure plots impulse responses of euro area GDP, HICP, and shadow interest rate to one st.dev. negative monetary policy shock. The vertical axis shows responses in percent. The solid lines are median responses and the shaded area represents 16th and 84th percentiles.

Figure A.4: **Euro area monetary policy shocks over 1999-2014**

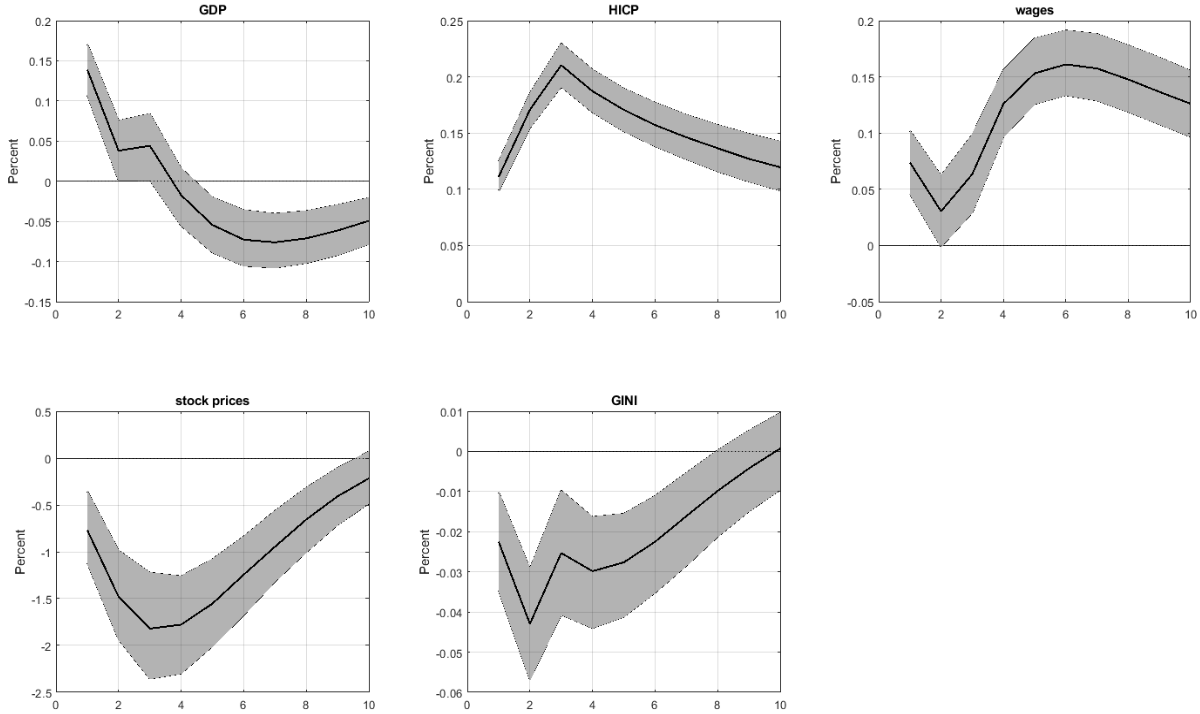


Notes: The figure plots (standardized) monetary policy shocks identified by Proxy-SVAR (benchmark), by SVAR with sign restrictions, and by Taylor rule.

Table A.2: **Correlation between monetary policy shocks**

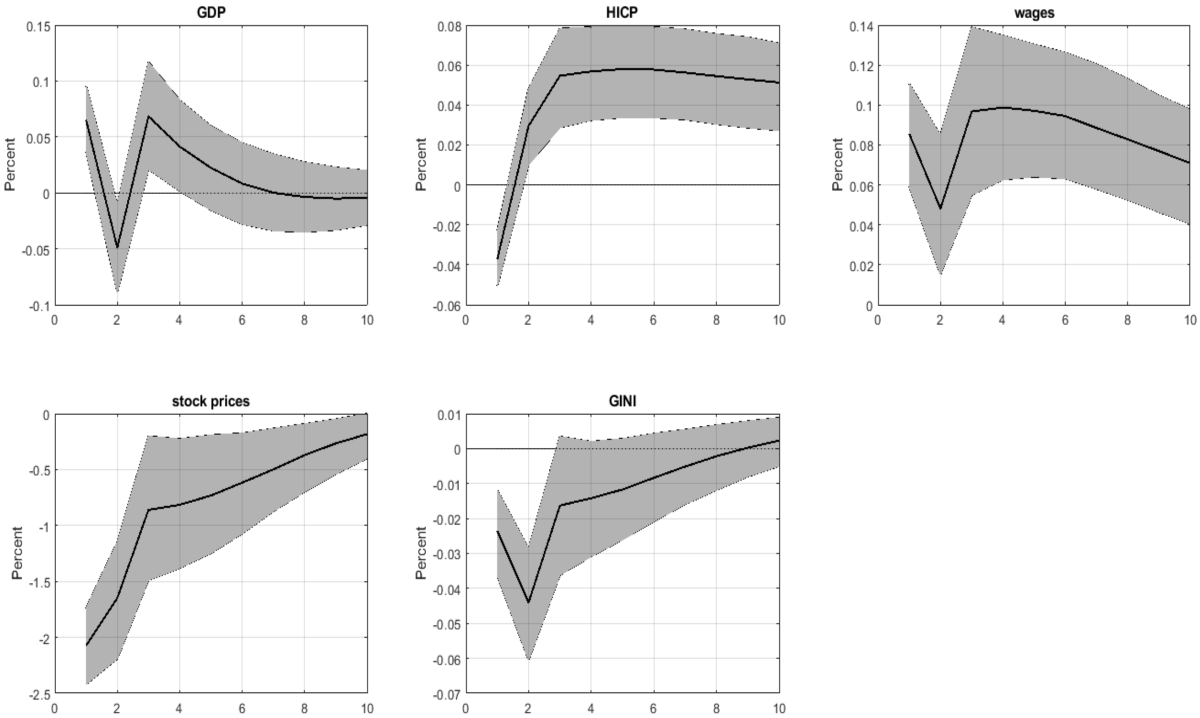
	Proxy-SVAR	Sign restrictions	Taylor rule
Proxy-SVAR	1.00		
Sign restrictions	0.66	1.00	
Taylor rule	0.92	0.74	1.00

Figure A.5: **Responses to an expansionary monetary policy shock (sign restrictions)**



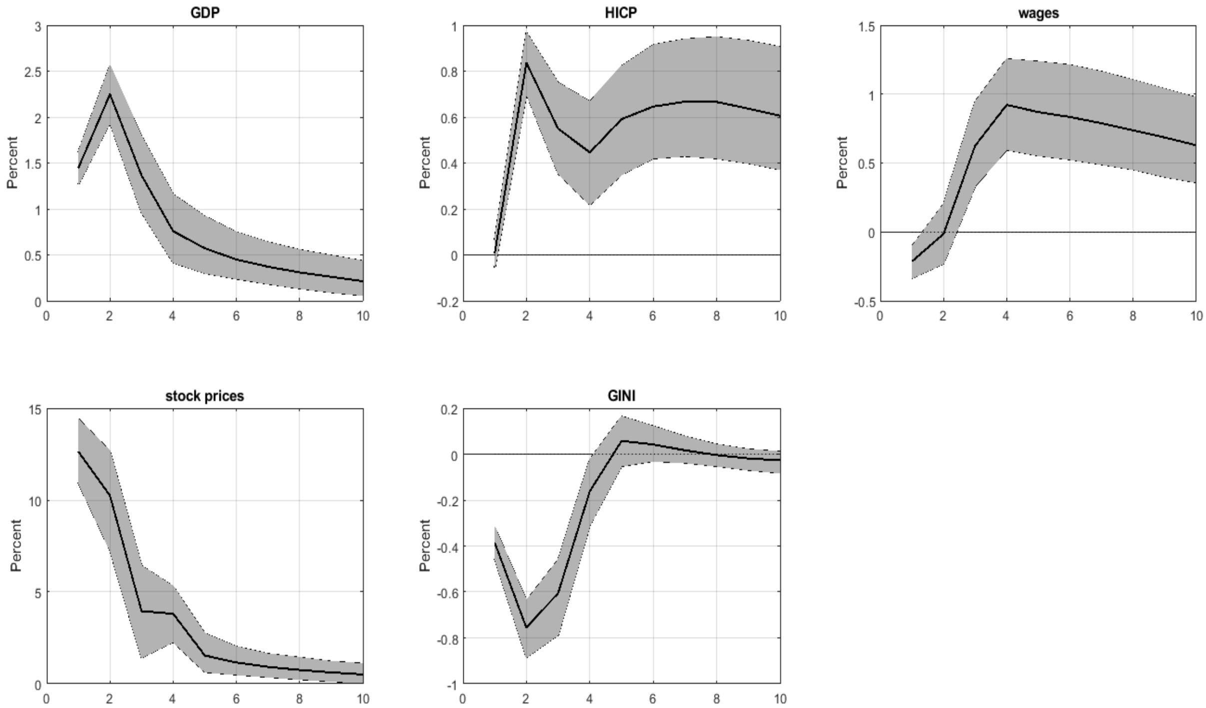
Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and Gini coefficient to one st.dev. negative monetary policy shock, identified by SVAR with sign restrictions. The vertical axis shows responses in percent. The solid lines are median responses and the shaded area represents 16th and 84th percentiles.

Figure A.6: **Responses to an expansionary monetary policy shock (Taylor rule)**



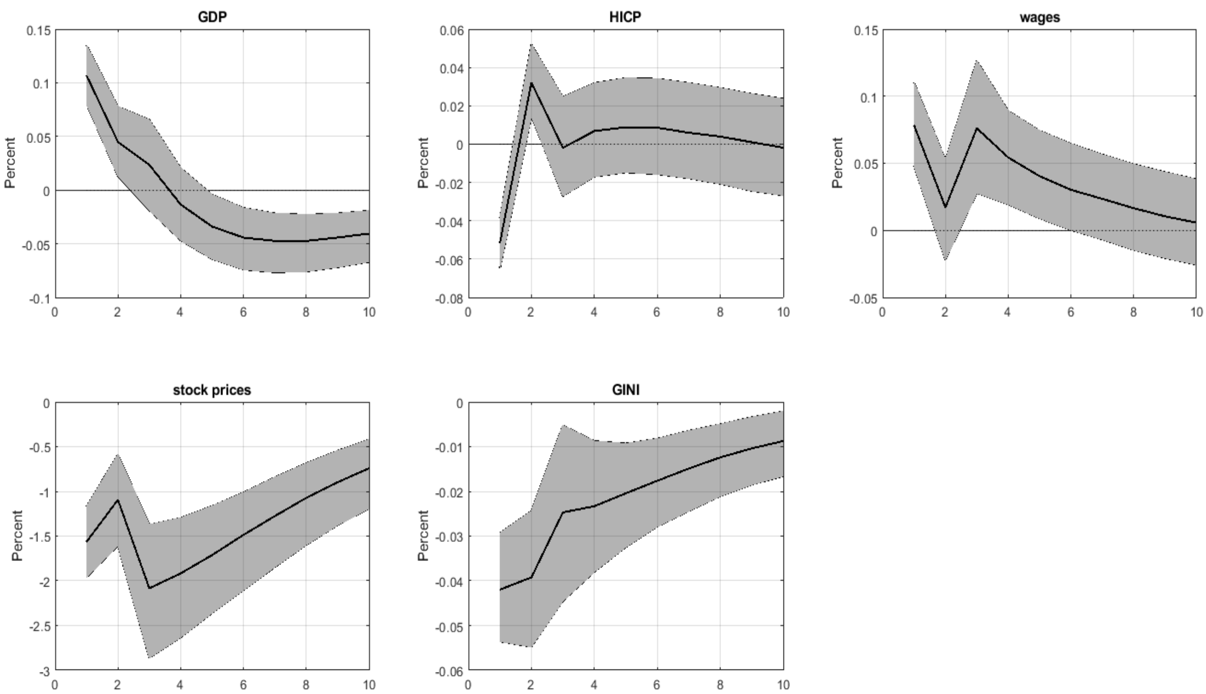
Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and Gini coefficient to one st.dev. negative monetary policy shock, identified by the Taylor rule equation. The vertical axis shows responses in percent. The solid lines are median responses and the shaded area represents 16th and 84th percentiles.

Figure A.7: **Responses to an expansionary monetary policy shock, yearly PVARX**



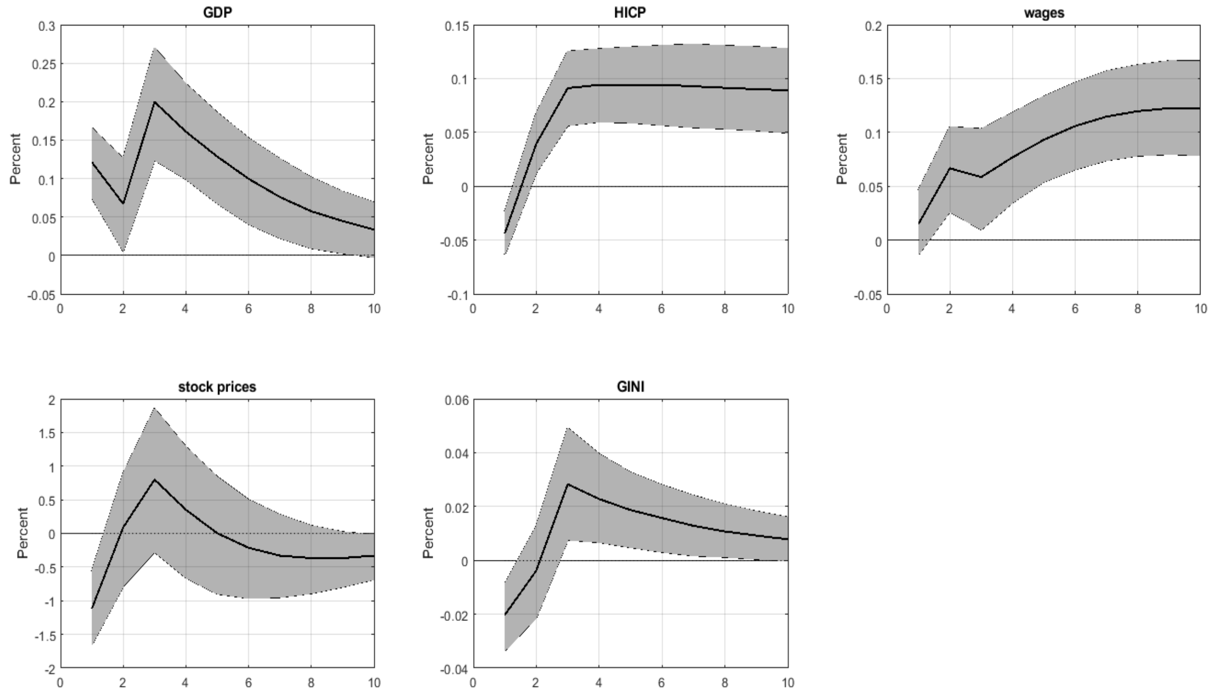
Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and Gini coefficient to one st.dev. negative monetary policy shock for PVARX model based on annual data over 1999-2014. The vertical axis shows responses in percent. The solid lines are median responses and the shaded area represents 16th and 84th percentiles. The IRF horizon is 10 years.

Figure A.8: **Responses to an expansionary monetary policy shock, 1999Q1-2008Q3**



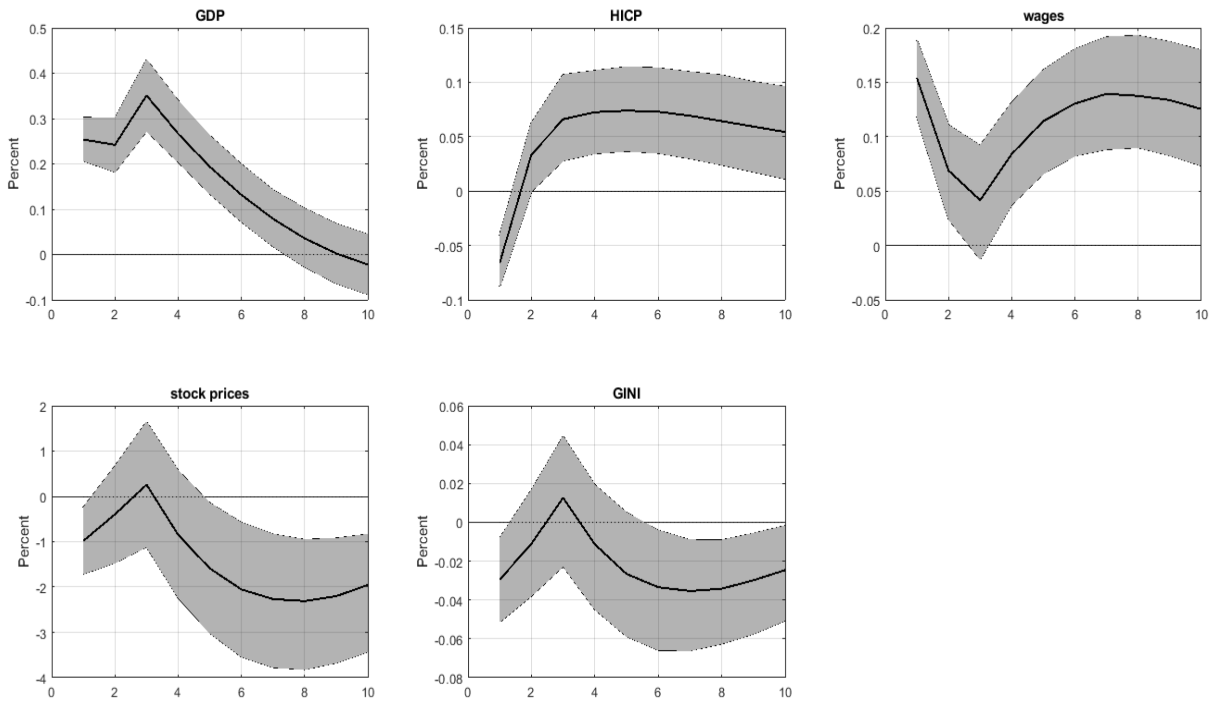
Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and Gini coefficient to one st.dev. negative monetary policy shock for PVARX model estimated over the period 1999Q1-2008Q3. The vertical axis shows responses in percent. The solid lines are median responses and the shaded area represents 16th and 84th percentiles.

Figure A.9: **Responses to an expansionary monetary policy shock (high-income)**



Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and the Gini coefficient to one st.dev. negative monetary policy shock for the high-income countries (AT, BE, FI, NL). The vertical axis shows the response in percent. The solid lines are median responses and the shaded area represents 16th and 84th percentiles.

Figure A.10: **Responses to an expansionary monetary policy shock (mid-income)**



Notes: The figure plots impulse responses of GDP, HICP, wages, stock prices, and the Gini coefficient to one st.dev. negative monetary policy shock for the mid-income countries (DE, FR). The vertical axis shows the response in percent. The solid lines are median responses and the shaded area represents 16th and 84th percentiles.

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