# SHOCKING ASPECTS OF MONETARY POLICY ON INCOME INEQUALITY IN THE EURO AREA

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## ABSTRACT

This paper examines the distributional effects of monetary policy, either standard, nonstandard or both, on income inequality in 10 EA countries over the period 2000-2015. We use three different indicators of income inequality in a Panel VAR setting in order to estimate IRFs of inequality to a monetary policy shock. Results suggest that: (i) the distributional effects of ECB's monetary policy have been modest and (ii) mainly driven in times of conventional monetary policy measures, especially in peripheral countries, while, overall, (iii) standard and non-standard monetary policies do not significantly differ in terms of impact on income inequality.terms of impact on income inequality.

## KEY WORDS

Euro Area, Monetary policy, income distribution, Panel VAR

## JEL

E62, E64, D63

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September 2019

**Abstract**

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# 1 Introduction

The growing income and wealth inequalities have recently become one of the defining characteristics of advanced economies. The notable contribution of Piketty (2014) distinctly documented the lasting stagnation of median wages, and especially the expanding share in national income held by top income households. It is actually accepted that inequality is shaped in the long-run by technological progress and political power struggles (see e.g. Roine and Waldenström (2015)). On the economic policy side, taxation and fiscal transfers are the traditional instruments that impact households income and wealth.

Monetary policy was commonly believed to be neutral with respect to inequality. Indeed, central banks' mandate primarily deals with preserving stable prices and sound economic conditions. However, given the non-standard measures implemented by central banks in response to the great recession, the view that monetary policy could widen income disparities – e.g. through higher asset prices and lower saving returns – has become increasingly popular. This debate was particularly heated in the U.S, given that households mainly rely on labor incomes, while a minority receives an important share of their income in the form of dividends and capital gains. In the Euro Area (EA henceforth), as soon as the ECB activated its unconventional monetary policy toolbox, questions also arose as to its possible side effects on inequality.

This paper examines the distributional effects of monetary policy in 10 EA economies over the period 2000-2015. We rely on three measures of income inequality: the Gini coefficient, the *net* Gini and the S80/S20 ratio. These measures allow to appraise the impact on inequality before and after redistribution, and also to consider if monetary policy widens inequality between high and low income earners. In order to account for monetary policy stance in the EA, we use the nominal short-term interest rate (as a policy rate) along with the shadow rate of Wu and Xia (2016). The latter encompasses standard and non-standard monetary policies. Our empirical approach features a Panel VAR setting where monetary policy shocks are identified using a Cholesky decomposition scheme. Such identification method consists of categorizing endogenous variables from slow to fast moving variables.

A growing body of research has attempted to document, from a short-run perspective, the effects of monetary policy shocks on income inequality. In the U.S., Coibion et al. (2017) use micro level data from the Survey of Consumer Finances (SCF), and find that contractionary monetary policy contributed to increase income inequality during the period 1980-2008. Mumtaz and Theophilopoulou (2017) rely on similar data of U.K. households from 1969 to 2012 and come up to the same conclusion. While the literature on the redistributive effects of unconventional monetary policy is still in progress, the reduction in income inequality – though small in magnitude – seems to be the most dominant effect (see e.g. Bivens (2015), Inui et al. (2017) or Colciago et al. (2019) for a complete survey on this issue).

At the EA level, Guerello (2018) builds a proxy of changes in income dispersion out of the European Commission Consumer Survey and studies the distributional implications of monetary policy in 12 EA countries for the period 1999-2014. The contribution of our paper departs from Guerello (2018) in two important respects: (i) we use proper income inequality data from the Standardized World Income Inequality Database (SWIID), supplemented by an inter-decile ratio (S80/S20), and (ii) instead of using ECB balance sheet to identify non-standard policies, monetary policy shocks are extracted from innovations to the short-term and the shadow rates.

Our results suggest that monetary policy has only a modest impact on income inequality. An unexpected increase in the policy rate or the shadow rate rises the Gini coefficient by respectively 0.1 and 0.12. Such impact is more than halved when we consider instead the *net* Gini and the S80/S20 ratio, but remains as persistent as the Gini coefficient. This evidence is mainly driven by Southern European economies and conventional monetary policies. Also, non-standard monetary policy does not yield striking differences in terms of impact on inequality, in comparison with conventional monetary policy. These findings are robust to a battery of robustness checks, which consider different sets of ordering, data sources and model specifications.

The paper is outlined as follows: Section 2 discusses the data and recent trends of income inequality in the EA. Section 3 sheds light on the estimation methodology, by specifying the empirical model and how monetary policy shocks are identified. Section 4 reports the Panel VAR results, while the fifth and last section concludes.

## 2 Data

The empirical analysis covers the period 2000Q3-2015Q3 and focuses on 10 EA economies, which account for more than 80 percent of the EA's GDP. Countries include: Austria, Belgium, Finland, France, Germany, Greece, Italy, the Netherlands, Portugal and Spain. The period choice is limited on the one hand by the availability of data on income inequality and, on the other hand, by the presence of structural breaks prior to 2000 as EA countries did not share similar macroeconomic characteristics.[1]

Addressing the topic of monetary policy and inequality requires ideally extensive surveys on households with large information on household incomes, assets and liabilities (see e.g. Coibion et al. (2017) or Albert and Gómez-Fernández (2018) for the U.S., Casiraghi et al. (2018) for Italy, Feldkircher and Kakamu (2018) for Japan and Park (2018) for South Korea). As far as the EA is concerned, the Household Finance and Consumption Survey[2] (HFCS) has been released for the first time in 2010 and contains only two waves, which makes it difficult to investigate how the ECB's monetary policy decisions have shaped income and wealth distribution. At the country level, household surveys are conducted at best on an annual basis and combining them would be a big deal given that they incorporate different definitions of income.

We are thus left relying on annual standardized data on income inequality. Therefore, we bypass issues related to different cross-national income definitions; this makes comparisons between countries more reliable. Given that our empirical analysis features a Panel VAR framework, it is also desirable (if not necessary) to have a relatively long estimation sample. To do so, we apply linear interpolation techniques to convert income inequality measures from the annual frequency to quarterly series. Such approach is justified by the fact that measures of income inequality generally show small variations in the short-run and could therefore be considered as slow-moving variables. Hence, interpolation does not change the information conveyed in a substantial way.

[1]Ireland is excluded from the sample due to the large recent revisions in macroeconomic data. Also, countries that have only recently joined the EA are excluded to limit breaks in time series.

[2]Adam & Tzamourani (2016) and Lenza & Slacalek (2018) use the available waves of the HFCS to derive households balance sheets per quantile in the EA and conduct microsimulations to determine who is likely to benefit from the monetary policy measures implemented by the ECB.

Time disaggregation of data on income inequality has been recently used in the literature on distributional impacts of monetary policy. For instance, Davtyan (2017) converts the Gini index in the United States to quarterly series using the interpolation method proposed by Boot et al. (1967). In our case, we follow the method of Chow and Lin (1971), which performs a Generalized Least Squares (GLS) regression of the annual values on the annualized quarterly indicator series.[3] According to Angelini et al. (2006) who develop a new method for data interpolation summarizing large information sets, Chow-Lin interpolation continues to perform well as they find that the ranking of factor-based interpolation and Chow–Lin is not clear-cut. And according to Sax and Steiner (2013), Chow-Lin interpolation is better suited for stationary or cointegrated series.

Precisely, data on Gini coefficients – a standard measure of income dispersion whose value ranges from 0 to 100 – are collected from the Standardized World Income Inequality Database (SWIID) produced by Solt (2018). The SWIID uses available information on income inequality from various sources, and then applies interpolation and imputation techniques to fullfil missing country-years observations. This allows to obtain the highest possible coverage (see Lang and Tavares (2018) on how different datasets of income inequality deal with issues related to availability, comparability and measurement methods). To better account for the interaction between monetary and fiscal policy, the Gini coefficients are considered both in terms of market income (pre-tax, pre-transfer) and disposable income (post-tax, post-transfer).

It is well established that the Gini coefficient tends to relatively attach a greater importance for observations in the middle of the distribution than those located at the extremes (Cobham and Sumner (2014)). This is why we add an additional inequality measure : S80/S20, which is the ratio of the average income of the 20 percent richest to the 20 percent poorest. This indicator is obtained from OECD (2017) and allows to take into account in our analysis the impact of monetary policy on the tails of income distribution. Since the S80/S20 ratio contains missing observations for some countries between 2002 and 2003, we use as well the Chow-Lin interpolation method to fill in the missing data and convert them afterwards to quarterly series.

[3] This exercise is performed using ECOTRIM, a software developed by Eurostat. We provide in Subsection 7.1 of the appendix a technical review of how interpolation *à la* Chow and Lin (1971) specifically works.

Along with the three measures of income inequality, other macroeconomic and monetary variables are included. The country-level data include real GDP, consumption deflator, stock prices, the total employed population and a real house price index.[4] Monetary policy stance is proxied by the short-term nominal interest rate and the shadow rate for the EA of Wu and Xia (2016). While the first allows to grasp only conventional monetary policy, the second captures episodes of unconventional monetary policy implementation by the ECB. All variables enter in log levels except the short term interest rate, shadow rate and the three inequality measures.

## 2.1 Income inequality in the Eurozone

Before setting up the empirical methodology, we draw a broad picture on the state of income inequality in the 10 EA economies included in our study. We conduct this exercise by considering two country-groups: the core which features the richest Northern European countries in terms of GDP per capita (i.e. Austria, Belgium, Finland, France, Germany and the Netherlands) and the periphery or Southern European countries (i.e. Greece, Italy, Spain and Portugal).

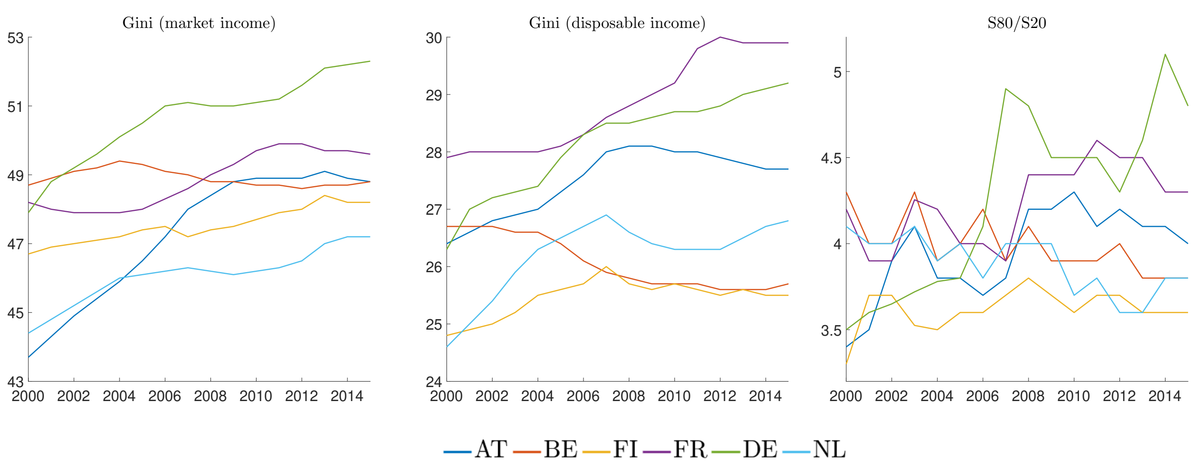



Figure 1: Income inequality in Northern European economies, 2000-2015

*Note: Data on Gini for market income, Gini for disposable income and the S80/S20 ratio are plotted from the SWIID and OECD.*

As illustrated in figures 1 and 2, income inequality strongly increased both in the core and periphery countries of the EA. With the exception of Germany and Austria, the core member-states countries have witnessed however a slower rise in the Gini for market income compared

[4]See Table 1 in appendix for detailed information on data.

to the periphery countries. Actually, the upward shift these countries have experienced was more pronounced following the Great Recession, particularly for Spain and Greece.

The Gini for disposable income highlights how fiscal policy and redistribution can lower income disparities. This turns out to be particularly true in Northern European economies where this measure is structurally lower in comparison with their counterparts in Southern European economies. Moreover, movements observed in the Gini for disposable income are relatively close to those we noticed in the Gini for market income. Indeed, while the Gini for disposable income decreased in Belgium, it has significantly increased in France, Germany and Spain.

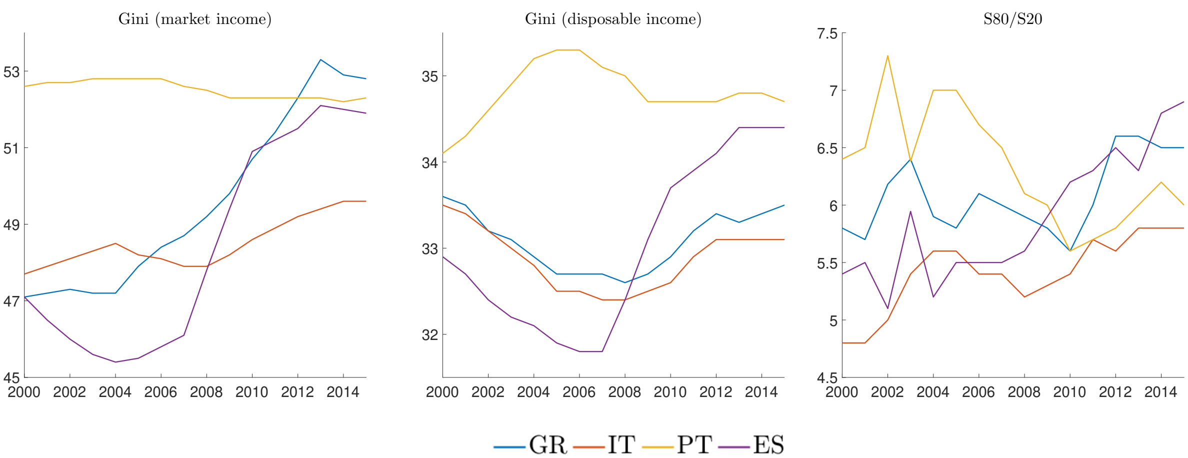



Figure 2: Income inequality in Southern European economies, 2000-2015

*Note: Data on Gini for market income, Gini for disposable income and the S80/S20 ratio are plotted from the SWIID and OECD.*

Similarly, the S80/S20 ratios of the 10 EA economies suggest that income inequality is lower in Northern Europe and support the assertion that richest countries in the EA are the most equal in terms of income distribution. Although decile ratios do not tend to vary much, the S80/S20 increased in Germany and Spain by respectively 42 and 27 percent between 2000 and 2015, which is economically considerable. This measure offers a first-hand illustration of how monetary policy – either conventional or unconventional – could shape income inequality. In fact, the extent to which central banks could boost asset prices or enhance employment and wages – on which low income earners rely substantially – could have a strong impact on the development of the S80/S20 ratio. We will empirically test if monetary policy shocks widen income disparities between top and bottom income earners.

## 3 Empirical methodology

### 3.1 Identification strategy

The identification of monetary policy shocks first raises the question of how to disentangle conventional from unconventional monetary policy measures. This issue is more demanding for the EA where monetary policy measures are decided for the Euro Area as a whole and may impact domestic economies heterogeneously.

Several alternatives have been put forward in the literature. For the EA, Guerello (2018) identified non-standard monetary measures as innovations to the ECB balance sheet, and conventional measures were identified from short-term nominal interest rate innovations. Guerello (2018) adopted this approach to identify monetary policy shocks both on aggregate Eurozone data and a panel of 12 EA countries. For Japan, Inui et al. (2017) followed the same strategy to identify standard monetary policy for the period 1981Q1-1998Q4. However, starting from 1999Q1, they used the shadow rate of Krippner (2015) in order to account for the distributional effects during the prolonged period of unconventional monetary policy.

We follow the same approach as Inui et al. (2017) in our analysis by using the shadow rate developed by Wu and Xia (2016) for the EA.

Shadow rates could be perceived as a substitute of standard policy rates in times of Zero Lower Bound (ZLB). Put differently, they address the following question: what would have been the level of nominal interest rates had they been allowed to move below zero? Indeed when short-term interest rates reach the ZLB, shadow rates are likely to become negative if central banks continue to implement other forms of monetary policy that go beyond the manipulation of interest rates.

In a context of ZLB, as noted by Francis et al. (2017), shadow rates proved to be good proxies of monetary policy stance.[5] Most importantly, unlike the central bank balance sheet, they particularly allow to capture all the unconventional monetary policy toolkit, including (T)LTRO for instance, instead of only asset purchase programs. Figure 3 below plots the time path of the shadow rate and short-term interest rate for the EA. Following ECB's non-standard

[5]Several shadow rates – which have mainly built on term structure models – have been proposed by De Rezende and Ristiniemi (2017) and Krippner (2015). See Ichiue and Ueno (2015) for a complete survey of shadow rates and their differences.

monetary policy actions, the shadow rate started deviating from the short-term interest rate as of 2004Q3, and entered the negative territory for the first time in 2009Q3 and then in 2012Q1 as the short-term nominal interest decreased towards the ZLB.


Figure 3.1: Policy rates in the Euro Area

Monetary policy shocks are identified as innovations to policy rates (short-term nominal interest rate and shadow rate, alternatively), which do not contemporaneously affect macroeconomic conditions. Specifically, our shocks identification scheme relies on a Cholesky decomposition[6] with the following ordering of variables:

$$Y_{it} = \begin{pmatrix} \text{Inequality measure} \\ \\ \text{Output} \\ \\ \text{Prices} \\ \\ \text{Policy instrument} \\ \\ \text{Stock returns} \end{pmatrix}$$

This ordering implies, on the one hand, that income inequality, output and price levels respond with a lag to an unexpected increase in the policy rate. On the other hand, stock prices

[6]This identification scheme and its implications have been widely discussed by Christiano et al. (1999).

are allowed to react within the same quarter to a monetary policy shock. Ordering real variables before financial ones is a widely-adopted practice in the macroeconomic literature, and underlines the idea that stock markets may respond immediately to real shocks. For what concerns the ordering of income inequality measures, we will test for the sensitivity of this identification scheme by considering different sets of ordering.

A possible concern regarding our identification strategy may be that we adopt a country-level approach for exogenous monetary policy shocks instead of estimating the latter at the EA level. Samarina and Nguyen (2019), for instance, follow the last approach by including the EA's monetary policy shocks into a PVARX in order to estimate their effect on the Gini coefficient. We believe, however, that such approach could potentially lead to the attrition of the scope of monetary policy shocks and consequently alter the outcome on income inequality. To put it differently, the identification of monetary policy shocks at the EA level stems from the estimation of a reaction function by the ECB. In contrast, we do not estimate reaction functions. We compute instead country-level shocks as the deviation between the common policy (or shadow) rate (which implicitly depends on variables at the EA level and an error term) and the country-level macroeconomic conditions. Hence we assert that desynchronized business cycles across EA countries will impinge on the nature and size of domestic policy shocks induced by the common ECB policy: a high (resp. low)-growth country takes the common interest rate as too-low (resp. high) as regards its domestic economic condition, and therefore faces a destabilizing policy that we define as a shock to its economy.

Figures 3.2 and 3.3 in section 6 report monetary policy shocks for each country, using the nominal short-term interest rate and the shadow rate, respectively. At first glance, the general pattern of the figures indicates that country-level shocks do not significantly differ from the monetary surprises documented by, for instance, Jarocinski and Karadi (2015) for the EA. However, some differences between countries in terms of monetary policy stance are worth noting. For example, in Figure 3.2, towards the end of the period, when monetary policy shocks are expansionary, particularly in Germany and Finland, the latter are restrictive in Greece.

### 3.2 Panel VAR

In order to empirically assess the dynamic interaction between monetary policy and income inequality in the EA, we use a panel VAR framework. The panel dimension allows to differentiate dynamics across countries via the estimation of country-fixed effects while shedding light on the whole area dynamics. The VAR approach has the advantage to tackle the endogeneity problem, since it allows for endogenous interaction between variables in the system.

The Panel VAR is estimated using the Least Squares Dummy Variable estimator (LSDV).[7] Specifically, country-fixed effects are included in order to account for the country time-invariant characteristics. In dynamic panel data models, the LSDV estimator is nonetheless inconsistent, whether individual effects are considered as fixed or random. This is known as the dynamic panel bias. As shown by Nickell (1981), this bias stems from the correlation between lagged endogenous variables and unobserved time-invariant characteristics. Consequently, the LSDV estimator is consistent only when the number of time observations in the data set tends to infinity. Yet, the importance of this bias decreases as the length of the sample increases. Given that our analysis aligns with a time dimension (61 observations per country) that is longer than the country dimension (10 countries), we believe that this bias remains small. The Monte Carlo evidence provided by Judson and Owen (1999)[8] regarding the importance of the bias in comparison to the sample size supports our assertion.

We checked the robustness of Least Squares Dummy VARs conducting the empirical analysis with the Mean Group (MG) estimator described in Pesaran and Smith (1995). This estimation method has the advantage to fit separate country-regressions and computes an arithmetic average of the coefficients. The MG does not contradict the results obtained in the baseline model. In the following, we thus continue relying on the LSDV estimator. The econometric model takes the following reduced form:

$$Y_{it} = A(L)Y_{it} + \alpha_i + \varepsilon_{it}$$

[7] Cagala and Glogowsky (2014) provide a Stata code and documentation to estimate panel VAR models.

[8] Judson and Owen (1999) argue that when the number of time observations is higher than 20, the bias of LSDV for dynamic panel data models is small.

where $Y_{it}$ is the vector of endogenous variables, which includes: income inequality measures, real GDP, consumption deflator, a policy rate and the stock market index. $A(L)$ illustrates a polynomial matrix in the lag operator with $A(L) = A_1L^1 + A_2L^2 + ... + A_pL^p$; $\alpha_i$ is a set of country fixed effects and $\varepsilon_{it}$ is a vector of uncorrelated *iid* shocks. Intuitively, the indices $i$ and $t$ respectively denote countries and quarters. Our 10 countries panel is strongly balanced for the period 2000Q3-2015Q3.

Monetary policy shocks are identified using, as aforementioned, a recursive identification scheme, which leads the impact matrix to be lower triangular. However, this identification scheme generally leads to the so-called "price puzzle", as inflation counter-intuitively reacts to monetary policy innovations and yields inconsistent estimates. In dealing with this issue, as suggested by Estrella (2015), we assume that prices react with a lag to unexpected changes in the policy instrument. Such restriction is empirically documented, among others, by Bernanke et al. (1999) and emphasizes the fact that monetary policy has a delayed impact on prices, hence the ordering of the consumption deflator before the short-term interest rate (or shadow rate).

Building on the estimation of the panel VAR, we are interested in generating the Impulse Response Function (IRF) of the income inequality measure to a monetary policy shock when the latter is calibrated as a +100 b.p. increase in the policy instrument. IRFs simulate the response of inequality measures to an exogenous increase in the monetary policy instrument and also allow to check if the model correctly behaves, i.e. if the responses of macroeconomic and financial variables to a monetary policy shock are in line with the empirical literature. The significance of the IRFs is evaluated using 90-percent confidence intervals. These intervals are computed based on a double bootstrap re-sampling scheme with 200 replications. The optimal number of lags, of value one, stems from the Akaike Information Criterion. The lag number is consistent with the VAR literature: e.g. Blot et al. (2017) and Guerello (2018) use 3 lags (but with monthly data).

# 4 Results

## 4.1 Baseline

The results obtained after estimating equation 1 use alternatively 3 measures of income inequality: the (pre-social transfers) Gini coefficients, the net (post-social transfers) Gini coefficients and the S80/S20 inter-decile ratio. As formerly mentioned, we alternatively use in our Panel VAR two instruments of monetary policy: the policy rate and the shadow rate *à la* Wu-Xia. Results of the model including the Gini coefficient are presented in Figures 4 and 5. The figures show the estimated responses to monetary shocks and their associated confidence bands. Results report a significant impact of monetary policy on inequality. A restrictive monetary policy increases inequality, in line with the findings documented by Coibion et al. (2017). The impact is relatively small though, also in line with the literature (see e.g. O'Farrel et al. (2016) for a selected panel of 8 OECD economies). A temporary positive shock on the nominal policy rate produces a maximum impact of .1 on the Gini coefficient 3 years after the shock. When the shock vanishes, so does its impact. The response to a shock on the shadow rate is slightly higher but as persistent as the first reported shock. To the best of our knowledge, this is the first estimation in the EA of the impact of the shadow rate (encompassing *both* the standard and non-standard monetary policy measures) on income inequality. In contrast, Guerello (2018) uses the innovations to the ECB balance sheet as a proxy for non-standard monetary policies only. One may argue though that unexpected changes in the balance sheet can be either attributed to standard *or* non-standard policies.

The other estimated responses to a monetary policy shock are also significant and very similar from one type of instrument ("standard") to another ("non standard"). On top of that, they are broadly consistent with expectations. A restrictive monetary shock of 100 b.p. reduces the output by 2.5 percent after 3 years and inflation by 1.2 percent after 5 years. The response of inflation lasts longer than that of the output. In contrast, stock prices move faster: the maximum drop is achieved 2 years after the shock and the response vanishes approximately 4 years after the shock (instead of 5 years when the shadow rate is used).

We confront our results to alternative measures of inequality: the *net* Gini coefficients and the S80/S20 ratios (both IRFs on inequality measures are reported in figures 6 and 7). Doing so allows to check the degree to which monetary policy could affect income inequality, net of the contribution of tax policy. In the same spirit, the inter-decile ratio has the advantage to show whether monetary policy shocks raises the gap between high-income earners and low-income ones. It appears that results are very similar to those obtained previously.

While comparing IRFs, we notice that the main difference concerns the first year after the (conventional or unconventional) shock, and it is limited to the response of income inequality (other responses show similar dynamics).[9] While the Gini coefficient started increasing significantly right after the shock, the responses of the *net* Gini coefficient and the S80/S20 ratio are not statistically different from zero before a year. Moreover, the maximum impacts of a restrictive monetary policy on these two complementary measures of income inequality are more than halved in comparison with the impact on the Gini coefficient. This suggests that distributional effects of monetary policy are less potent when redistribution and fiscal transfers are taken into account. Besides, the assertion that monetary policy widens disparities between the tails of income distribution is not supported by the data.

Also in line with the findings of Coibion et al. (2017) and Guerello (2018), the Forecast Error Variance Decomposition (FEVD) of the Gini coefficients (see figures 8 and 9) show that the monetary policy instruments are relatively relevant in accounting for the volatility of income inequality measures in the medium-long run.[10] In other words, they are as relevant as output or inflation in explaining the variance of income inequality measures. It is worth noting however that the shadow rate explains a higher share of the Gini coefficient's volatility than the policy rate. This makes sense inasmuch as the shadow rate encompasses numerous monetary policy measures (i.e. asset purchase programs, credit easing facilities, forward guidance, etc.).

[9]Figures for the entire Panel VAR models are reported in the appendix

[10]The FEVD of net Gini and the S80/S20 ratio are similar to the Gini ones; they are available upon request.

## 4.2 Robustness checks

To check the robustness of results, we adopt two complementary orderings. Results are reported in figures 10 to 17.[11] On the one hand, we adopt the same ordering as Guerello (2018), with the indicator of income inequality ordered last in the vector of dependent variables. In contrast with the baseline model, this ordering assumes a faster reaction of the indicator of income inequality to macroeconomic and financial changes. Results confirm those from the baseline and add only a few elements: overall, the impact of the policy and shadow rates on indicators of income inequality is slightly higher and, as regards *net* Gini coefficients and S80/S20 ratios, the impact is more significant in the short run.

On the other hand, we order the monetary policy variable last in order to "purge" it from all possible changes in the preceding variables and therefore identify a "pure" policy shock. In contrast with the baseline, the policy shock is also adjusted for the possible immediate impact of stock price changes. This ordering scheme does not affect the results, which are very similar, if not identical, to those in the baseline. In both cases, the ordering change has no impact on the IRFs of macroeconomic and financial variables.

To make sure that our baseline results are not sensitive to the income inequality measures considered, we estimate our Panel VAR using gross Gini series extracted from the World Inequality Database (WID, 2017). As a matter of fact, the WID uses up-to-date national survey statistics and does not face issues related to the imputation procedures of missing data as in the SWIID; but features, in contrast, a narrower country coverage.[12] Results are reported in figures 18 and 19. They do not contradict our baseline findings: the effect of monetary policy on the gross Gini – both under the policy and shadow rates – remains the same, compared to IRFs generated using the SWIID data, although it is not statistically significant in the short-run.

In the same spirit, it is worth checking how income inequality indicators respond when using a different proxy of unconventional monetary policies. The term structure models that build shadow rates rely on different assumptions and may potentially yield contrasting estimates. In

[11]For the Gini coefficient, we present the entire Panel VAR with both monetary policy instruments, while we only report the response of the *net* Gini and the S80/S20 ratio in the main text (their respective entire IRFs are displayed in the appendix in figures 30 to 37).

[12]As a case in point, Gini coefficients for Germany are not available in the WID. Hence we conduct the estimations on the remaining 9 EA economies.

fact, Krippner (2019) recently argued that the Wu and Xia (2016) shadow/lower-bound model produces "*wide variations in the inferred effects of unconventional monetary policy on inflation and unemployment outcomes*". This is why we estimate our baseline model using the Shadow short rate (SSR) of Krippner (2015). The results reported in figure 20 are consistent with those from the baseline: a temporary positive shock on the shadow rate increases the three indicators of income inequality. We note, however, that the maximum impact on inequality is lower and occurs later, compared to IRFs generated with the shadow rate of Wu and Xia (2016); while the response of the S80/S20 inter-decile ratio is less statistically significant.

### 4.3 Northern vs. Southern economies

It is fair to ask whether monetary policy shocks have a distinct effect between Northern and Southern economies of the EA. As a matter of fact, while all countries have been hit by the Global Financial Crisis (GFC), the European sovereign debt crisis has mostly hit Southern economies of the EA. Given the fact that austerity measures may have weakened redistribution in these countries, ECB policies may have contributed to mitigating their impact on income inequalities. To empirically assess this assumption, we decompose the impact of monetary shocks on income inequality between EA Northern (Austria, Belgium, Finland, France, Germany and the Netherlands) and Southern (Greece, Italy, Spain and Portugal) countries. Results are reported in figures 21 to 24 in section 6. They show that the baseline results are mainly driven by Southern EA countries.

Indeed, in the Northern economies, the impact of monetary policy shocks on indicators of income inequality is not different from zero, whatever the horizon. There is just one exception, at a 1-year horizon, for the impact on S80/S20 ratio after a shock on the shadow rate. In contrast, the impact of monetary policy shocks in the Southern countries is positive: it is only weakly significant in the short-run on the Gini coefficient but it is highly significant in the mid- to long-run on the S80/S20 ratio. The mitigation of the impact on income inequality by monetary policy is full once its effect on redistribution is accounted for: monetary policy has no impact on *net* Gini coefficients. The same argument cannot hold for the Northern countries where austerity measures have been much softer.

### 4.4 Standard vs. non-standard monetary policies

Are the distributional effects of non-standard monetary policies more pronounced, with respect to those of standard monetary policy? This question has been at the heart of the policy debate on the distributional implications of monetary policies. To address this question, we separately estimate on the one hand, the impact of unconventional monetary policy shocks on income inequality from 2008Q3 to 2015Q3 and, on the other hand, the impact of conventional monetary policy shocks on income inequality until the ZLB was hit. Thus, in contrast with the baseline, we alternatively remove the period over which the policy rate and the shadow rate had the same value (more or less before the ZLB) and the period of constant policy rate (after the ZLB).

Results are reported in figures 25 and 26. They show that baseline results are mostly driven by conventional policies. Indeed, responses of indicators of income inequality to monetary policies before the ZLB are very similar to those in the baseline. In contrast, shocks on the shadow rate after 2008Q3 give only mixed results: the response of S80/S20 ratios is faster, lower and more temporary than in the baseline; the response of the Gini coefficient is weakly significant, when it is; and the response of the *net* Gini coefficient is not different from zero.

### 4.5 The case for missing variables

We check whether the results do not depend on missing variables. To do so, we include three additional variables to the baseline model: inflation expectations, employment and real estate prices. Inflation expectations are usual determinants of policy rates in the literature on monetary rules.[13] Employment can give additional information on the real dynamics of the economy and it can also serve as a proxy for income inequality, while real estate prices may give additional information on financial trends.[14] We include these additional variables alternatively, then we retain those that give statistically significant IRFs in an extended VAR, and discuss the impact of monetary policy shocks on income inequality. It appears from the results of the Panel VAR with a 6th variable[15] that the IRFs of inflation expectations are

[13]The estimaton of monetary rules is implicit in the identification of policy shocks that we follow.

[14]Real estate prices can move differently from stock prices.

[15]IRFs are available upon request. In the successive VAR estimations, 1-year inflation expectations and employment were respectively ordered between GDP and the price deflator whereas real estate prices were ordered between the policy rate (or

never significant after a monetary shock. We therefore end up studying a VAR(7) including employment (ordered 3rd in the VAR) and real estate price index (ordered 6th). Results are reported in figures 27 and 28. They confirm the baseline results about income inequality and, meanwhile, they show that the full empirical model has good properties: IRFs are statistically significant and show usual signs. Monetary policy looks stabilizing: a positive shock reduces all macroeconomic and financial variables.

### 4.6 Monetary policy, inequality and redistribution

Finally, we question the relevance of our baseline results after taking into account redistributive policies. It is well-known that the inequality debate has raised questions on the extent to which redistribution policies could mitigate income dispersion. Meanwhile, questions arose on the possible impact of redistributive transfers on economic growth. Using data from the SWIID on Gini coefficients for 35 developed and developing countries, Berg et al. (2018) study the relationship between inequality, redistribution and growth. In particular, they compute redistributive transfers as the difference between the Gini coefficient for market income and for net income inequality, and test their impact on per capita growth. They notably show that the effects of redistribution are on average pro-growth.

We follow their identification of redistributive transfers and allow the latter to endogenously vary in the Panel VAR framework. Introducing redistributive transfers in the vector of endogenous variables has two advantages: first, it gives an assessment of the impact of redistribution policies on the contribution of monetary policy shocks to market income inequality; second, it highlights the possibility of a dynamic causal effect of monetary policy on the level of redistribution policies. The vector of endogenous variables takes the following ordering:

shadow rate) and stock prices.

$$Y_{it} = \begin{pmatrix} \text{Gini coefficient} \\ \text{Redistributive transfers} \\ \text{Output} \\ \text{Prices} \\ \text{Policy instrument} \\ \text{Stock returns} \end{pmatrix}$$

Results are reported in figures 29 and 30. The model exhibits the same effects on macroeconomic variables as the baseline. An increase of 100 b.p of the nominal policy rate produces a maximum impact of .06 on the Gini coefficient 3 years after the shock. Moreover, a temporary positive shock on the shadow rate has a slightly higher effect on income inequality (a peak increase of .08 in the Gini coefficient 3 years after the shock). In terms of magnitude, this finding is quite similar to what the Panel VAR has documented when using the *net* Gini as the main inequality measure. Therefore, this confirms that the effect of monetary policy on income inequality (before taxes and transfers) is lower when redistribution is taken into account. It also confirms that despite redistributive transfers, the impact of monetary policy on income inequality still holds.

Results also point out that a positive monetary policy shock increases redistributive transfers. This effect is, however, weakly significant and not persistent in the context of conventional monetary policy, while the opposite is true for a temporary shock on the shadow rate. This would lend support to the conclusion by Berg et al. (2018) that “more unequal societies tend to redistribute more“.

## 5 Conclusion

The topic of monetary policy and inequality has raised a debate among academics and policymakers in the U.S. Yet, what do we know about the distributional effects of monetary policy in the Eurozone? This paper seeks to examine the redistributive impacts of monetary policy in 10 EA economies over the period 2000-2015. Our contribution to the literature on monetary policy and income distribution is twofold. First, we use comprehensive standardized data on income inequality and mobilize three different indicators: Gini coefficient, *net* Gini and the S80/S20 ratio. Second, monetary policy stance is proxied by the nominal short-term interest rate and the shadow rate *à la* Wu-Xia. This is done in order to jointly capture the standard and non-standard measures implemented by the ECB. Monetary policy shocks are identified – using a Cholesky decomposition – as innovations to the policy rate (or shadow rate), which do not contemporaneously affect macroeconomic conditions. Empirically, we estimate a Panel VAR model with quarterly data and generate IRFs of income inequality indicators to a monetary policy shock.

The obtained results indicate that contractionary monetary policy increases income inequality. The effect is statistically significant for the three indicators of inequality, though small in magnitude. These results are consistent with the empirical findings of Coibion et al. (2017) and more specifically Guerello (2018). The results hold up to a battery of robustness checks, including the introduction of complementary sets of ordering, inequality data from the World Inequality Database and a different proxy of unconventional monetary policies. In addition, our paper offers two contributions as: (i) we do not find a striking difference in terms of impact on inequality between conventional and unconventional monetary policy; and (ii) the effects on income inequality in the 10 EA economies appear to be driven by conventional monetary policy measures, primarily in periphery countries (i.e. Southern European countries). In contrast with most papers on the topic, we have checked that results continue to hold after redistributive transfers are taken into account. Two implications can be drawn from these results. First, the recent non-standard monetary policy implemented by the ECB are likely to have reduced income inequality or, at worst, produced a negligible impact on income distribution. Second, the normalization of monetary policy may raise income inequality in the euro area. While this rise may be limited, it is important for policymakers to anticipate it. Then they could try to elude, with redistributive policies, that this limited rise in inequality is perceived as the last straw that breaks the camel's back.

# 6 Main figures

Figure 3.2: Country-level monetary policy shocks (Conventional)

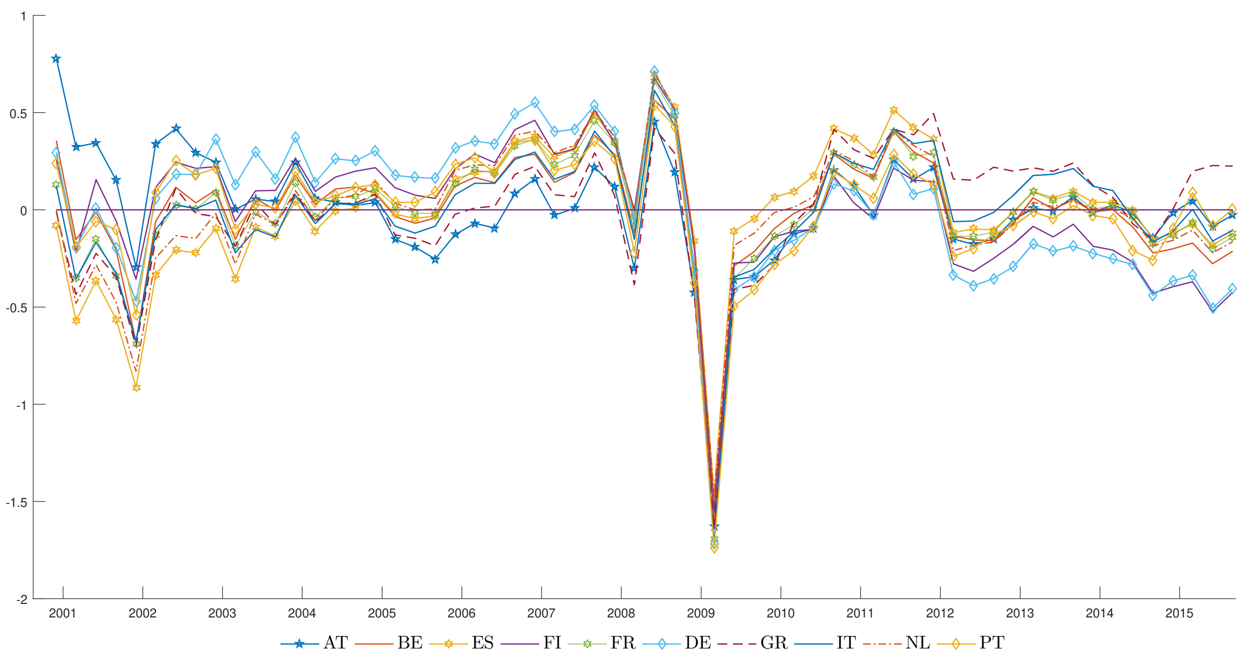
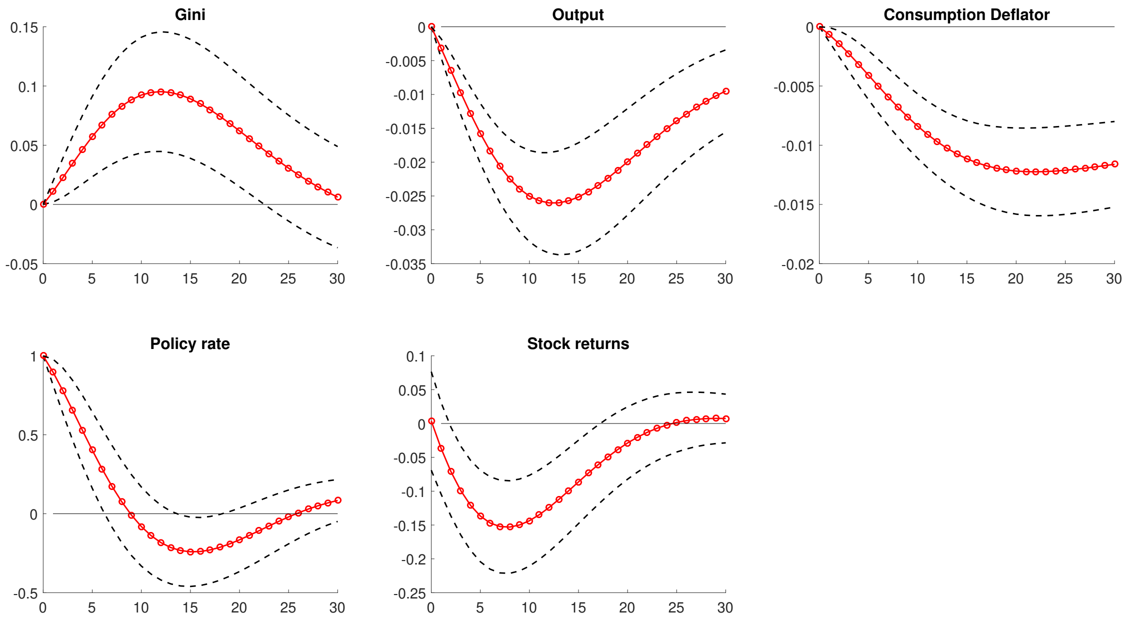


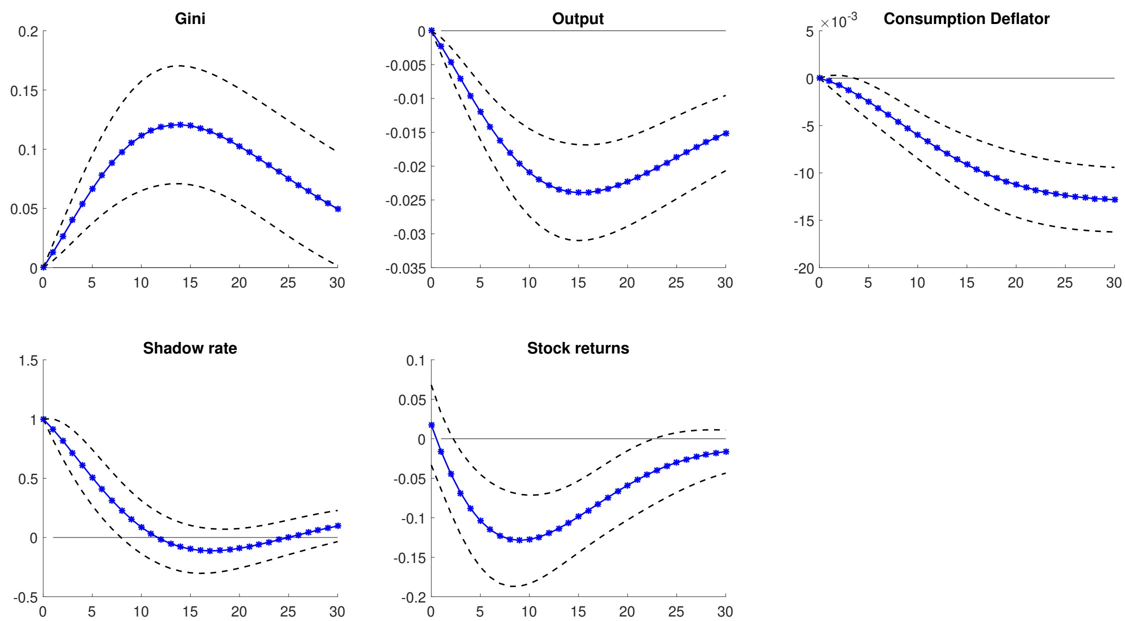

Figure 3.3: Country-level monetary policy shocks (Unconventional)

Figure 4: Responses to a shock on the policy rate, baseline model



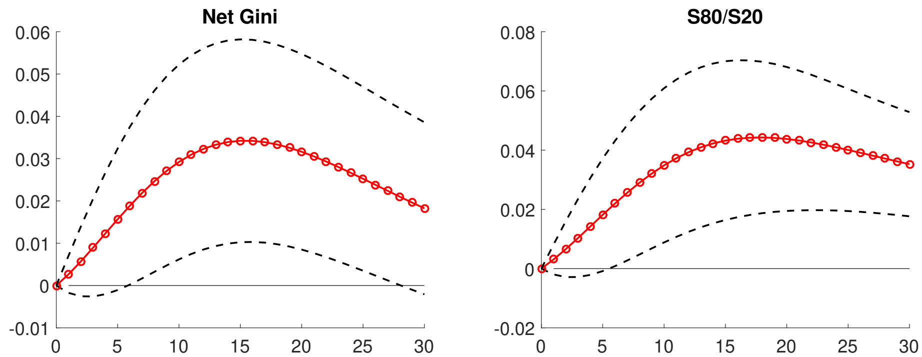

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 5: Responses to a shock on the shadow rate, baseline model



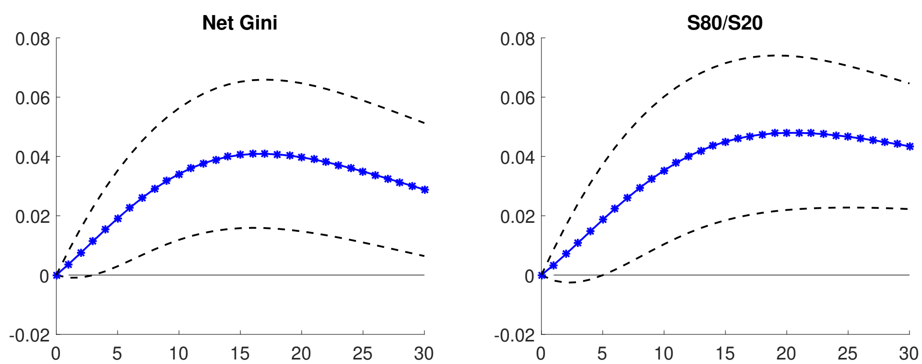

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 6: Responses to a shock on the policy rate, baseline model




Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 7: Responses to a shock on the shadow rate, baseline model




Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 8: FEVD of Gini coefficient (shock to policy rate), baseline model

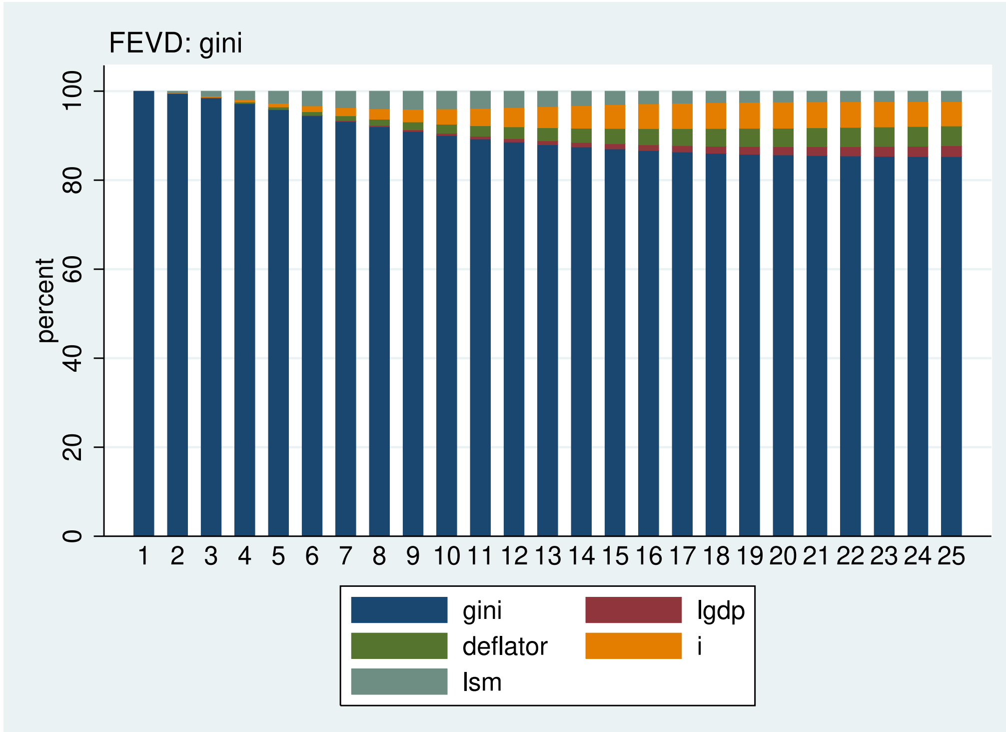



Figure 9: FEVD of Gini coefficient (shock to the shadow rate), baseline model

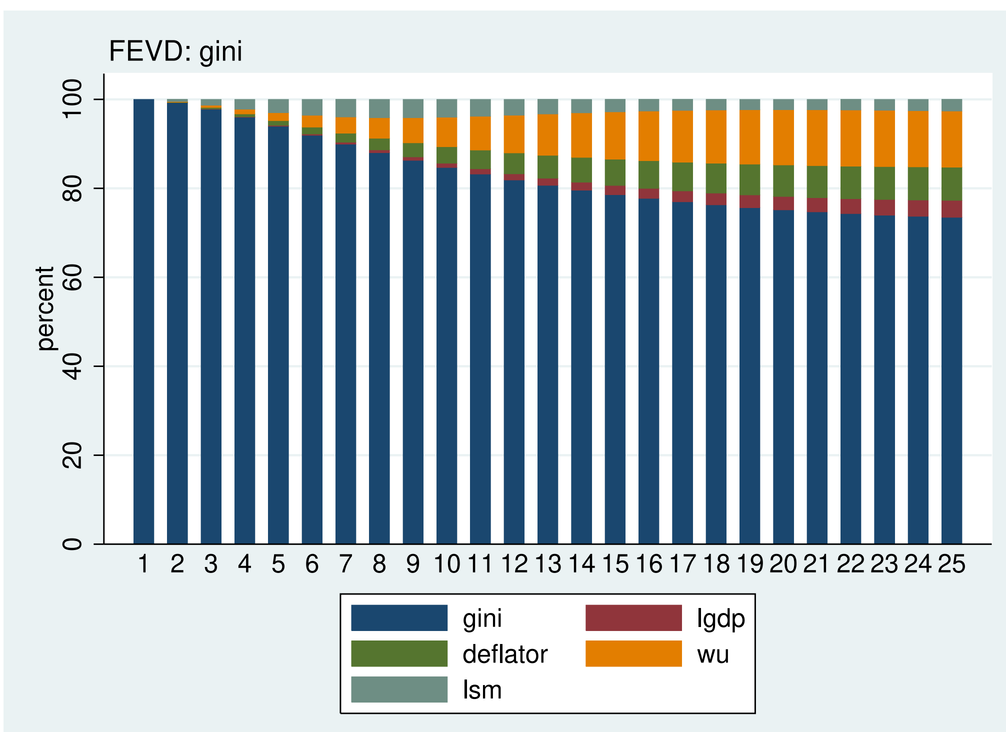
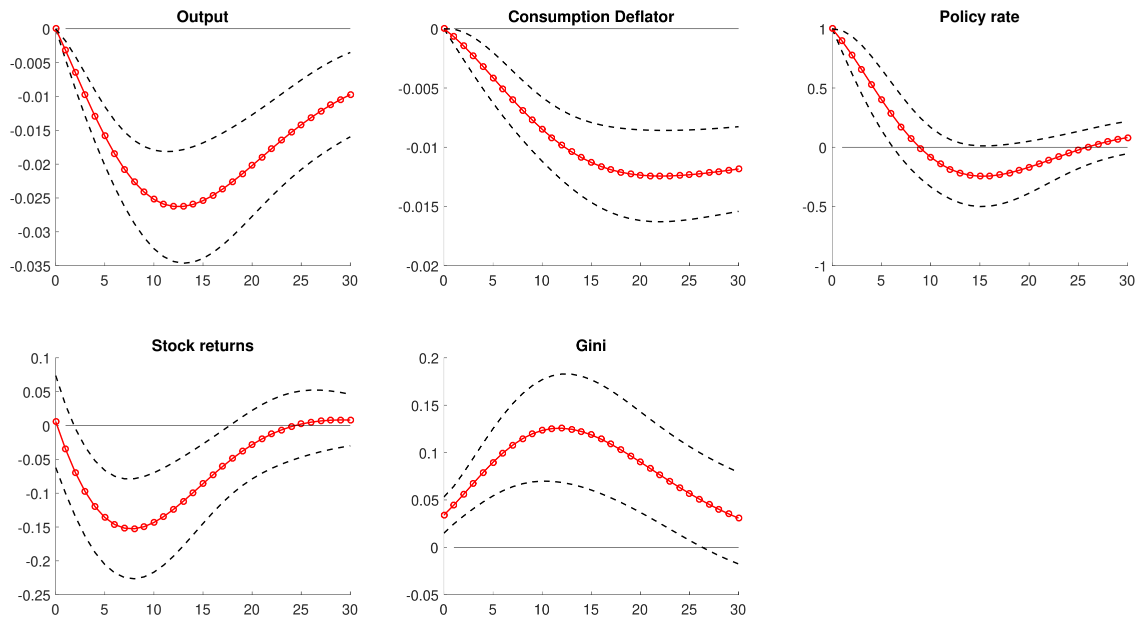
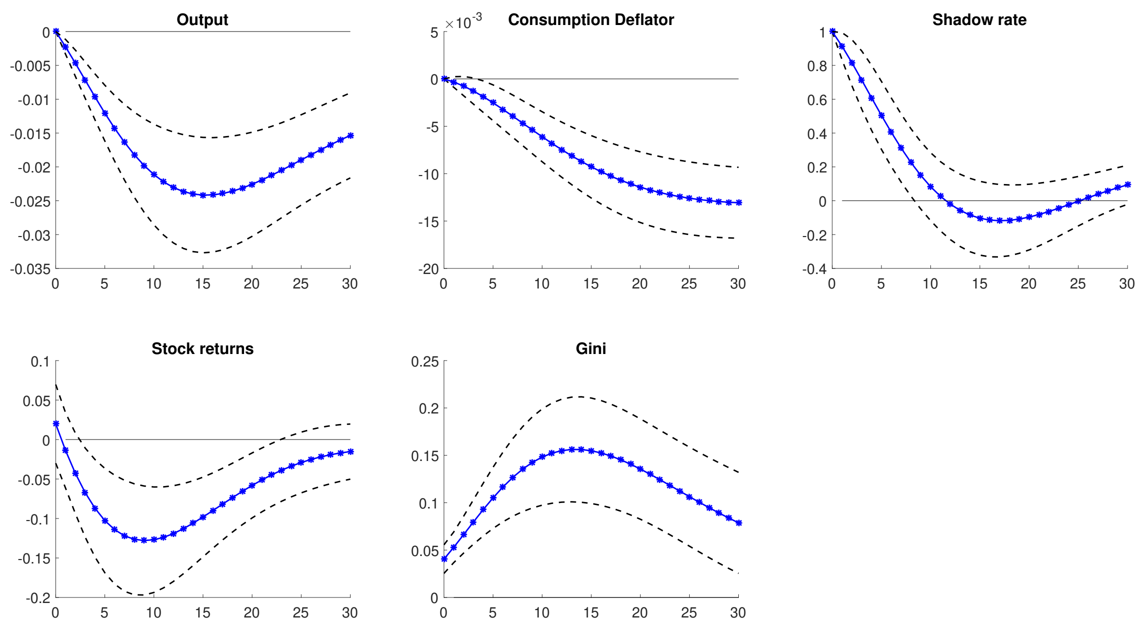


Figure 10: Responses to a shock on the policy rate (Ordering à la *Guerello*)



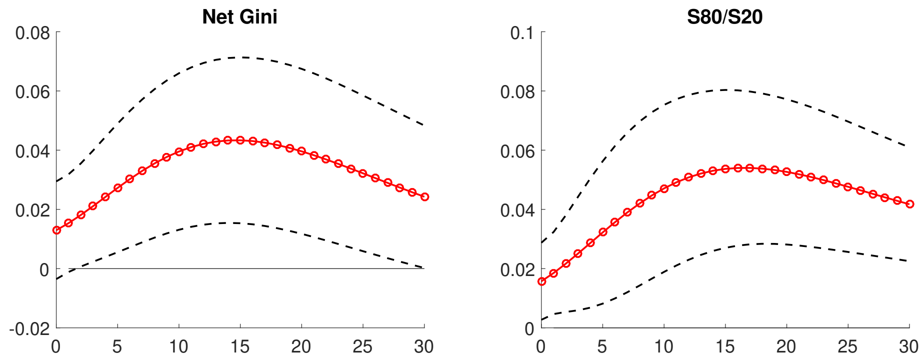

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 11: Responses to a shock on the shadow rate (Ordering à la *Guerello*)



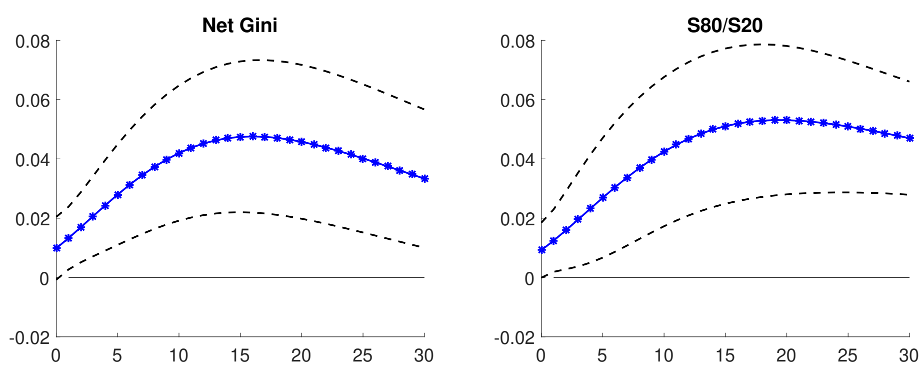

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 12: Responses to a shock on the policy rate (ordering à la *Guerello*)



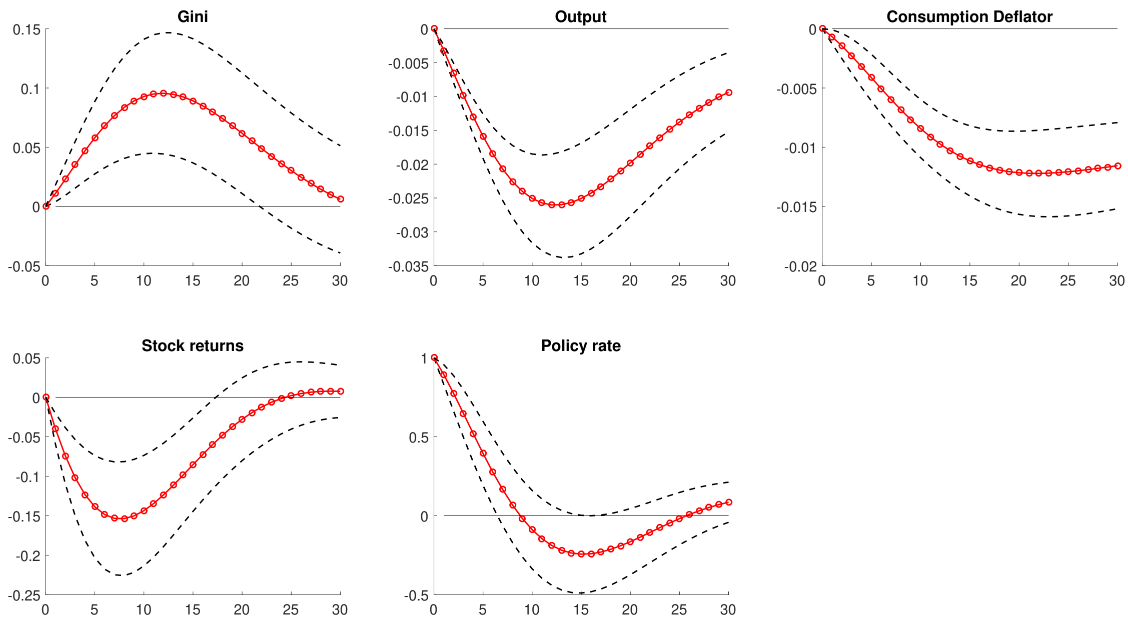

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 13: Responses to a shock on the shadow rate (ordering à la *Guerello*)



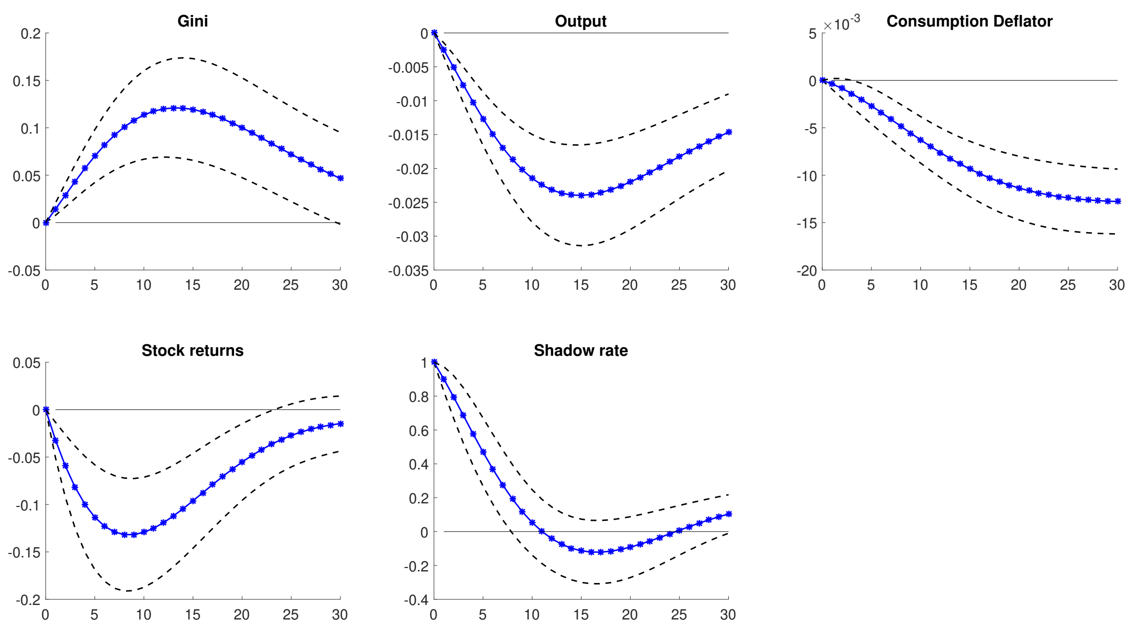

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 14: Responses to a shock on the policy rate (ordered last)



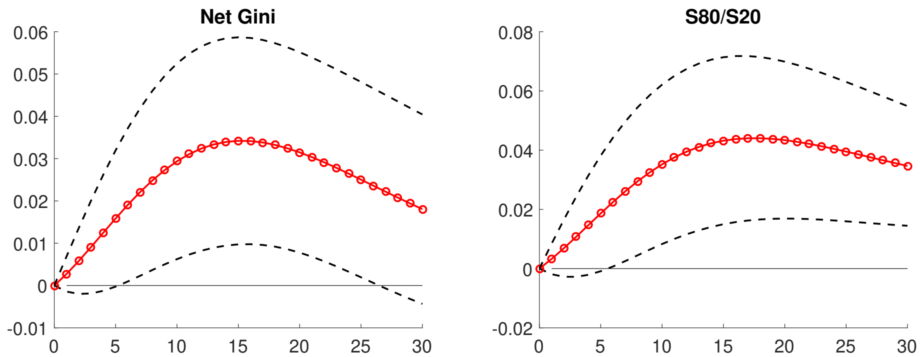

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 15: Responses to a shock on the shadow rate (ordered last)



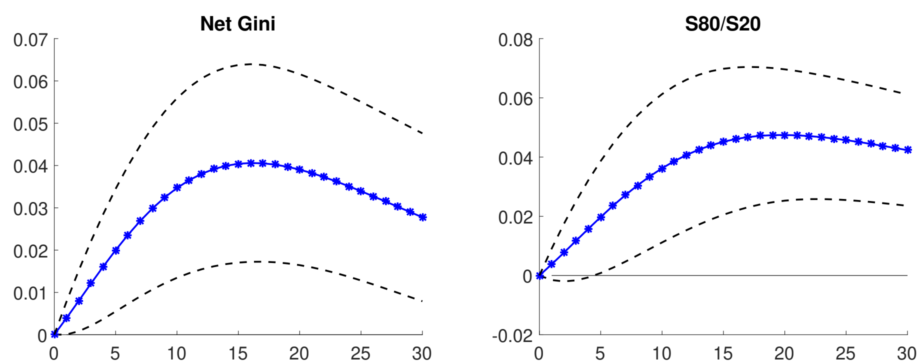

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 16: Responses to a shock on the policy rate (ordered last)



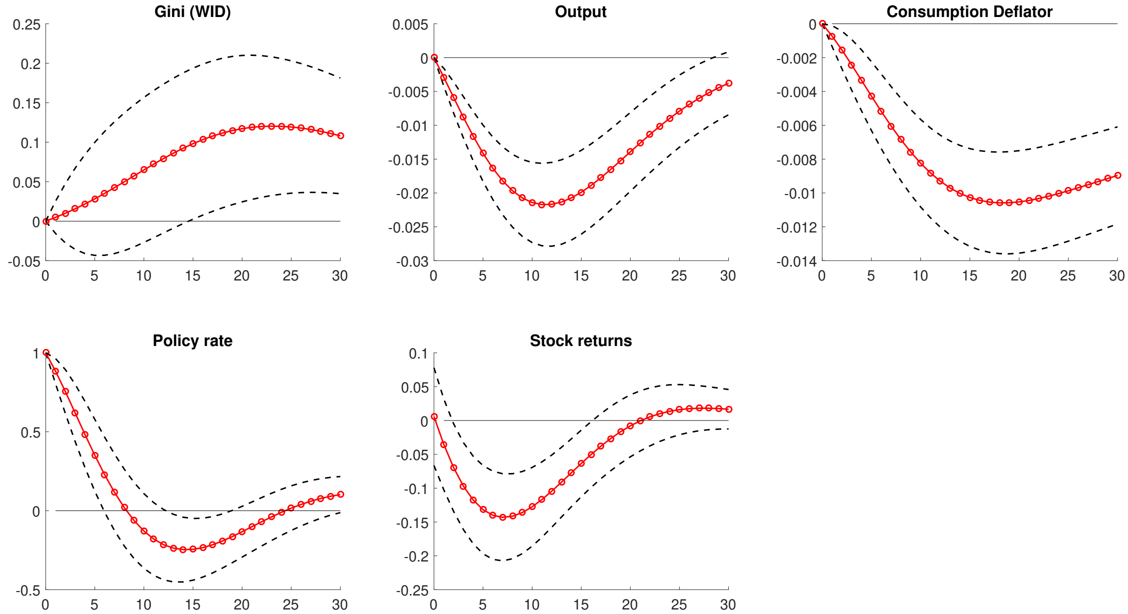

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 17: Responses to a shock on the shadow rate (ordered last)



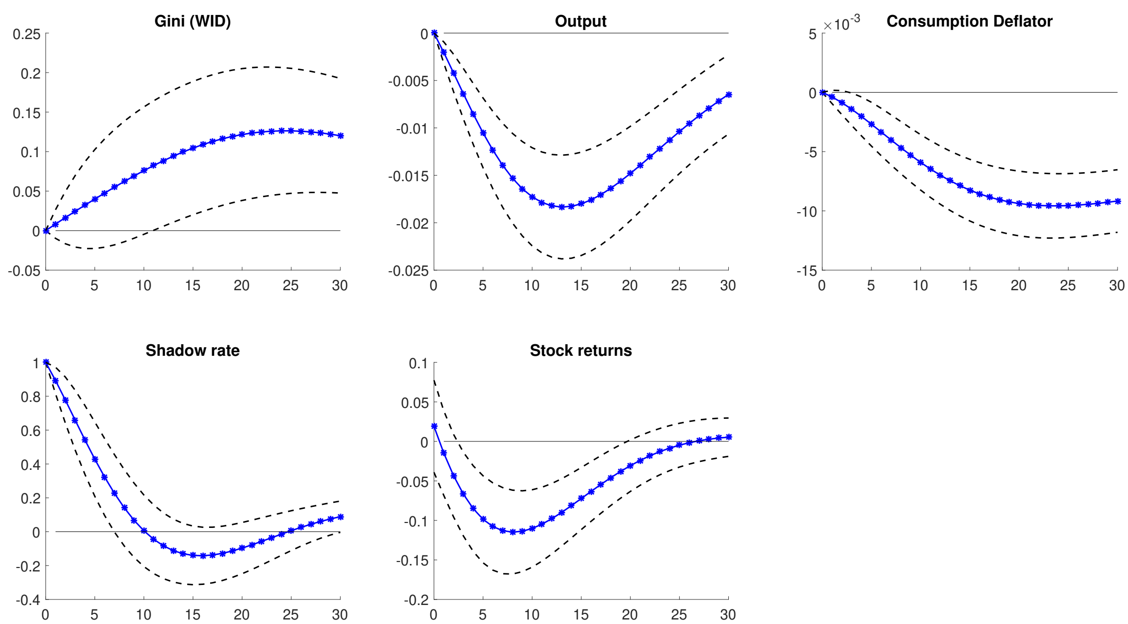

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 18: Responses to a shock on the policy rate, WID Gini



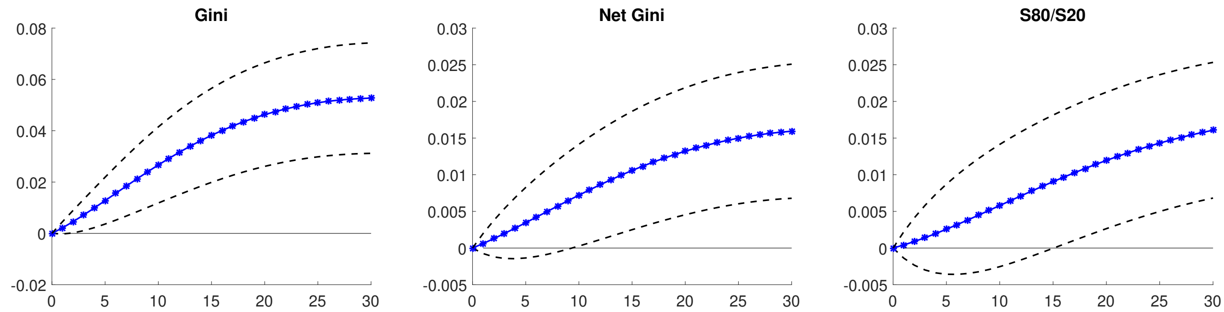

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 19: Responses to a shock on the shadow rate, WID Gini



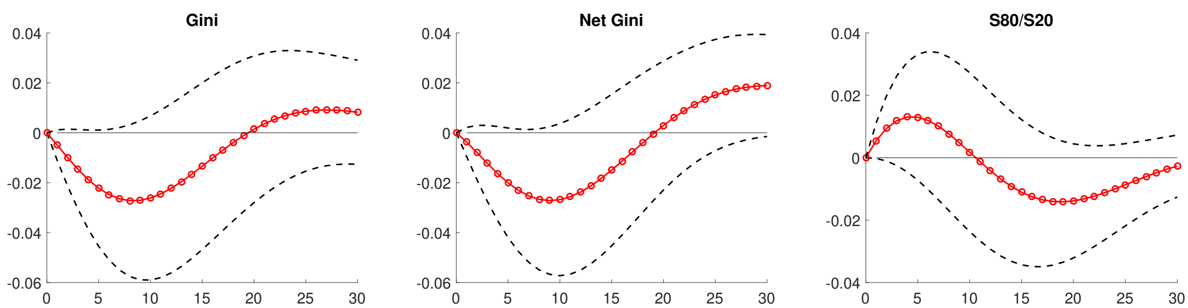

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 20: Responses to a shock on the shadow rate of Krippner (2015)



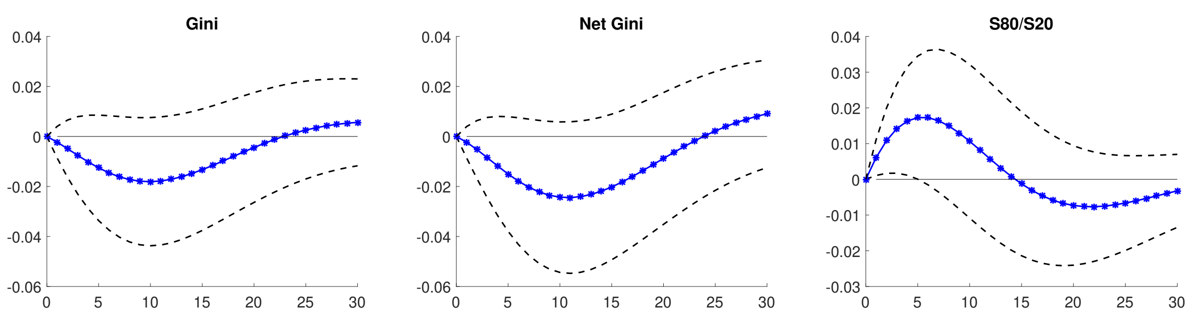

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate of Krippner. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 21: Responses to a shock on the policy rate (Northern Europe economies)



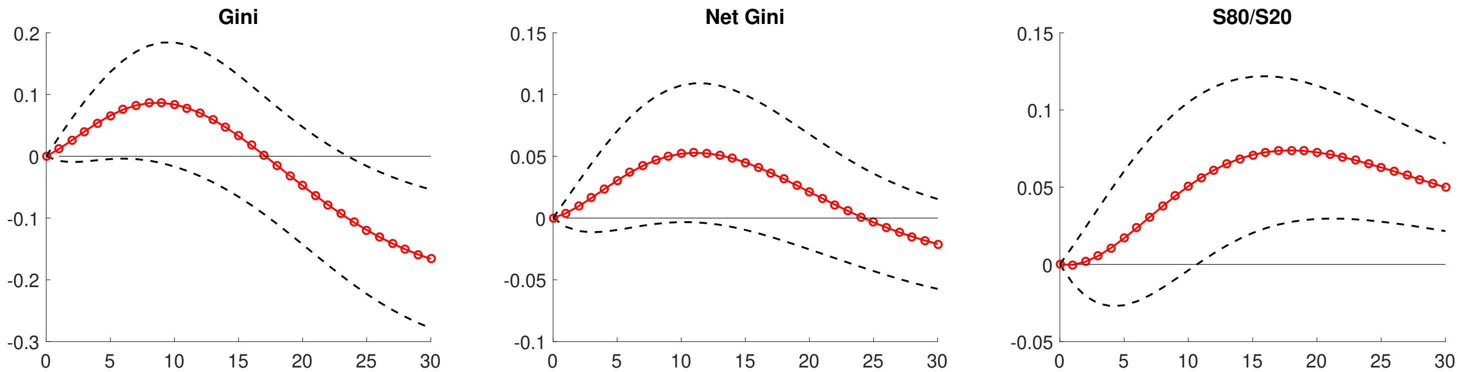

Note: The figure shows the impulse responses of income inequality measures to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 22: Responses to a shock on the shadow rate (Northern Europe economies)



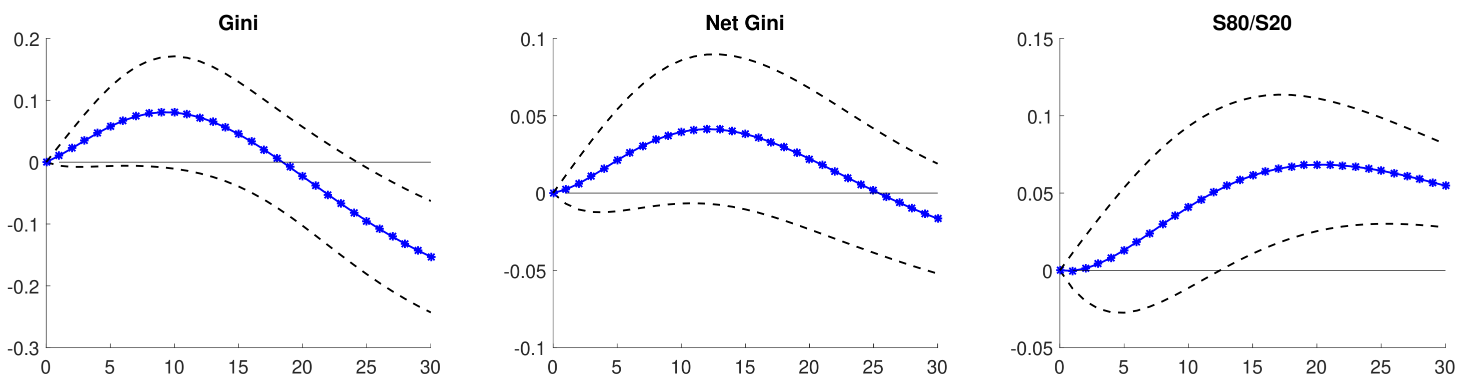

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 23: Responses to a shock on the policy rate (Southern Europe economies).



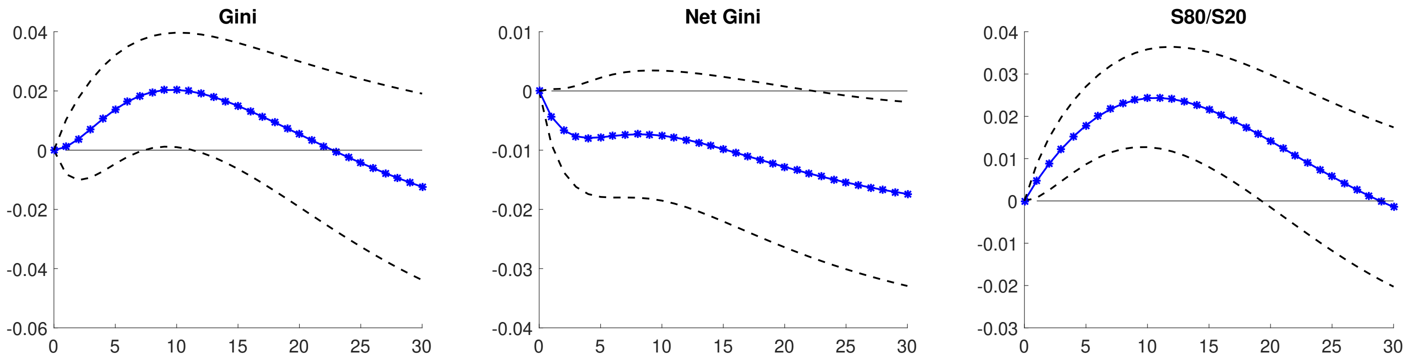

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 24: Responses to a shock on the shadow rate (Southern Europe economies)



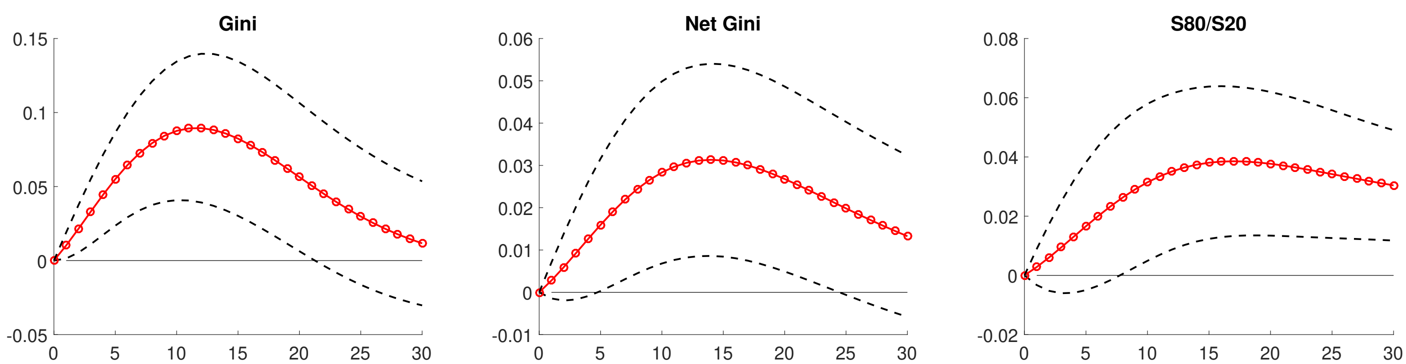

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 25: Responses to a shock on the Shadow rate (2008Q3-2015Q3)




Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 26: Responses to a shock on the policy rate (2000Q3-ZLB)

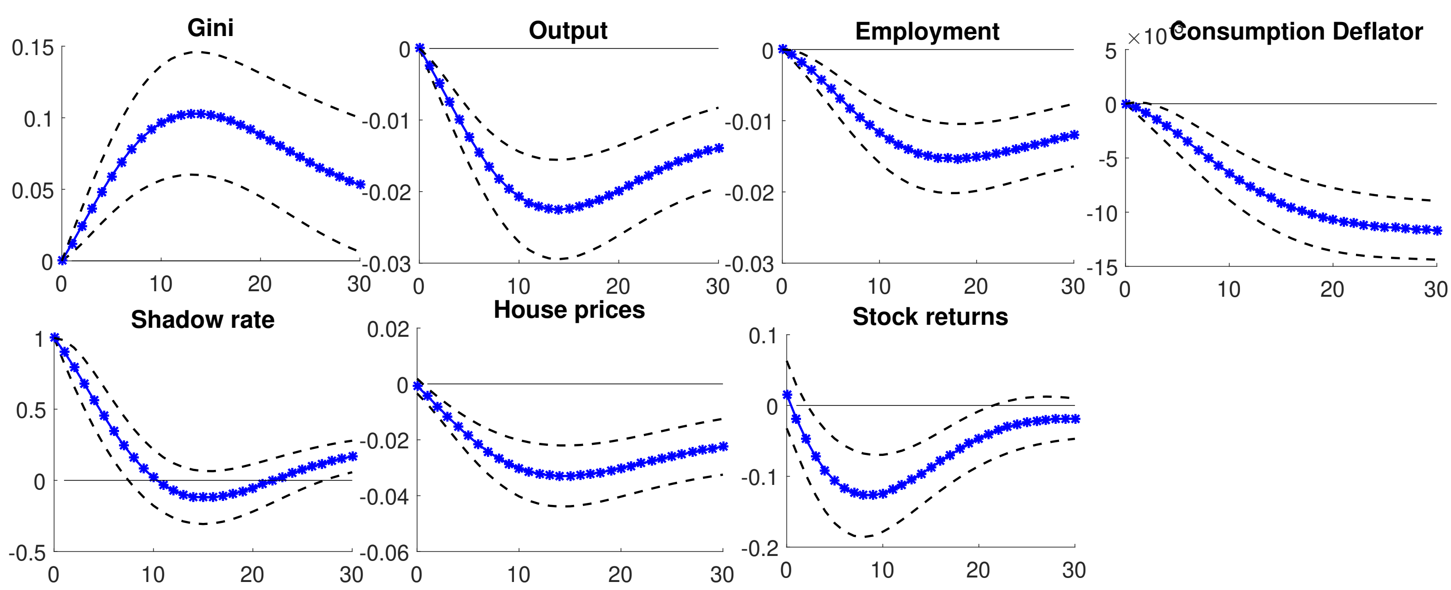



Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 27: Responses to a shock on the policy rate, VAR(7)

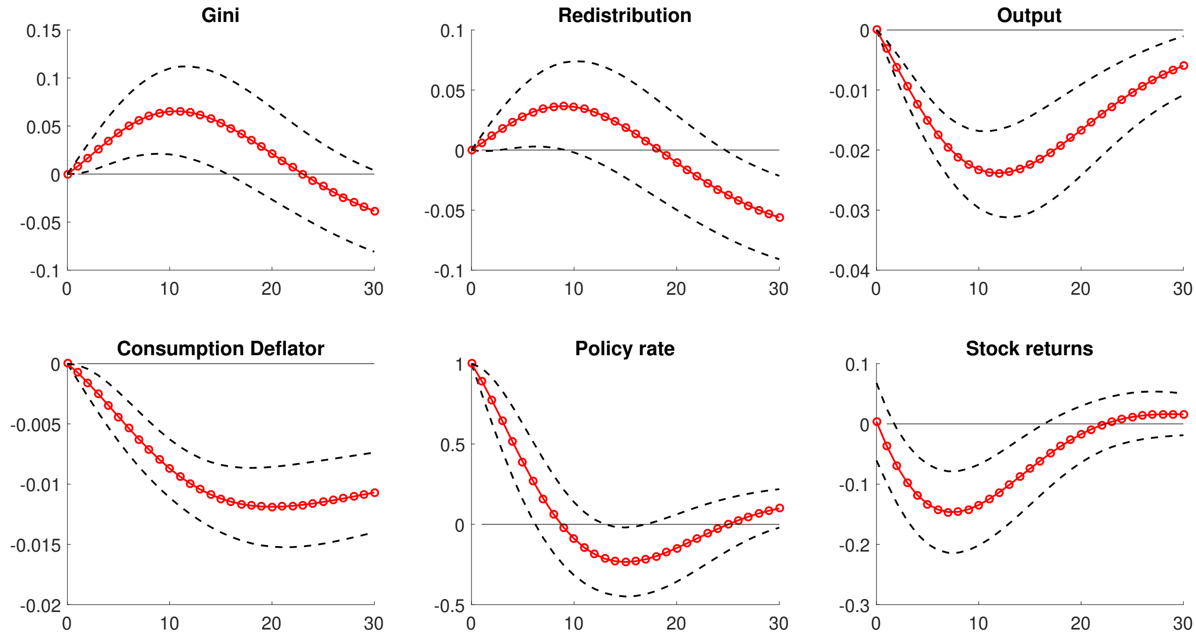

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 28: Responses to a shock on the shadow rate, VAR(7)



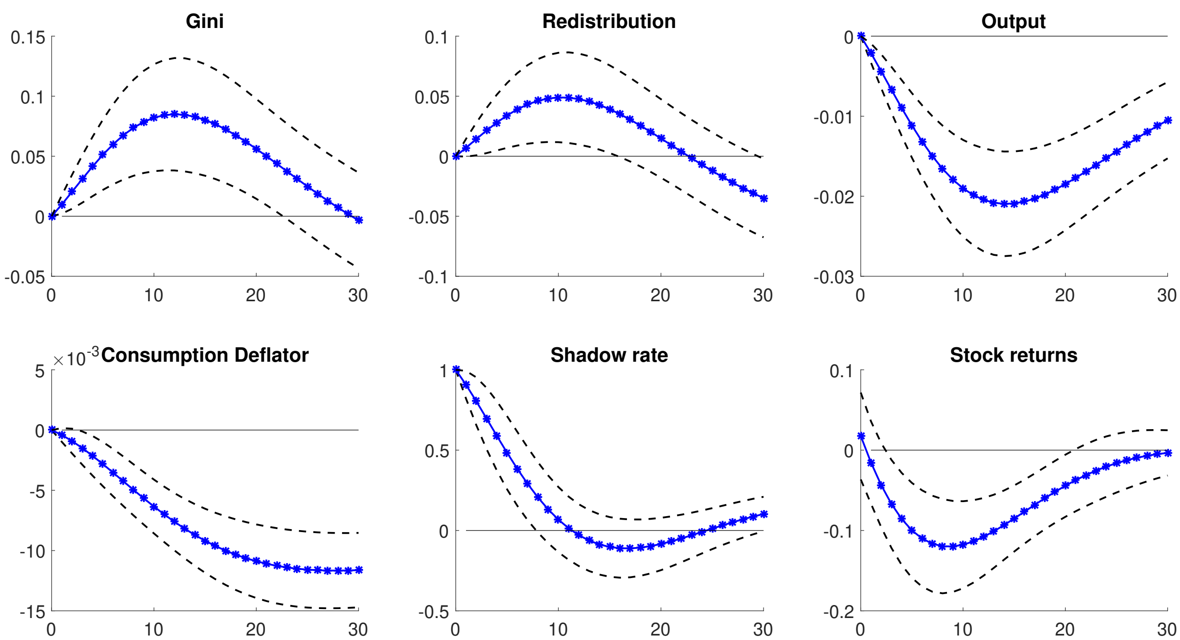

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 29: Responses to a shock on the policy rate, VAR(6)




Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 30: Responses to a shock on the shadow rate, VAR(6)




Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

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# 7 Appendix

Table 1: Description of country level data and sources

| Variable | Variable definition | Source |
|---|---|---|
| Real GDP | Seasonally and calendar adjusted, chain linked volumes (2005), mln euro | Eurostat |
| Stock returns | Stock prices index | Yahoo Finance |
| Consumption deflator | Ratio of nominal to real (chain linked volumes, index 2005=100) final consumption expenditure of households | Eurostat, own calculations |
| Short term interest rate | Euribor 3-month, average of observations through period | ECB Statistical Data Warehouse |
| Employment | Total employed population | OECD.Stat |
| Real house price index | Seasonally adjusted, ratio of nominal price to the consumers' expenditure deflator | OECD.Stat |
| Income inequality | Gini coefficient for market and disposable incomes. The ratio of total income received by the 20 % of the population with the highest income to that received by the 20 % of the population with the lowest income | Solt (2016) and OECD.Stat |

### 7.1 The Chow-Lin regression-based method

We follow Cholette and Dagum (2006)'s notation and assume we are studying a variable series $y_{\bullet}$ available on an annual basis along with a set of corresponding quarterly indicator $x$. The objective consists in obtaining the corresponding $3n$ quarterly estimates of the series $y_{\bullet}$. To do so, the corresponding quarterly estimates of $y$ must satisfy the following standard multiple regression:

$$y = X\beta + u, E(u) = 0, E(uu') = V \tag{1}$$

where $y$ is a 3nx1 vector of quarterly non-observable data $X$ is a 3n×p matrix of the related indicator series and u is a random error assumed to follow autoregessive model of order 1. To ensure the linear interpolation from annual to quarterly series, the n-dimensional annual series of $y_{\bullet}$ must also satisfy (1), which implies:

$$y_{\bullet} = Cy = CX\beta + Cu = X_{\bullet}\beta + u_{\bullet}, E(u_{\bullet}u_{\bullet}') = CVC' = V_{\bullet} \tag{2}$$

where $C = I_n \otimes c$ with $c$ is a 3x1 matrix, which, stands for temporal distribution when $c = [1 \quad 1 \quad 1]$ and interpolation when $c = [0 \quad 0 \quad 1]$. Chow and Lin (1971) introduce a $m$x1 vector $z$ for potential extrapolations outside the temporal range of $y_{\bullet}$ along with its corresponding regressors $X_z$. Hence, the Chow-Lin regression model becomes $z = X_z\beta + u_z$, with the best linear unbiased estimator of $\hat{z}$:

$$\hat{z} = Ay_{\bullet} = X_z\hat{\beta} + V_{z\bullet}V^{-1}\hat{u_{z\bullet}} \tag{3}$$

where $A$ is a $n$x$m$ matrix and $AX_{\bullet} - X_z = 0$, with such constraint ensuring the unbiasedness property of the estimator. That said, determining the value of matrix $A$ allows to obtain $\hat{\beta} = (X_{\bullet}'V_{\bullet}^{-1}X_{\bullet})^{-1}X_{\bullet}'V_{\bullet}^{-1}y_{\bullet}$, which corresponds to the generalized least square estimator of the regression coefficients using the n annual observations.

Figure 31: Responses to a shock on the policy rate (Baseline model)
*Income inequality measure: net Gini*

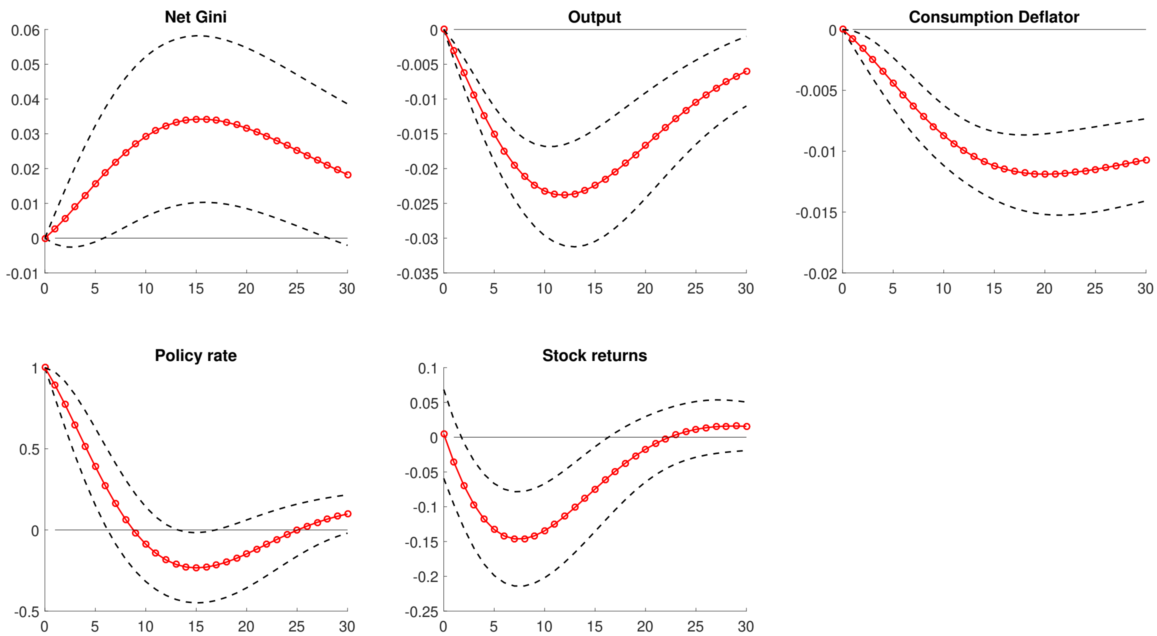



Figure 32: Responses to a shock on the shadow rate (Baseline model)
*Income inequality measure: net Gini*

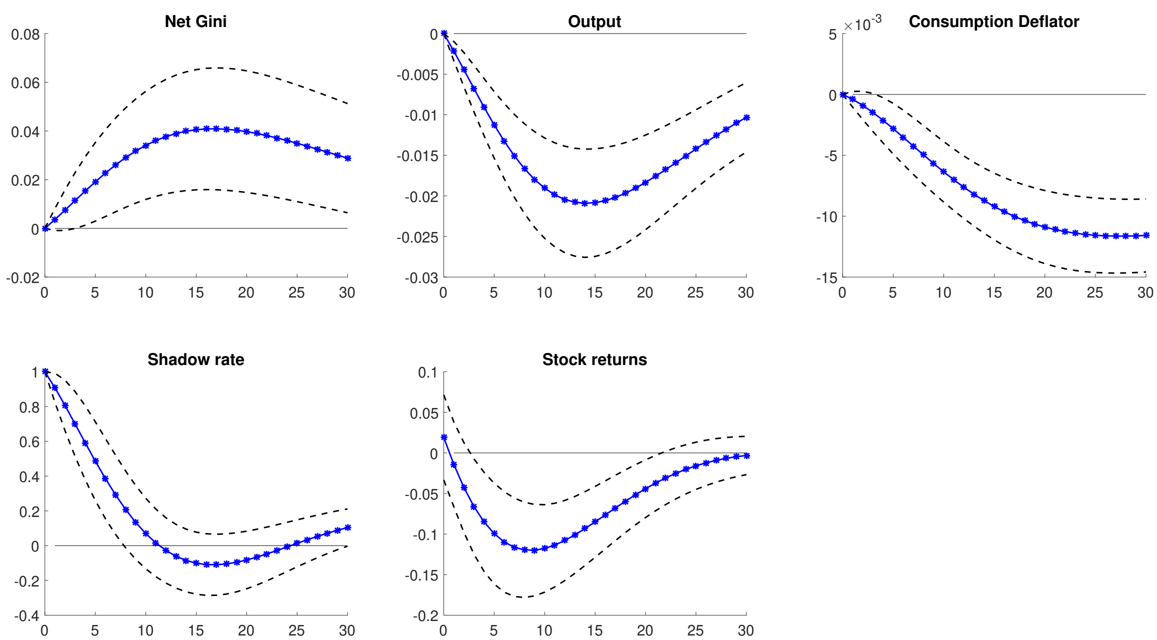


Figure 33: Responses to a shock on the policy rate (Baseline model)
*Income inequality measure: S80/S20*

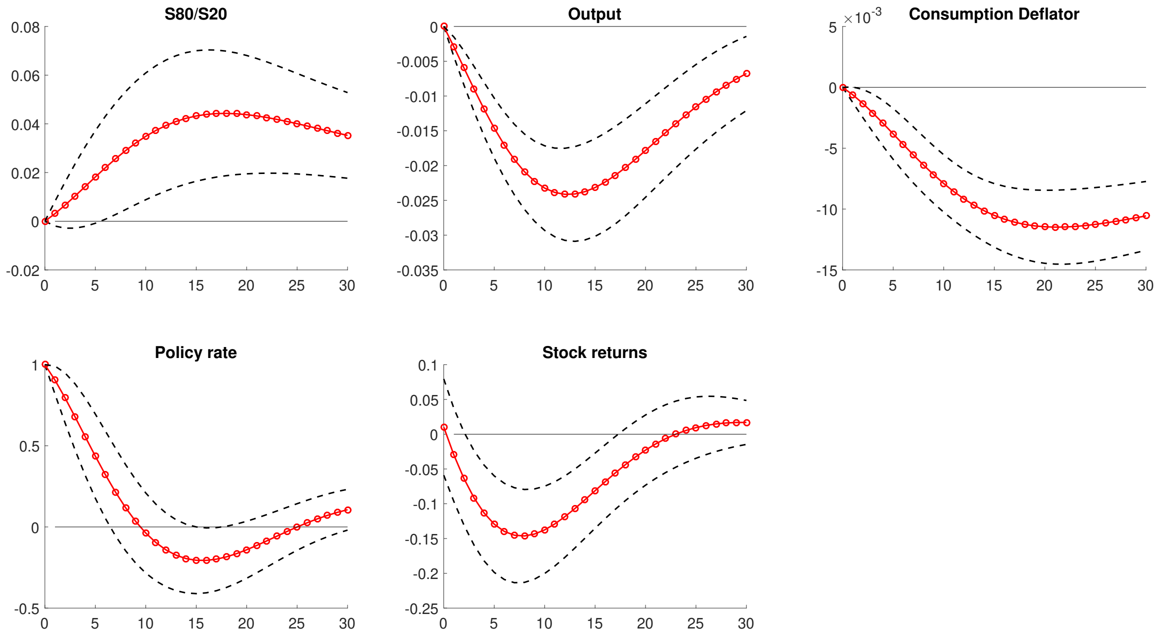



Figure 34: Responses to a shock on the shadow rate (Baseline model)
*Income inequality measure: S80/S20*

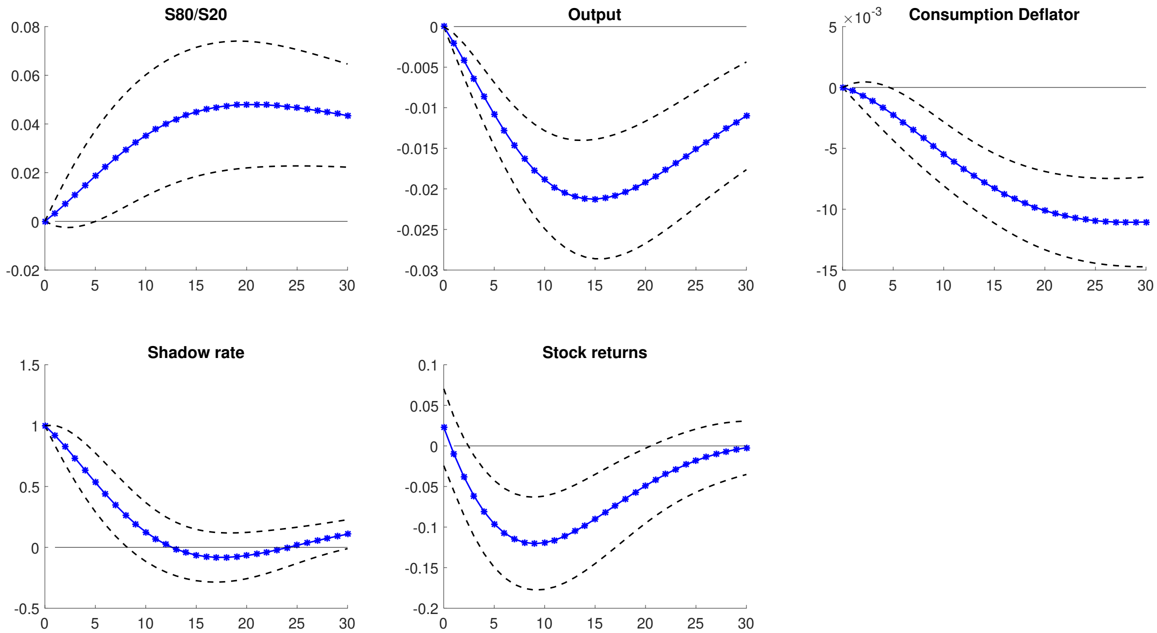


Figure 35: Responses to a shock on the policy rate (Ordering à la *Guerello*)
*Income inequality measure: net Gini*

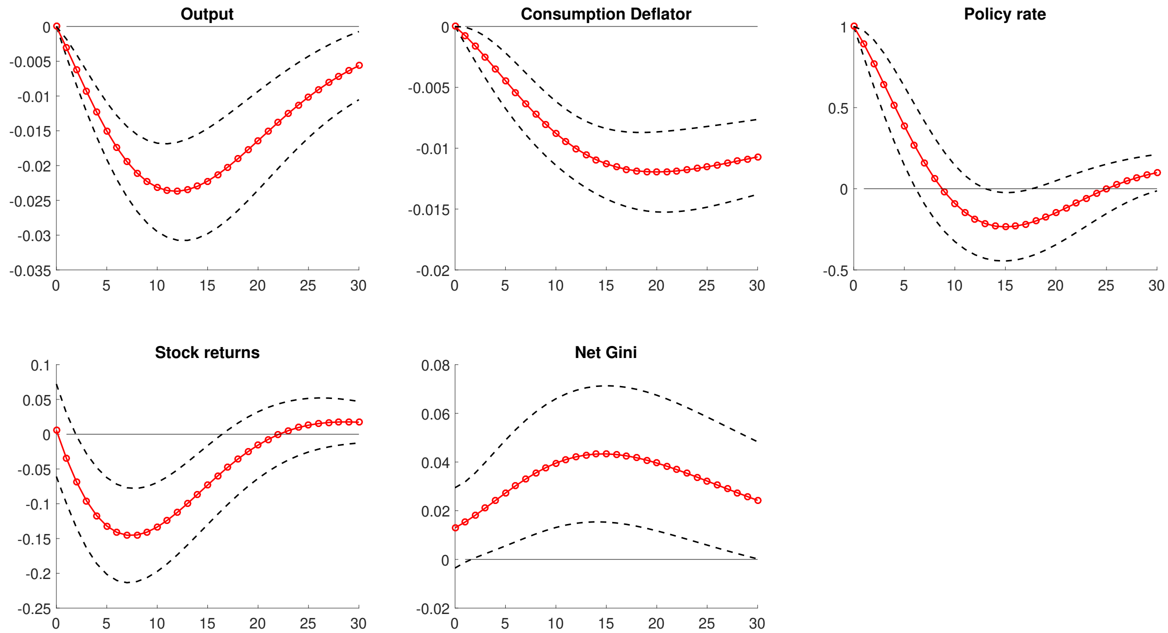



Figure 36: Responses to a shock on the shadow rate (Ordering à la *Guerello*)
*Income inequality measure: net Gini*

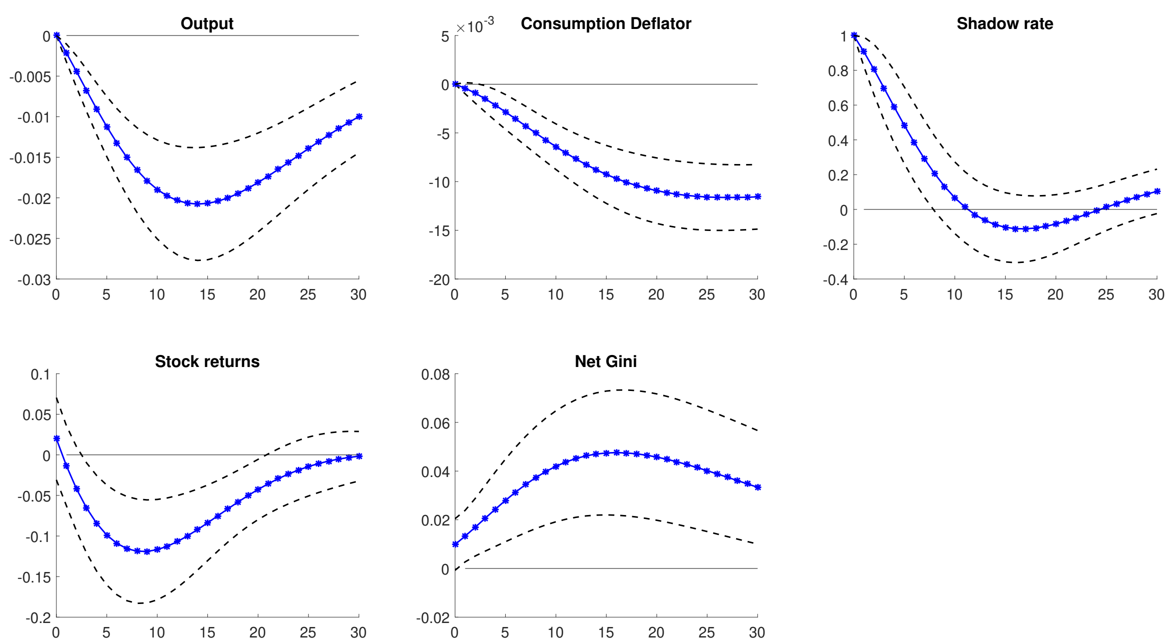


Figure 37: Responses to a shock on the policy rate (Ordering à la *Guerello*)
*Income inequality measure: S80/S20*

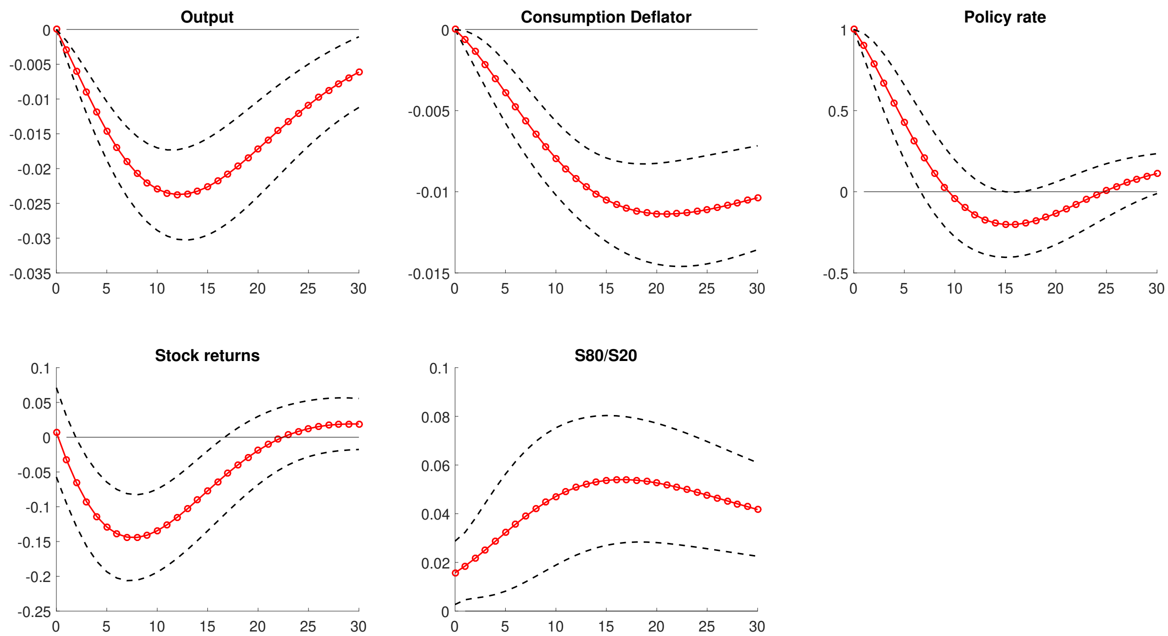



Figure 38: Responses to a shock on the shadow rate (Ordering à la *Guerello*)
*Income inequality measure: S80/S20*

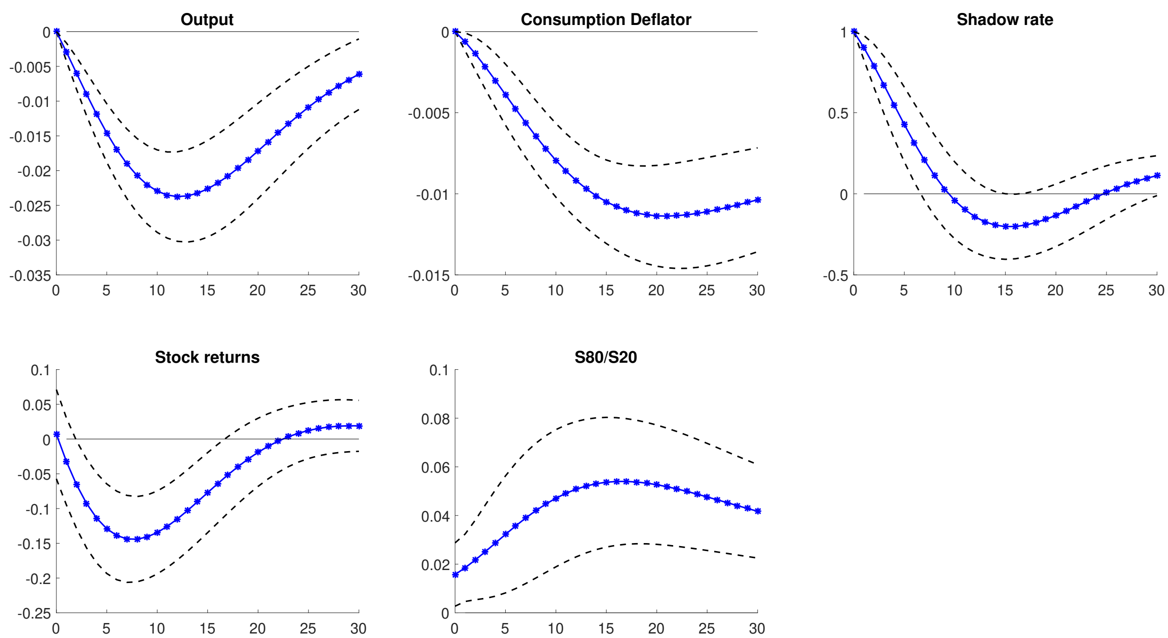


Figure 39: Responses to a shock on the policy rate (ordered last)
*Income inequality measure: net Gini*

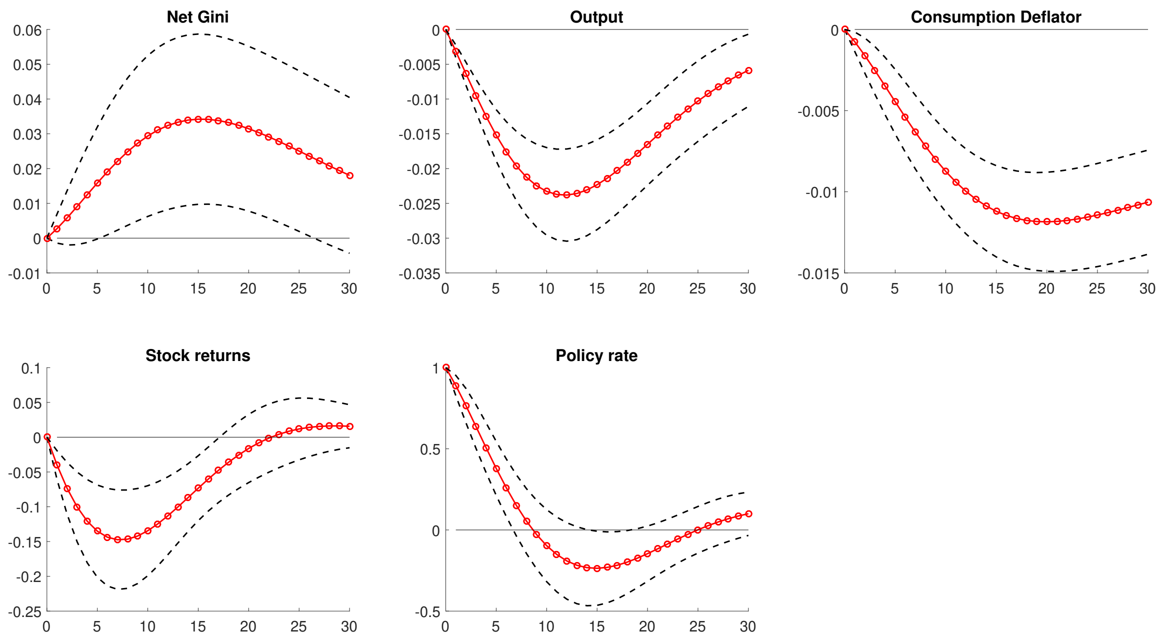



Figure 40: Responses to a shock on the shadow rate (ordered last)
*Income inequality measure: net Gini*

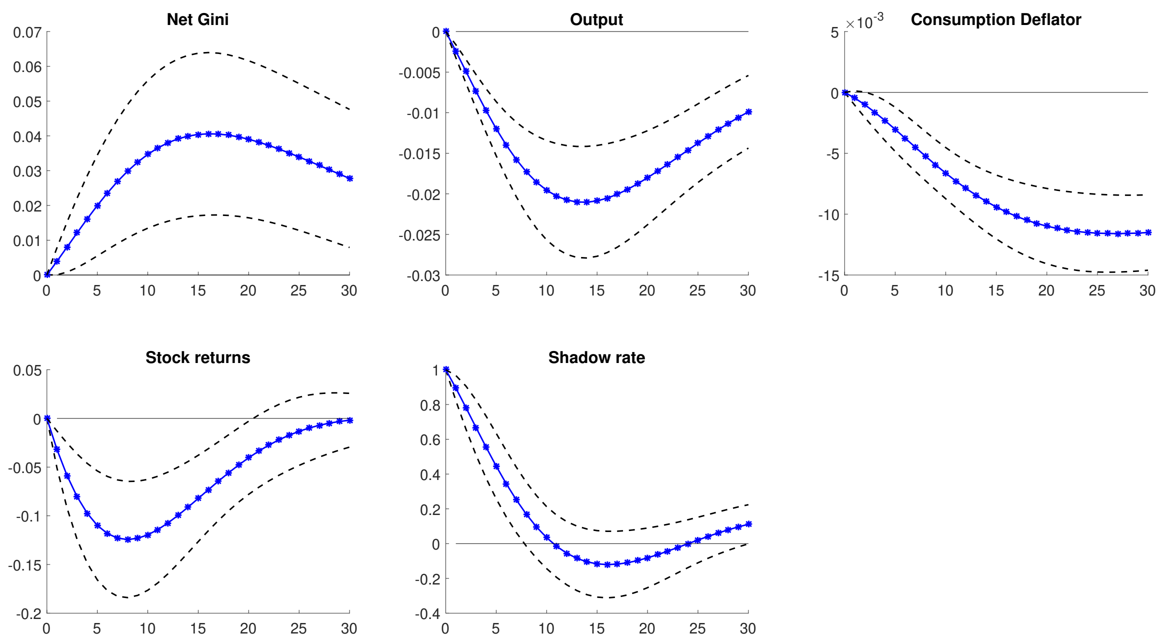


Figure 41: Responses to a shock on the policy rate (ordered last)
*Income inequality measure: S80/S20*

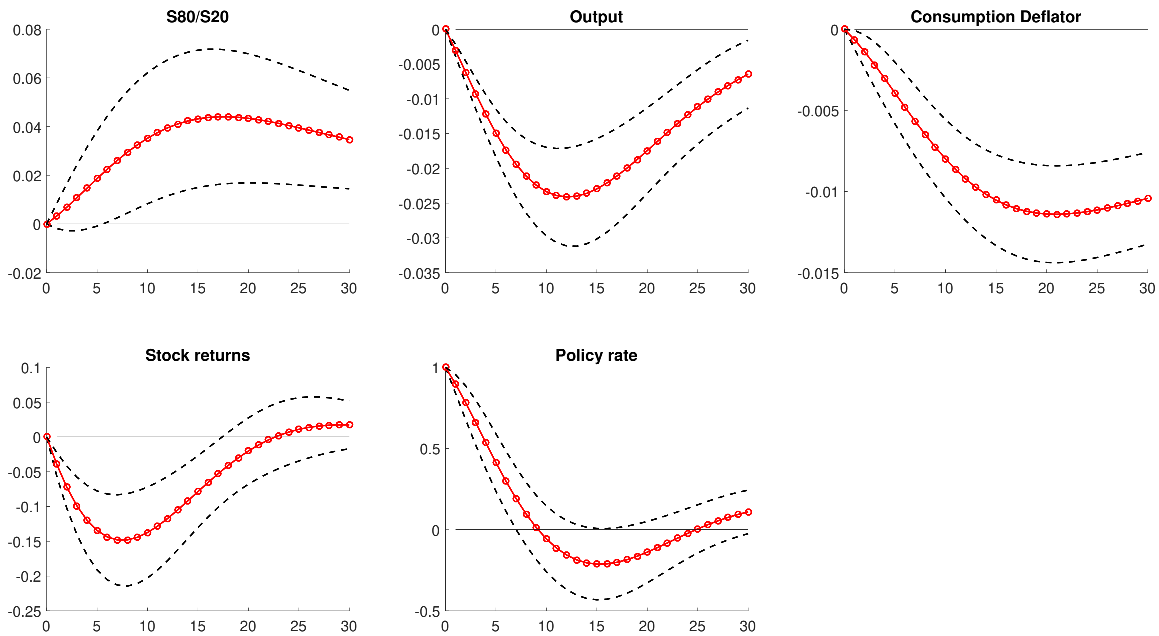



Figure 42: Responses to a shock on the shadow rate (ordered last)
*Income inequality measure: S80/S20*

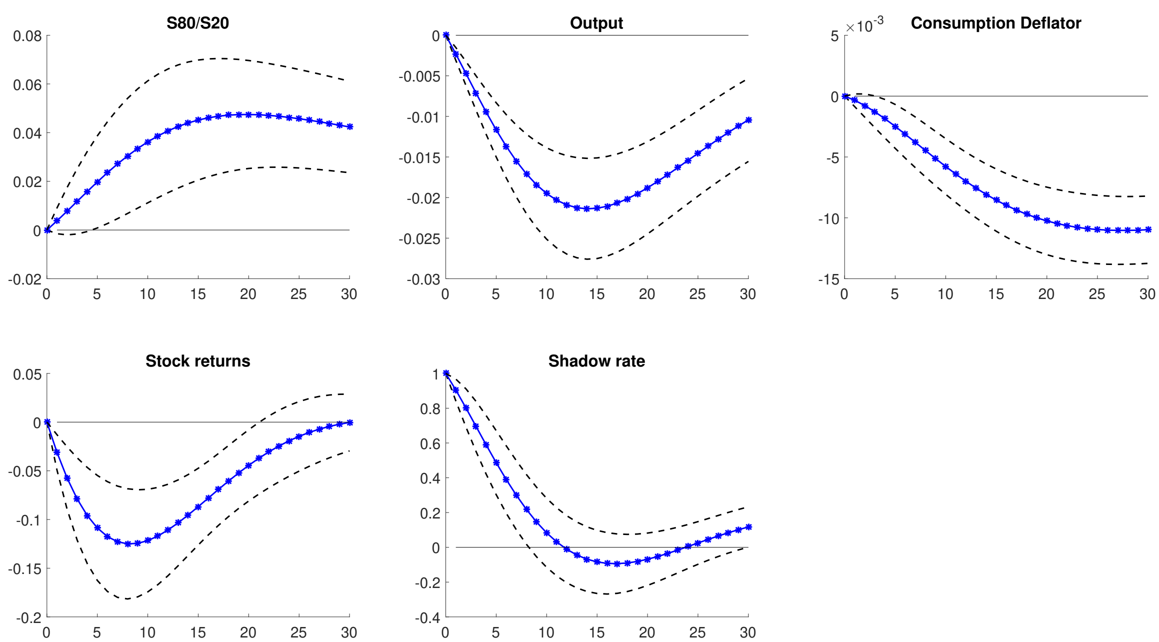
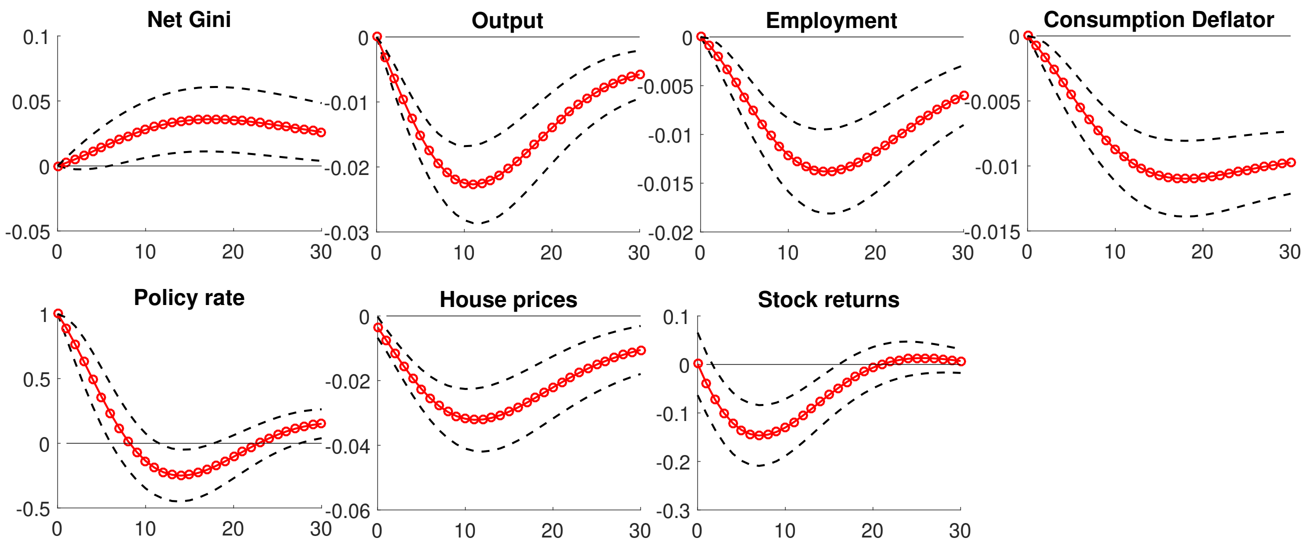
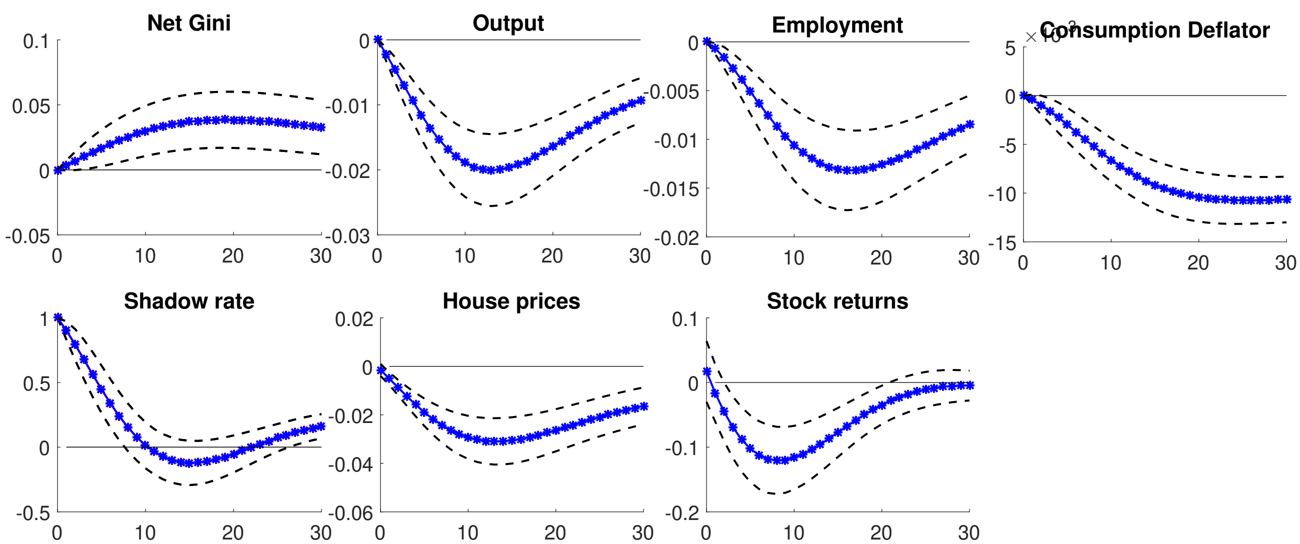


Figure 43: Responses to a shock on the policy rate, VAR(7) - net Gini



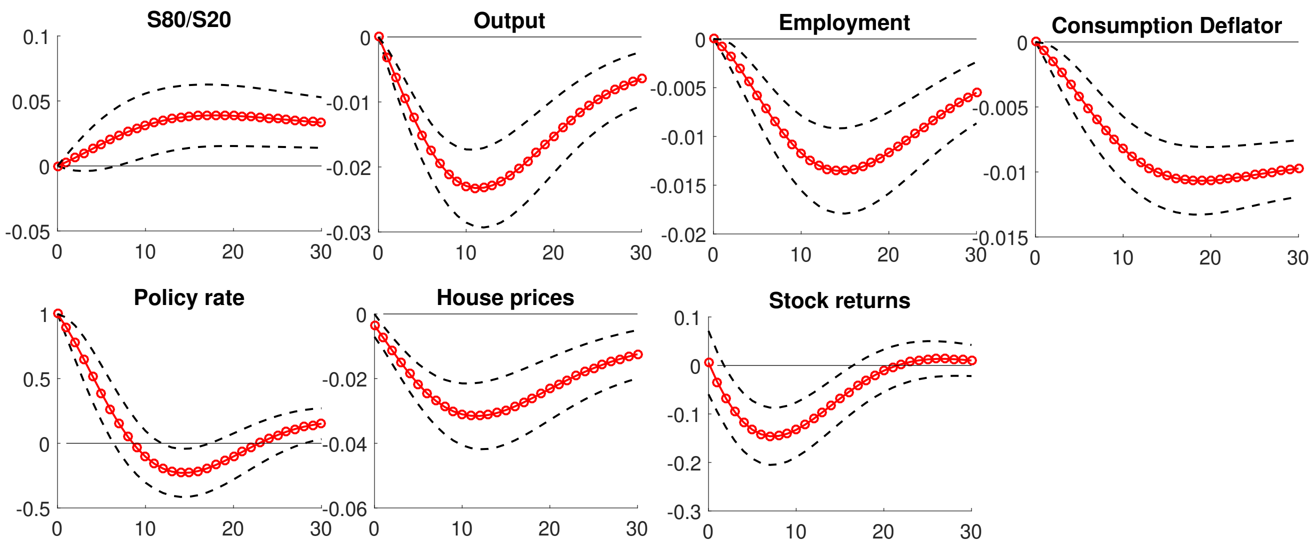

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 44: Responses to a shock on the shadow rate, VAR(7) - net Gini



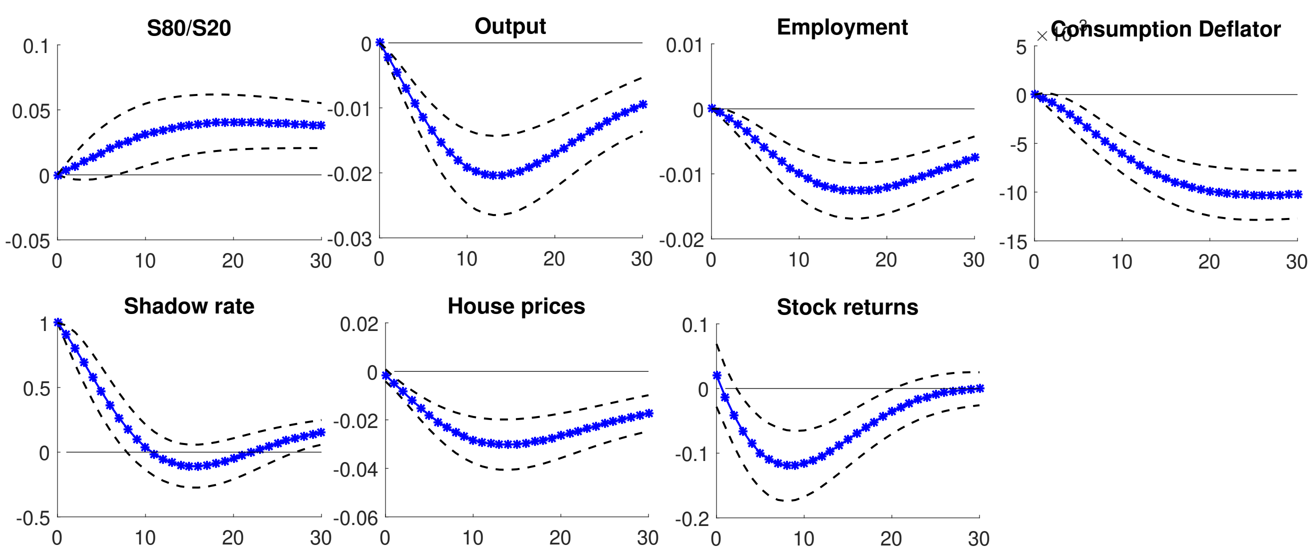

Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 45: Responses to a shock on the policy rate, VAR(7) - S80/S20




Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

Figure 46: Responses to a shock on the shadow rate, VAR(7) - S80/S20




Note: The figure shows the impulse responses of income inequality indicators to a 100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded areas are 90 percent confidence intervals.

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