# INCOME INEQUALITY AND MONETARY POLICY IN THE EURO AREA

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## ABSTRACT

This paper examines the distributional implications of monetary policy, either standard, non-standard or both, on income inequality in 10 Euro Area 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. The identification of monetary shocks follows a one-step procedure and relies only on country-specific determinants of income distribution. 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 countries with a high level of market inequalities, while, overall, (iii) standard and non-standard monetary policies do not significantly differ in terms of impact on income inequality. Results are robust to alternative data sources either for income distribution or for non-standard monetary policies.

## KEYWORDS

Euro Area, Monetary policy, Income distribution, Panel VAR

## JEL

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# Income inequality and monetary policy in the Euro Area

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**Abstract**

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## 1 Introduction

Monetary policy is commonly believed to be neutral with respect to income and wealth distributions. In fact, 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. Central bankers argue, however, that their post-crisis measures produced positive macroeconomic outcomes. That is, they would have succeeded in stabilizing output, enhancing employment and making debt service less painful. The debate on the incidence of monetary policy on income distribution 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 alternatively include the nominal short-term interest rate (as a policy rate) and the shadow rate of Krippner (2015) in a Panel VAR. The shadow rate encompasses standard and non-standard monetary policies. The Panel VAR structure sets the dynamic framework of the interrelationships between income inequality and macroeconomic variables as surveyed, e.g. by Bertola (1999). In contrast with related papers applied to the Euro Area, we identify monetary policy shock following a one-step procedure. Determinants of income distribution are thus exclusively country-specific. Stated differently, monetary determinants are not netted out of euro area average macroeconomic variations.

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 increasing 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. Similarly, cross-country evidence of Furceri et al. (2018) shows, for a selection of advanced and emerging economies, that contractionary monetary policy and income inequality are positively related. The magnitude of this effect, however, depends on business cycle fluctuations but also on the labor share of income and redistribution policies. Specifically, monetary policy has a stronger impact on inequality in countries with a high share of labor income and limited redistribution policies. 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. Casiraghi et al. (2018), Bivens (2015), Inui et al. (2017) or Colciago et al. (2019) for a complete survey on this issue).

At the EA level, Adam and Tzamourani (2016), Lenza and Slacalek (2018) use the available waves of the ECB Household Finance and Consumption Survey (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. While the former highlight the extent to which top income households in the EA would benefit from higher asset prices; the latter argue that the effect of ECB's non-standard monetary policy on growth and employment have mitigated the side effects of assets price appreciation on inequality. Further, 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)[1], 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 country-specific innovations to the short-term and the shadow rates following the one-step procedure alluded above that limits the potential attrition of policy shocks.

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 raises the Gini coefficient by respectively 0.1 and 0.13. This 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 EA countries with a high level of market inequality (i.e. France, Germany, Greece, Portugal and Spain) and in times of 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 considers different sets of ordering, data sources on income inequality and on non-standard monetary policies as well as 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.

[1]In that, we follow Berg et al. (2018)

## 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 existence of the Euro as a single currency.[2]

Addressing the topic of monetary policy and inequality ideally requires extensive household surveys with large information on 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 HFCS has been released for the first time in 2010 and contains only two waves, which makes it difficult to investigate how the gradual expansion of ECB non-standard measures have shaped income and wealth distributions in comparison with standard measures. 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.

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 performs well in comparison with factor-based interpolations.[4] Finally, Sax and Steiner (2013) show that Chow-Lin interpolation is better suited for stationary or cointegrated series.

[2]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.

[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.

[4]As a robustness check, we conducted our empirical analysis with annual data. This did not affect our outcomes. Results are available upon request.

Data on Gini coefficients – a standard measure of inequality whose value ranges from 0 to 100[5] – 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 fulfil missing country-year observations. This allows to obtain the highest possible coverage[6]. 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, relatively, to attach a greater importance to observations in the middle of the distribution than to those located at the extremes (see e.g., 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 the impact of monetary policy on the tails of income distribution. Because the S80/S20 ratio contains missing observations for some countries between 2002 and 2003, we use the Chow-Lin interpolation method to fill in the missing data and convert them to quarterly series.

Along with the three measures of income inequality, other macroeconomic and monetary variables are added. The country-level data include real GDP, consumption deflator, stock prices, the total employed population and a real house price index.[7] Monetary policy stance is proxied by the short-term nominal interest rate and the shadow rate for the EA of Krippner (2015). While the first allows to grasp only conventional monetary policy, the second captures episodes of unconventional monetary policies 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 picture on the state of 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).

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 to the periphery countries. Actually, the upward shift these countries have experienced was

[5]For instance, recently, Bayer et al. (2020) use Gini coefficients to evaluate the distributional effects of US Coronavirus stimulus package.

[6]Lang and Tavares (2018) provide a discussion on the differences in terms of comparability and measurement methods of the different datasets of income inequality)

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

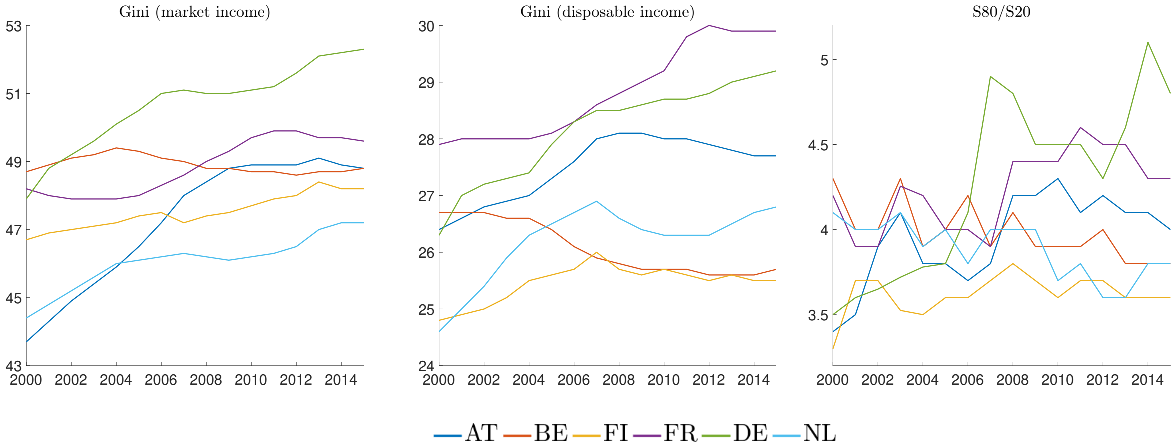



Figure 1: Income inequality in Northern European economies, 2000-2015

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

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.

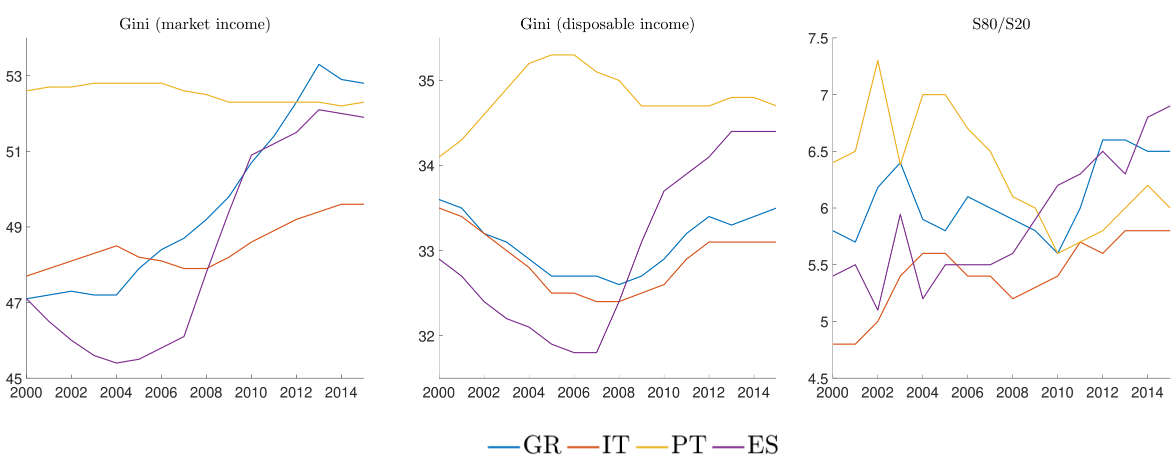



Figure 2: Income inequality in Southern European economies, 2000-2015

*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 the 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 raises two challenges. The first one relates to the disentangling of conventional and unconventional monetary policy measures. The second one involves identifying specifically what a monetary policy shock to income distribution may be, in an area in which the central bank takes decisions at the EA level although these decisions may impact domestic economies heterogeneously.

Several alternatives have been put forward in the literature to disentangle unconventional policy shocks from conventional ones. 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. It may well be argued though that innovations to the central bank balance sheet can be either attributed to standard *or* non-standard policies. 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 Krippner (2015) for the EA. Shadow rates can 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 (substantially) 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 the context of the ZLB, Francis et al. (2017) show that shadow rates have proved to be good proxies of monetary policy stance.[8] Most importantly, they allow to capture all features

[8]Several shadow rates – which have mainly built on term structure models – have been proposed by De Rezende and

of unconventional monetary policies in central banks' toolkit, including the measures of "qualitative easing" that may modify the structure of the central bank balance sheet. Indeed, some unconventional measures, like (T)LTRO, for instance, not only raised the size of the central bank balance sheet but they have also changed its composition when they replaced some conventional main refinancing operations. Moreover, even for those measures that have directly increased the size of central bank balance sheet, like asset purchase programs, the information included in the shadow rate goes beyond that of the mere increase in the balance sheet: by definition, the shadow rate illustrates the maturity features of the assets purchases. In contrast, the evidence of the rise in the balance sheet does not allow to distinguish the volume from the price effects that the computation of the shadow rate tries to obtain.

Figure 3.1 plots the time path of the shadow and short-term rates for the EA. Following ECB's non-standard 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 rate decreased towards the ZLB.

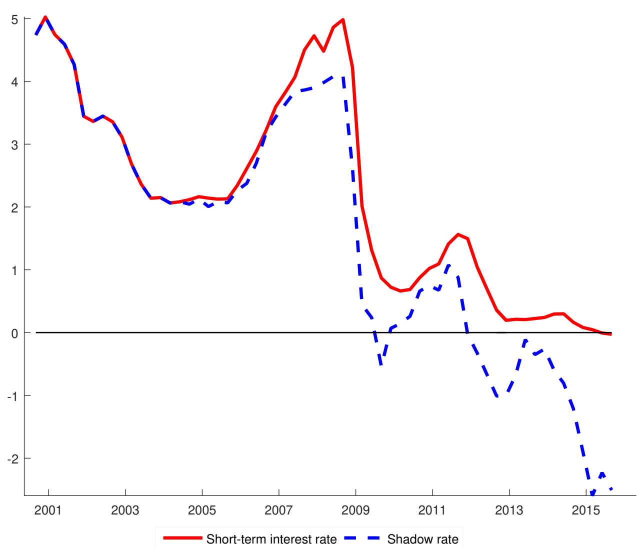



Figure 3.1: Policy rates in the Euro Area

*Source: European Central Bank (ECB) and Krippner (2015).*

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[9] with the following ordering of variables:

Ristiniemi (2017) and Wu and Xia (2016). See Ichiue and Ueno (2015) for a complete survey of shadow rates and their differences.

[9]This identification scheme and its implications have been widely discussed by Christiano et al. (1999) and used ever since. We use this decomposition for two reasons. First and foremost, there is no universally admitted linkage between income inequality and other macro variables that would justify sign restrictions or structural specifications. The Cholesky decomposition therefore permits to let the data speak, while respecting a hierarchy between slow-moving and fast-moving variables. Second, the same decomposition applies for (Panel) VARs in the literature on the impact of monetary policy on income inequality (see e.g., Feldkircher and Kakamu (2018) on the effects of monetary policy on income inequality in Japan).

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

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 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 literature, and underlines the idea that stock markets may respond immediately to real shocks. In the robustness section, we test for the sensitivity of the baseline results to different sets of ordering.

In macro setting using Panel VAR models, ECB monetary shocks usually stem from a two-step procedure. The first step nets out the EA average variations and identifies the euro area monetary policy shock, while the second step introduces the euro area shock as a country-specific determinant in the panel and then identifies country-specific euro-area-average-netted-out shocks. Impulse response functions are computed from these latter shocks. Samarina and Nguyen (2019), for instance, follow this 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.

A distinctive feature regarding our identification strategy is that we adopt a country-level approach for exogenous monetary policy shocks instead of estimating the latter at the EA level. Actually, we draw on the literature to specify the macroeconomic determinants of income inequality. Income inequality depends on income dynamics (Kuznets, 1955; Barro, 2000), inflation (Beetsma and Van der Ploeg, 1996), business cycle and public policies (Aghion and Howitt, 1997; Heathcote et al., 2010) and more broadly, on financial market imperfections as discussed in Bertola (1999) and Stiglitz (2016). Consequently, income distribution at the domestic level depends on country-specific features of the financial markets, like the level of (and not the shock on) the interest rate. As a first approximation, we introduce the ECB policy rate and asset prices in the Panel VAR. In a subsequent setting, we also add long term interes rates.

So doing, the domestic policy shock in our setting is the error term between the ECB policy rate and the country-specific determinants. If, for instance, there were desynchronized business

In contrast with Mumtaz and Theophilopoulou (2017), our results with a Cholesky decomposition yield inflation responses that are consistent with predictions from standard models.

cycles across EA countries, they would impinge on the nature and size of domestic policy shocks after the common ECB policy: in a high (resp. low)-growth country, the ECB policy rate would be too-low (resp. too-high) as regards its domestic economic conditions, which would therefore induce a policy shock to its economy.[10]

Figures 3.2 and 3.3 in section 7 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 noticing. 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. In 2005-2006, the EA was divided between countries facing expansionary shocks (e.g. Austria, Greece and Italy) and countries facing restrictive shocks (e.g. Finland and Germany). In figure 3.3, shocks on the shadow rates are much larger after 2010 than those arising from the ECB conventional policy but their discrepancy across EA member states is smaller.

### 3.2 Panel VAR

The Panel VAR is estimated using the Least Squares Dummy Variable estimator (LSDV).[11] 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 with the length of the sample. 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)[12] 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 estimator does not contradict the results obtained in the baseline model. In the following, we thus continue relying on the LSDV estimator. The

[10]Identification of monetary shocks at the EA and domestic levels produces similar outcomes for EA countries whose inflation and real GDP growth rates are equal to the EA average. While there may have been inflation convergence in the EA (see Broz and Kocenda (2018)), there remains features of nominal divergence (see Ederer and Reschenhofer (2018)), which remove the possibility that both identification procedures always yield similar outcomes.

[11]We use the Stata code developed by Cagala and Glogowsky (2014)

[12]Judson and Owen (1999) argue that when the number of time observations is higher than 30, the bias of LSDV for dynamic panel data models is small.

econometric model takes the following reduced form:

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

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 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 generate the Impulse Response Functions (IRFs) of the income inequality measures 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. Their significance 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 (AIC). 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 coefficient, the net (post-social transfers) Gini coefficient 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* Krippner. 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.

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"), although the impulse response of inflation is not significant the first quarters following an unexpected shock on the shadow rate. On top of that, they are broadly consistent with expectations. A restrictive monetary shock of +100 b.p. reduces the output by 2 percent after 3 years and inflation by 1.1 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 (Full IRFs are reported in figures 31 to 34 of the appendix). 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 and low-income earners. 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). 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 expansion 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 (figures 6 and 7) shows that the monetary policy instruments are relatively comparable in accounting for the volatility of income inequality measures in the medium-long run.[13] Put differently, they are as relevant as output or inflation in explaining the variance of income inequality measures. It is worth noticing, however, that the shadow rate explains a higher share of the Gini coefficient's volatility than the policy rate. This is normal as the shadow rate encompasses a wide array of monetary policy measures (i.e. asset purchase programs, credit easing facilities, forward guidance, etc.).

### 4.2 Robustness checks

To check the robustness of results, we adopt two complementary orderings. Results are reported in figures 8 to 11.[14] 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.

The unconventional monetary policy measures implemented by the ECB aimed at repairing the channels of transmission and at relaxing the financing constraints of the EA member states during the sovereign debt crisis. Thus, to better account for the unfolding of non-standard monetary policy, we include long-term interest rates in our baseline model. In particular, we follow the existing literature (e.g., Feldkircher and Kakamu (2018), Mumtaz and Theophilopoulou (2017)) by allowing long-term rates to react contemporaneously to a monetary policy shock. Results are reported in figure 12.[15] They confirm, on one hand, the robustness of our baseline finding on income inequality; and show, on the other hand, the consistency of the long-term yields' response to an unexpected increase in the shadow rate.

In addition, it is fair to remind that our sample period covers episodes during which the short-term interest rate reached the lower bound and therefore (conventional) monetary policy was constrained. To deal with this issue, we use the long-term interest rates as a proxy of the monetary policy instrument. Figure 13 reports the IRFs of the Gini coefficient, the net Gini and the S80/S20 inter-decile ratio to an unexpected +100 b.p. increase in the long-term

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

[14]For the Gini coefficient, we present the entire Panel VAR with both monetary policy instruments, while we report those of the *net* Gini and the S80/S20 ratio in the appendix in figures 35 to 42.

[15]The IRFs of this sensitivity check on the net Gini and the S80/S20 inter-decile ratio are reported in the appendix.

interest rate. The displayed impulse responses confirm that monetary tightening increases income inequality. Moreover, they are very similar – in terms of magnitude – to the dynamic responses of income inequality indicators to a shock on the shadow rate. For example, a +100 b.p. increase in the long-term interest rate produces 4 years after the shock a maximum impact of 0.12 and 0.04 on the Gini coefficient and the net Gini, respectively.

To make sure that our baseline results are not sensitive to alternative income inequality measures, we use data from the Atkinson index.[16] The latter has the advantage of deriving an inequality measure that considers all the parts of the income distribution and not only that of the middle as in the Gini coefficient. Results are reported in figures 14 and 15. They are consistent with our baseline findings: the effect of monetary policy on the Atkinson index – both under the policy and shadow rates – is positive, thereby suggesting that contractionary monetary policy increases inequality, irrespective of the inequality indicator considered.

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 fact, Krippner (2020) 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 rate of Wu and Xia (2016). The results reported in figure 16 are consistent with those from the baseline: a temporary positive shock on the shadow rate increases the three indicators of income inequality. Furthermore, the impulse responses of output, inflation and stock returns are in line with those obtained using the shadow rate of Krippner (2015).

### 4.3 High vs. low inequality economies

After having shown that the baseline results are robust, we confront them to recent policy debates. Here we ask specifically whether monetary policy shocks have a distinct effect between high and low inequality economies of the EA. Actually, while all countries have been hit by the Global Financial Crisis (GFC), the European sovereign debt crisis may have affected more countries with relatively higher levels of market inequality (Southern European countries, see figure 2). Given that austerity measures have weakened redistribution in these countries, one may wonder whether ECB policies 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 countries with high inequality (France, Germany, Greece, Portugal and Spain) and low inequality (Austria, Belgium, Finland, Italy and the Netherlands) countries at the time of the sovereign debt crisis.[17] Results are reported

[16] We have also estimated the baseline model using the Palma ratio i.e. the income share of the richest 10% of the population divided by the poorest 40%'s share. The findings are consistent with our baseline result and the IRFs are available upon request.

[17] To do so, we compute the median level of the gross Gini coefficient of the 10 EA economies when the sovereign debt crisis started, in 2011. Then, we distinguish between the two groups (high vs. low inequality) relying on the median.

in figures 17 to 20 in section 7. They show that the baseline results are mainly driven by EA countries with high market inequalities.

Indeed, in countries with low inequality, the impact of a monetary policy shock is not significant in the short-run for the pre and post-transfers Gini coefficients. The responses of the Gini and the net-Gini turn significant only after 3 years (both under the policy and shadow rates), while the S80/S20 ratio is much more responsive following a shock on the policy rate. In contrast, the impact of monetary policy shocks in the high inequality countries is larger: it is significant in the short and medium run, especially for the Gini coefficients. Further, the maximum impact of monetary policy on the net-Gini and inter-decile ratio is more than halved in comparison to the gross Gini. It seems then that monetary policy may have helped mitigate a bit the impact of fiscal austerity on EA countries with high inequality. This mitigation effect appears, however, to be weaker in countries with a low level of market inequality.

### 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 reached. 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 21 and 22. They show that baseline results are mostly driven by conventional policies. Indeed, responses of indicators of income inequality to monetary policy shocks 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. 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.[18] 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 that the IRFs of inflation expectations are never significant after a monetary shock.[19] 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 23 and 24. 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

In this section, 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 GDP 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:

[18] Real estate prices can move differently from stock prices (see e.g., Jordà et al., 2015)

[19] 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 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 25 and 26. 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 Monetary policy, inflation and inequality

Finally, we study the extent to which inflationary shocks could affect income inequality. As noted by Coibion et al. (2017), inflation falls within the transmission channels of monetary policy towards income distribution. In fact, inflation redistributes wealth from lenders (high net worth households) at the benefit of borrowers (low net worth households); but it may also widen income and wealth dispersion through changes in the real valuation of financial assets (assuming that poor households hold assets that are more liquid and hence less protected against inflation, i.e. cash).

The existing empirical evidence on the distributional consequences of inflation is, however, inconclusive. One strand of the literature argues that inflation is positively correlated with income inequality using cross-country evidence (see Li and Zou (2002) and Albanesi (2007), among others). This finding is also supported by country-level evidence by Doepke and Schneider (2006) and Doepke et al. (2015) who conclude that inflation has distributional implications in the US and particularly harms *"rich, old households, the major bondholders in the economy"*. Another strand of the literature claims that the relationship between inflation and income inequality is non-monotonic. For the US and a sample of 15 OECD countries, Galli and von der Hoeven (2001) find that income inequality declines for low to moderate inflation rates while the opposite is true when inflation moves from moderate to high levels. Similarly, Kang et al. (2013) document with Korean household-level data that inflation reduces poverty and improves income distribution, but only in the short run.

To assess the distributional effects of inflation in the 10 EA economies, we maintain our baseline model and identify inflationary shocks as innovations to the consumption deflator, which do not contemporaneously affect income inequality and output. We therefore assume that monetary authorities react within the same quarter to a change in price levels. Such an assumption seems to be fairly reasonable in light of the very frequent meetings of the ECB's governing council. Subsequently, we generate IRFs of income inequality indicators following a one-standard deviation shock in the consumption deflator.[20] Results are reported in figures 27 and 28.[21] They show that an unexpected shock to inflation results in a very modest increase of income inequality. The impact is smaller than that achieved after a policy shock. Also, the introduction of the shadow rate instead of the policy rate does not significantly change the response of income inequality to a shock on inflation.

## 6 Conclusion

The topic of monetary policy and inequality has raised much debate among academics and policymakers. Yet, what do we know about the distributional effects of monetary policy? 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 threefold. 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 short-term interest rate and the shadow rate *à la* Krippner. This allows to jointly capture the standard and non-standard measures implemented by the ECB. Third, monetary policy shocks are identified in a single-stage procedure: domestic shocks are deviations of the ECB policy rate (not ECB policy shock) with respect to domestic conditions. Hence, there is no risk of attrition of the size of the EA-driven policy shock on domestic income inequality and there is consistency with the links between income distribution and macroeconomics reported in the literature. Empirically, we estimate a Panel VAR model with quarterly data and generate IRFs of income

[20] Because the consumption deflator is defined in log-level, calibrating its shock as +100 b.p. would result in sizable estimates.
[21] Figures of the entire Panel VAR model for each income inequality indicator are reported in the appendix

inequality indicators to a monetary policy shock.

The 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) in the US and more importantly Guerello (2018) and Samarina and Nguyen (2019) in the Euro Area. The results hold up to a battery of robustness checks, including the introduction of complementary sets of ordering, alternative inequality measures (Atkinson index and the Palma ratio) 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 high market inequality countries (i.e. France, Germany, Greece, Portugal and Spain). In contrast with most papers on the topic: (i) we have checked that results continue to hold after redistributive transfers are endogenously taken into account and (ii) provided evidence that inflationary shocks have limited distributional consequences. 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.

# 7 Main figures

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

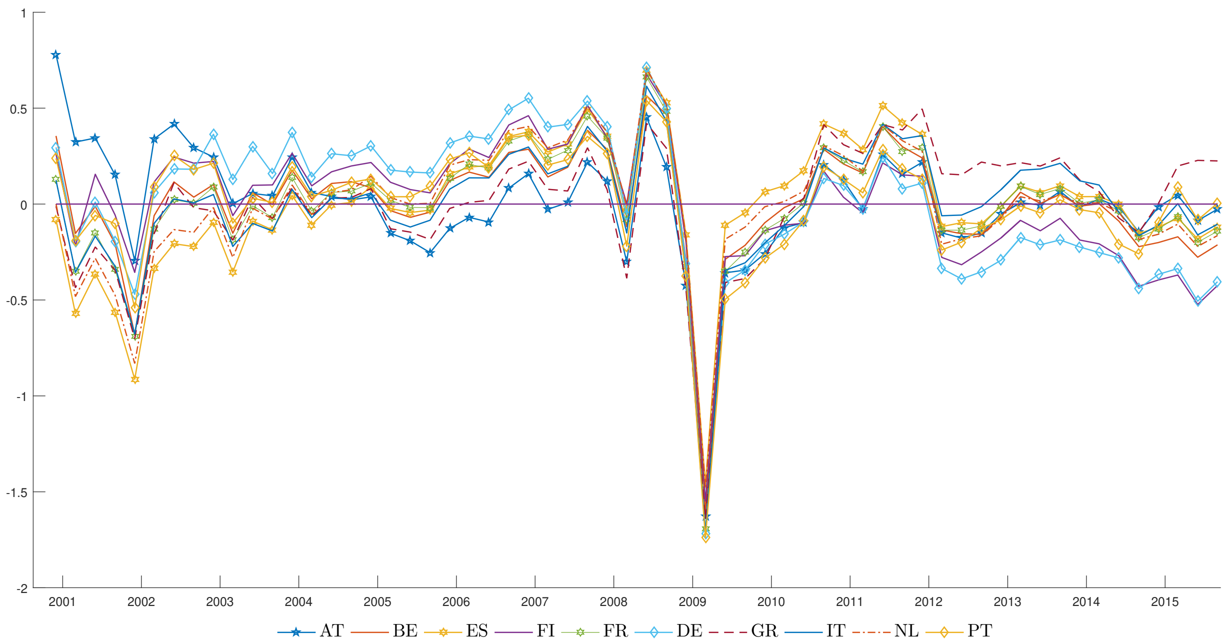
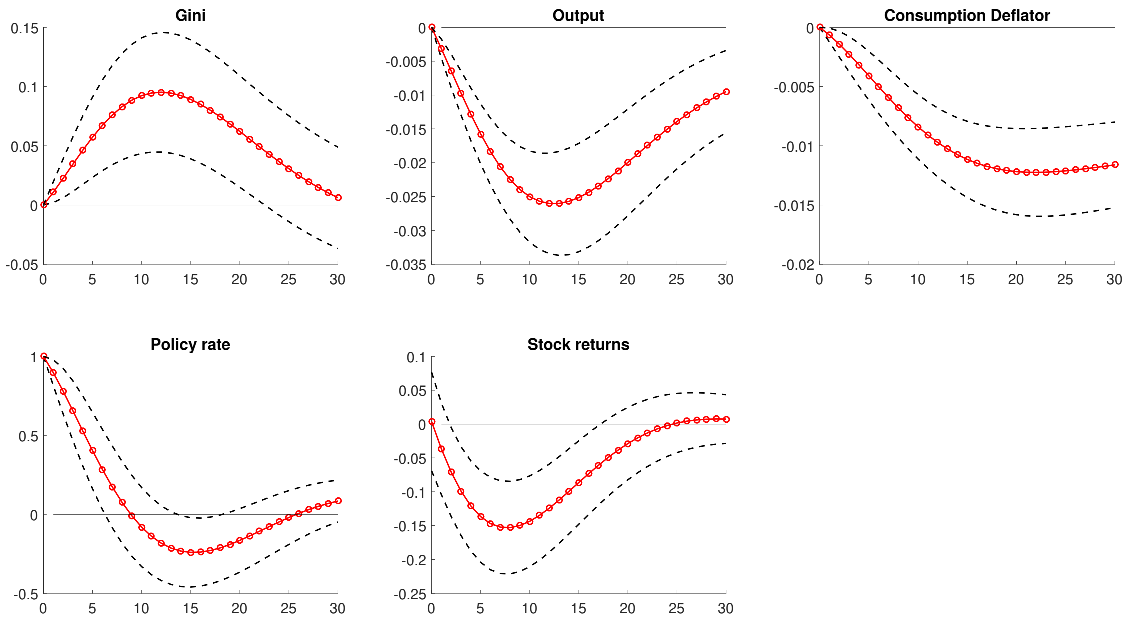


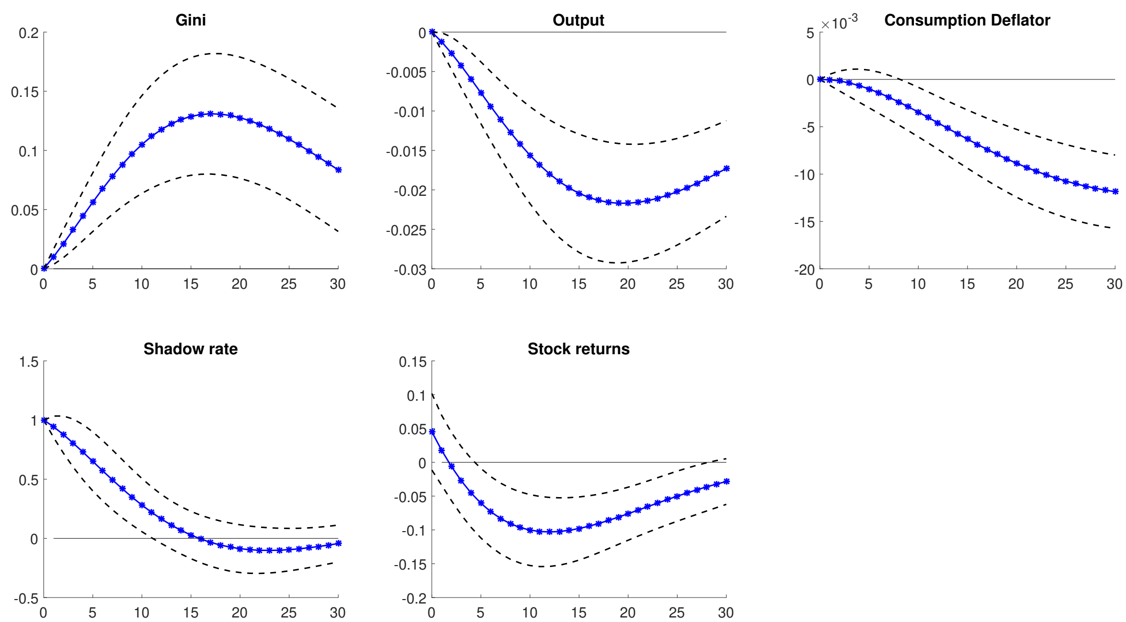

Figure 3.3: Country-level monetary policy shocks (Unconventional)

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 lines 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 lines are 90 percent confidence intervals.

Figure 6: FEVD of Gini coefficient (shock to policy rate), baseline model

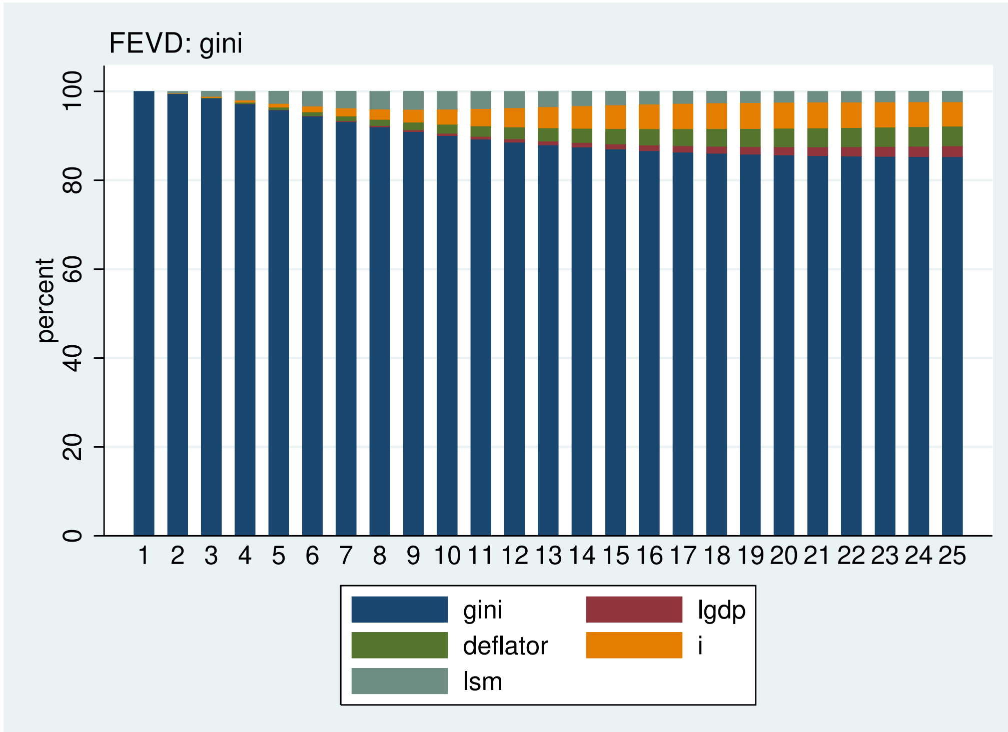



Figure 7: FEVD of Gini coefficient (shock to the shadow rate), baseline model

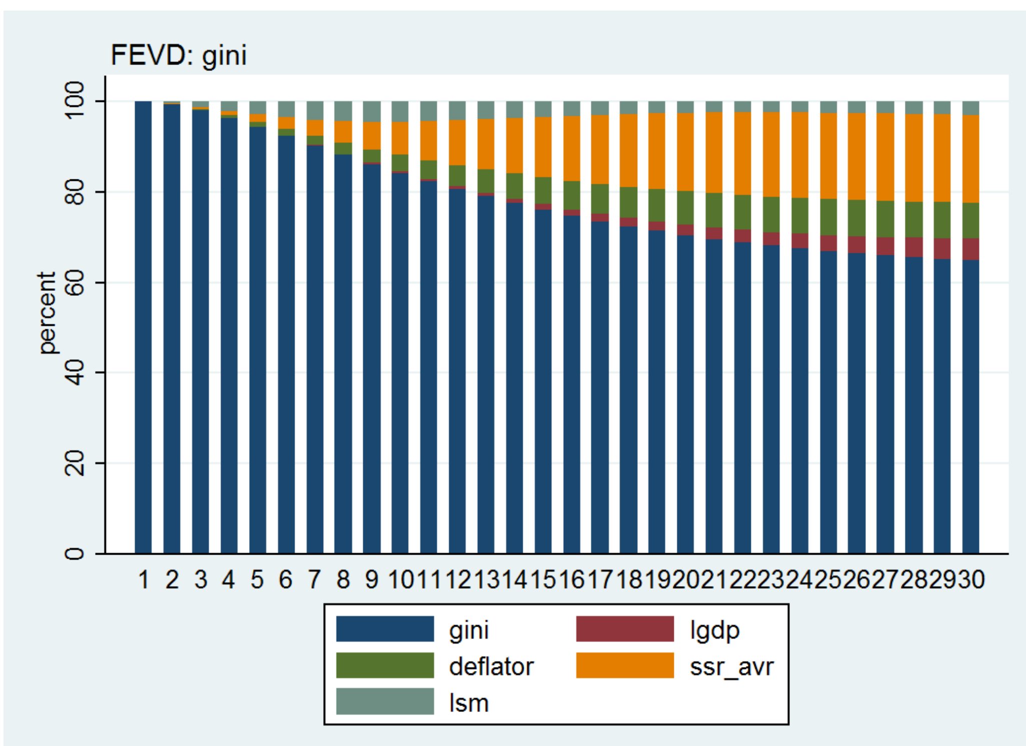
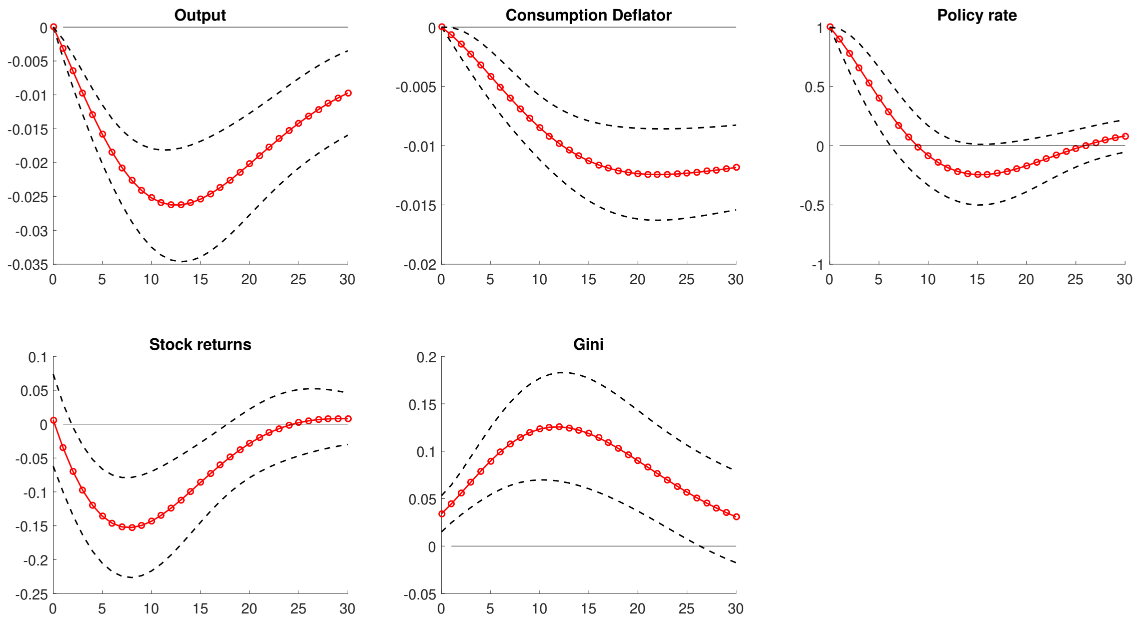
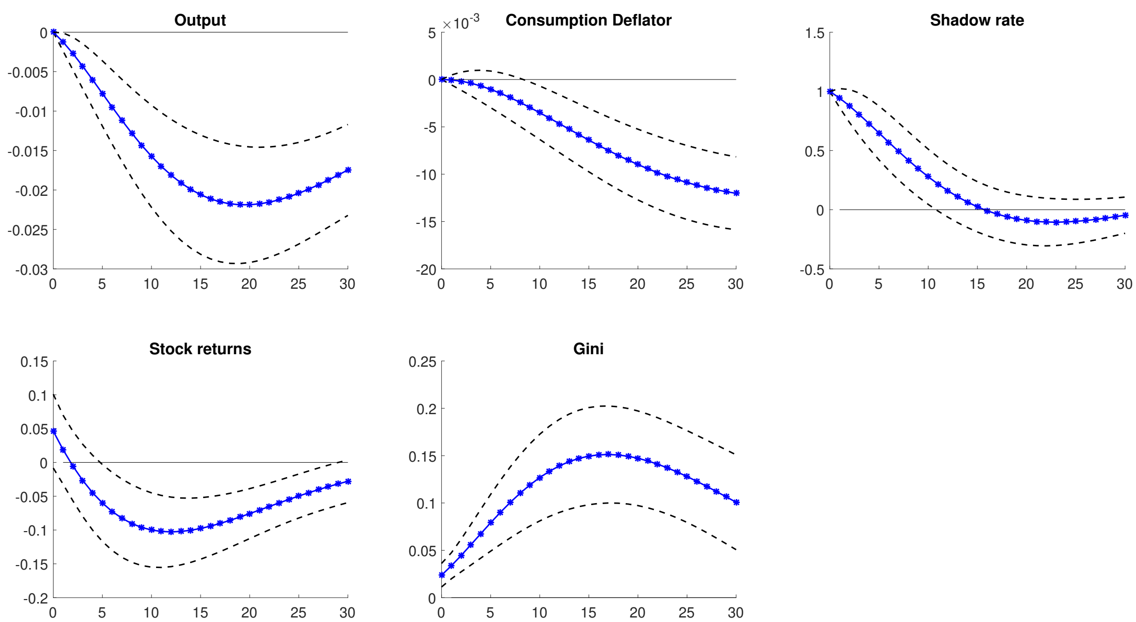


Figure 8: Responses to a shock on the policy rate (Ordering à la *Guerello*)



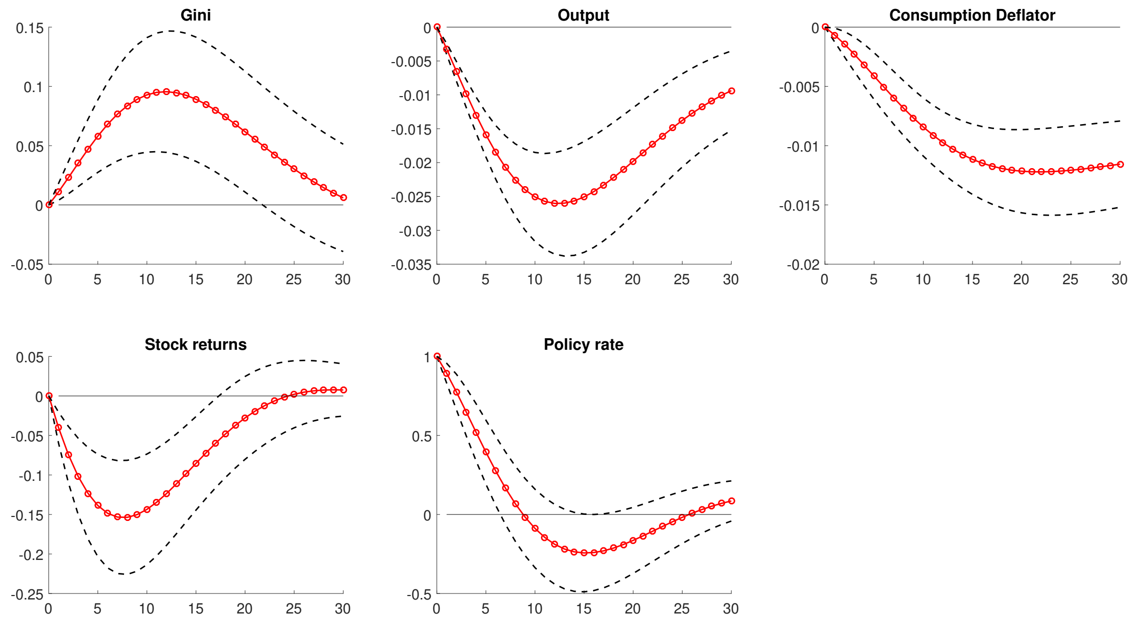

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 9: Responses to a shock on the shadow rate (Ordering à la *Guerello*)



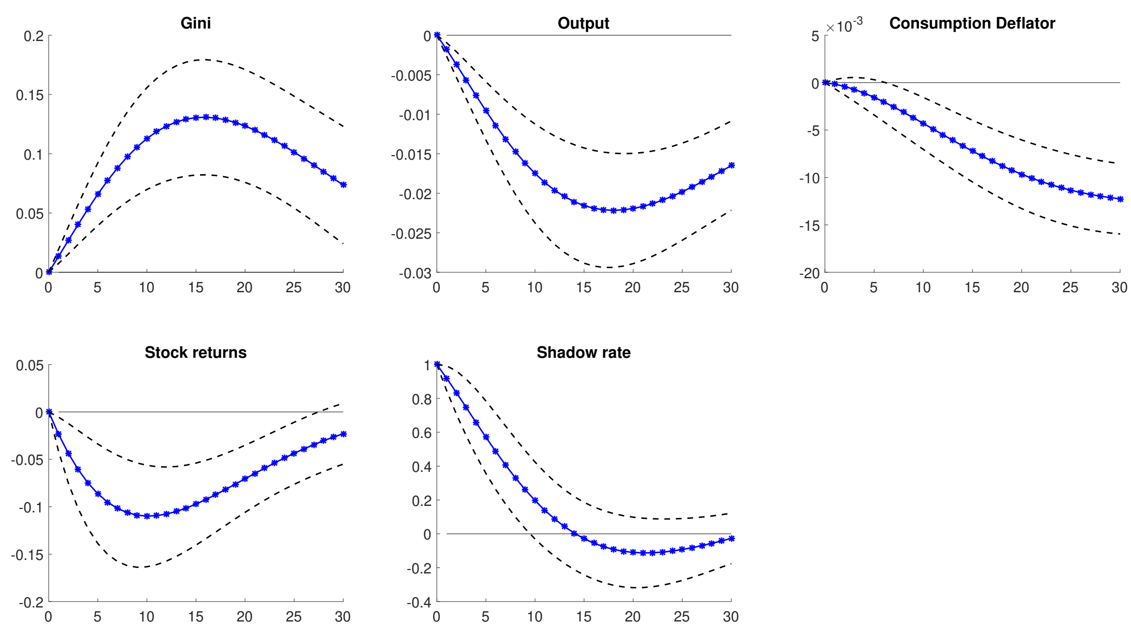

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 10: Responses to a shock on the policy rate (ordered last)



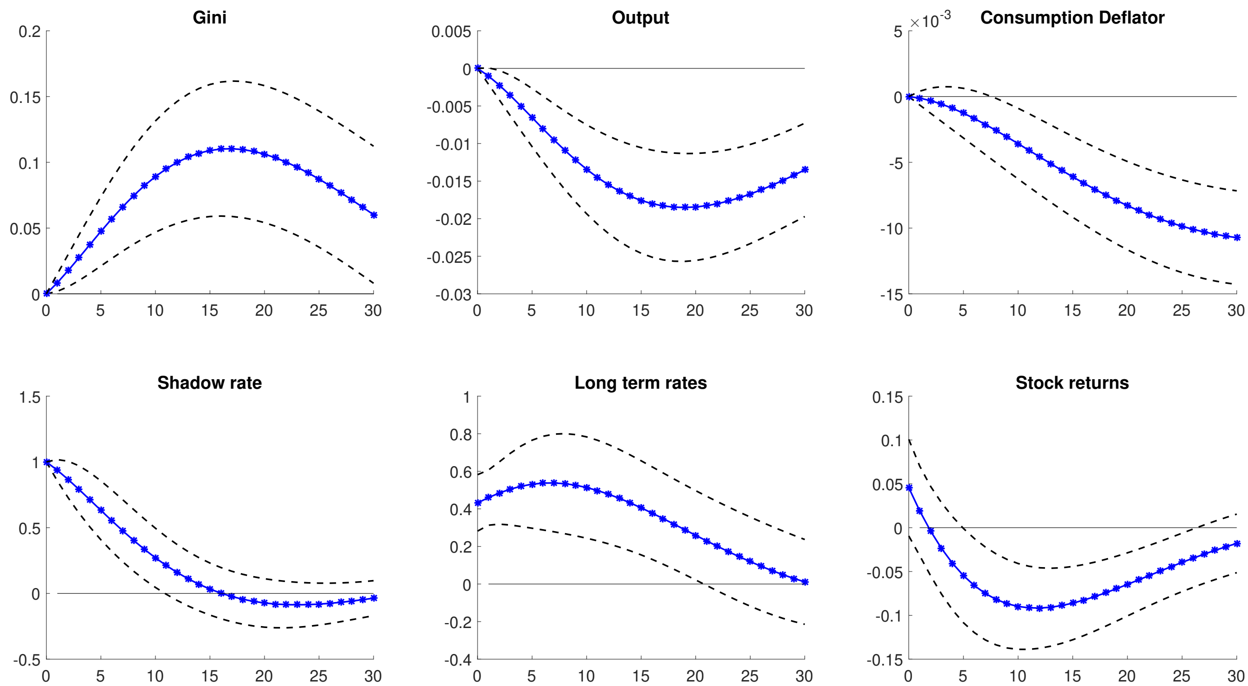

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 11: Responses to a shock on the shadow rate (ordered last)



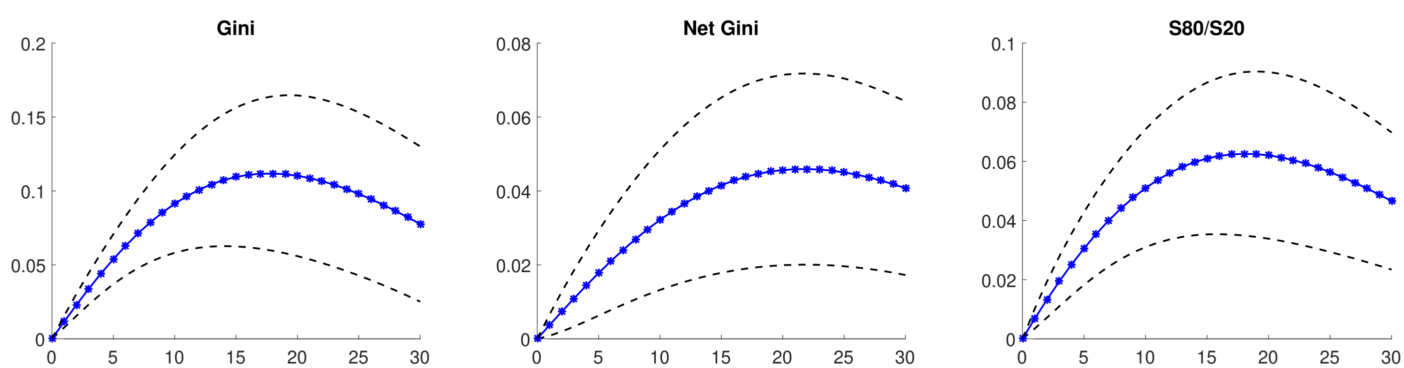

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 12: Responses to a shock on the shadow rate



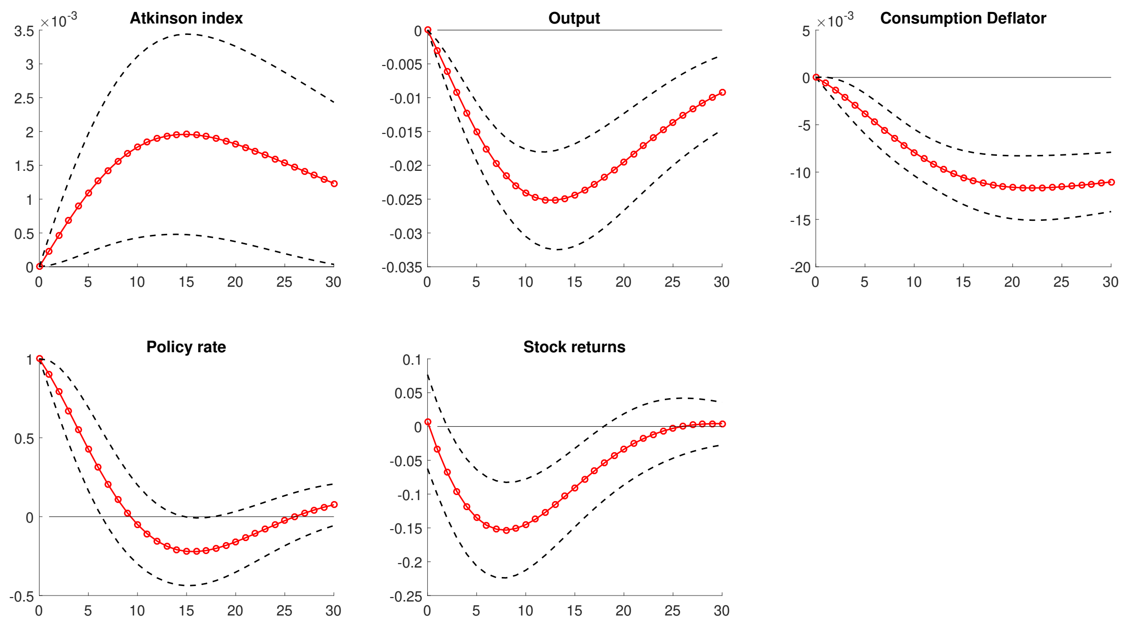

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 13: Responses to a shock on the long-term rate



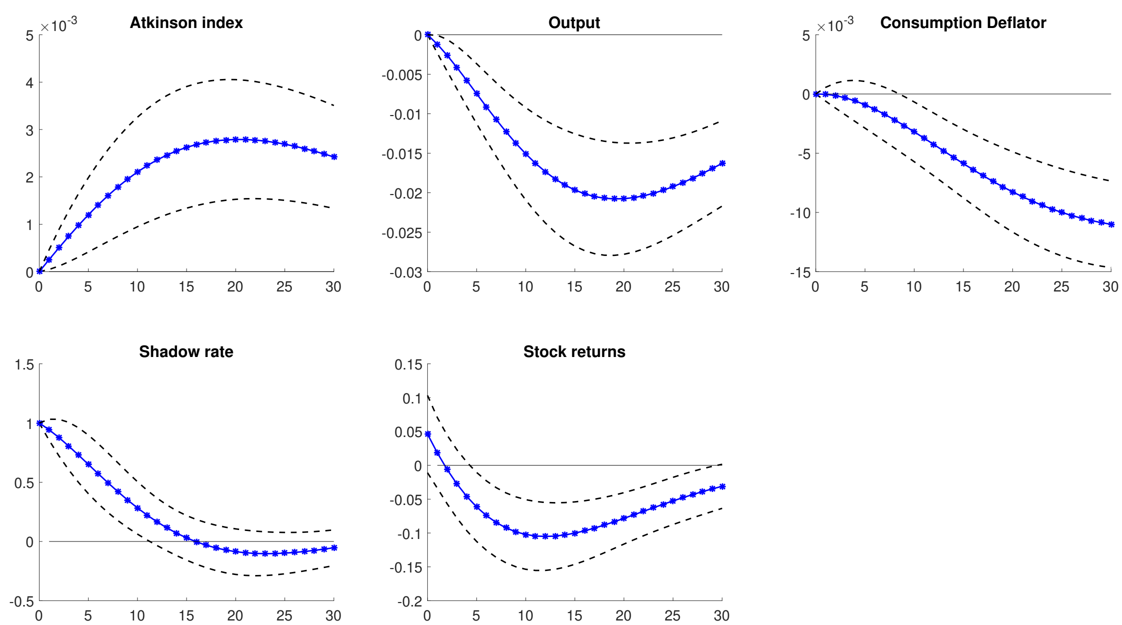

Note: The figure shows the impulse responses of income inequality indicators to a +100 b.p. increase in the long term rate. The solid line is the point estimate and the shaded lines are 90 percent confidence intervals.

Figure 14: Responses to a shock on the policy rate, Atkinson index



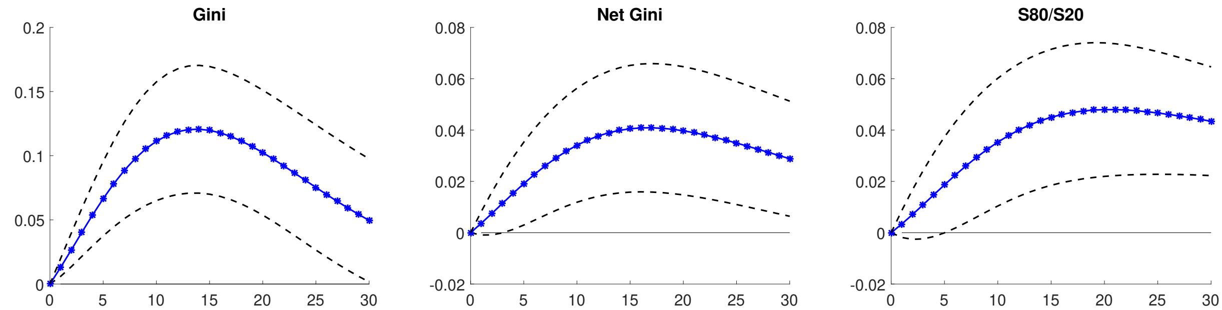

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 15: Responses to a shock on the shadow rate, Atkinson index



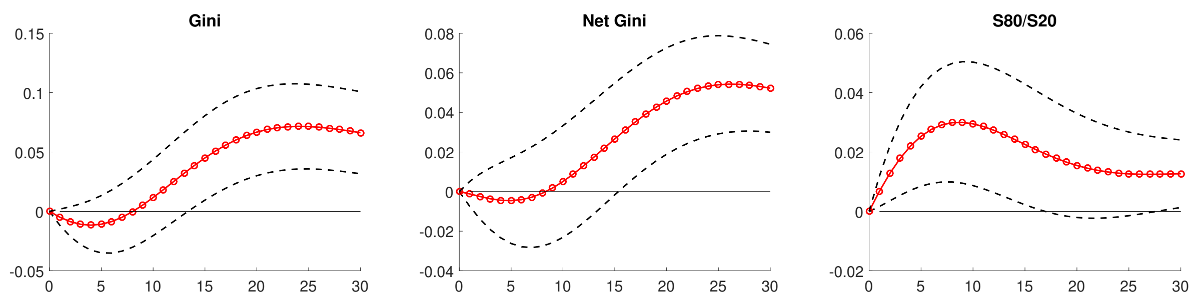

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 16: Responses to a shock on the shadow rate of Wu & Xia (2016)



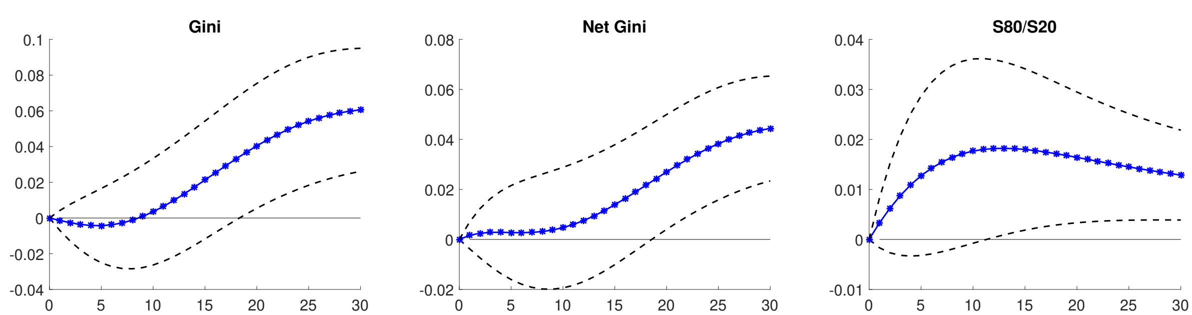

Note: The figure shows the impulse responses of income inequality indicators to a +100 b.p. increase in the shadow rate of Krippner. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent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

Figure 17: Responses to a shock on the policy rate (Low Inequality countries)



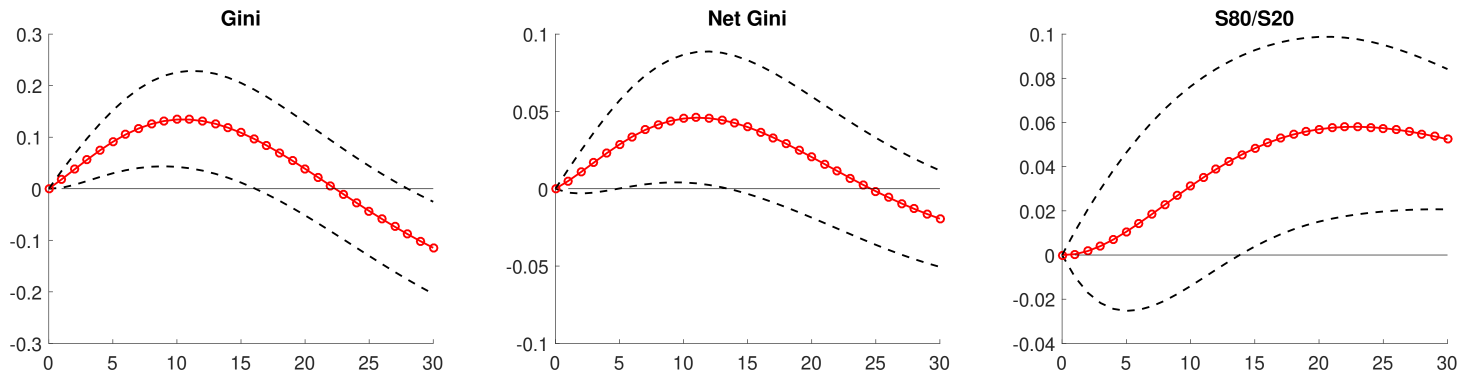

Note: The figure shows the impulse responses of income inequality measures to a +100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence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

Figure 18: Responses to a shock on the shadow rate (Low Inequality countries)



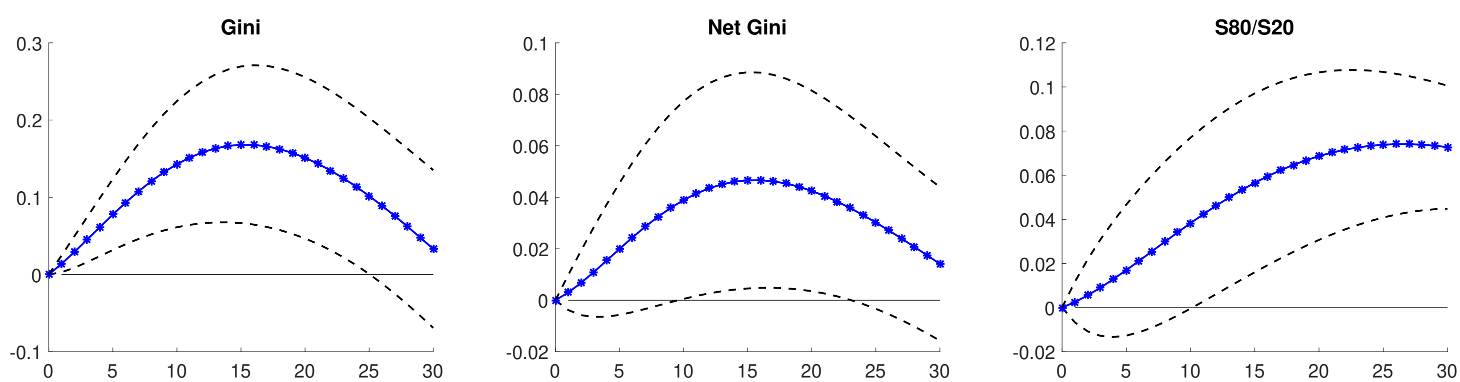

Note: The figure shows the impulse responses of income inequality indicators to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence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

Figure 19: Responses to a shock on the policy rate (High Inequality countries)



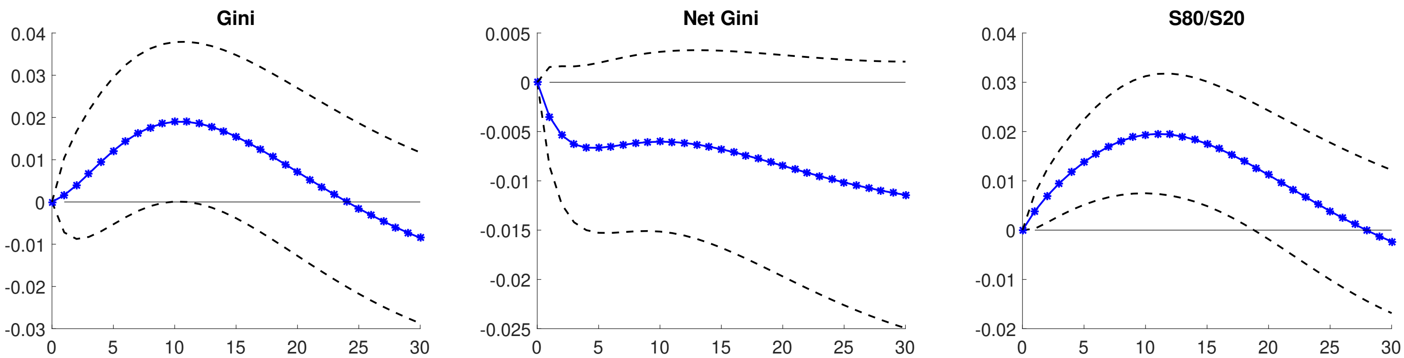

Note: The figure shows the impulse responses of income inequality indicators to a +100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence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

Figure 20: Responses to a shock on the shadow rate (High Inequality countries)



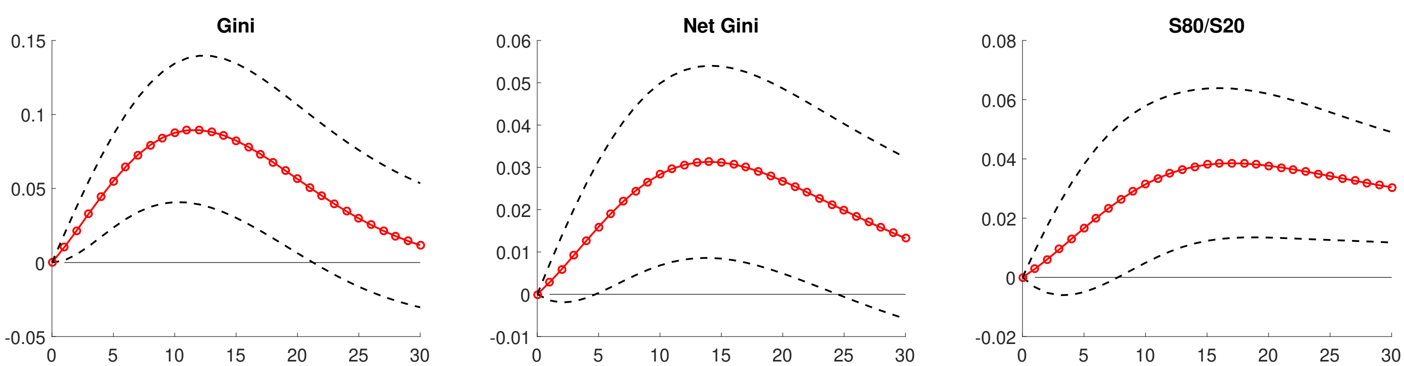

Note: The figure shows the impulse responses of income inequality indicators to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence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

Figure 21: 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 lines are 90 percent confidence intervals.

Figure 22: Responses to a shock on the policy rate (2000Q3-ZLB)

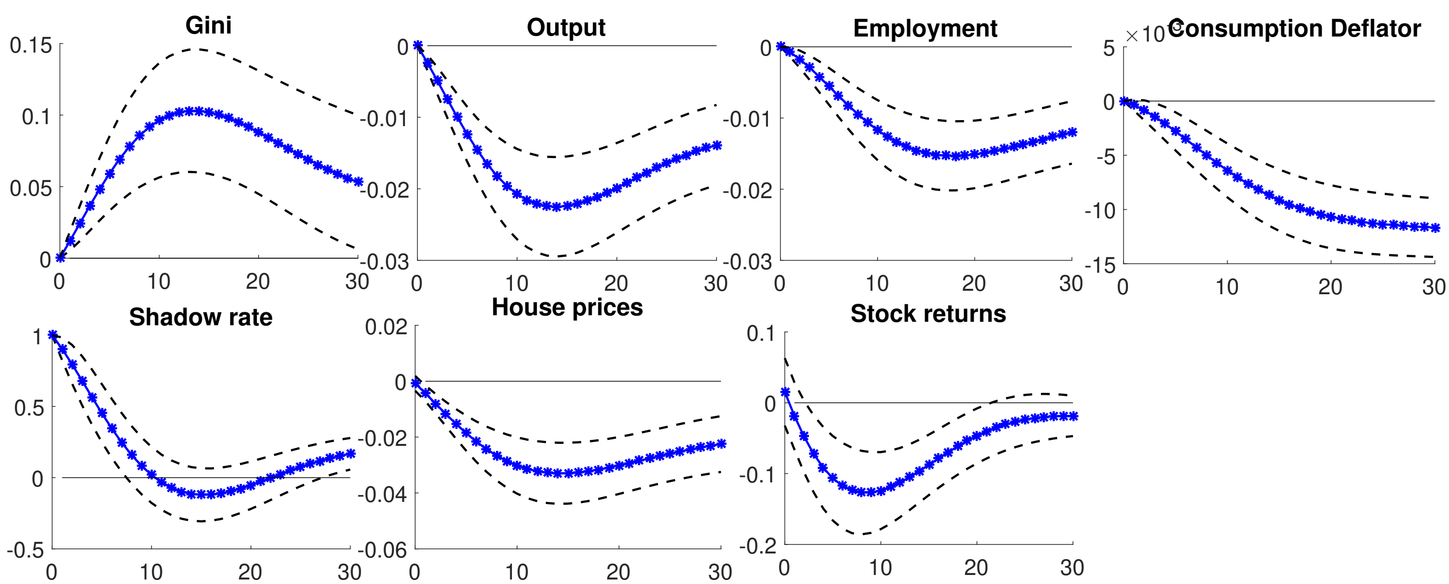



Note: The figure shows the impulse responses of income inequality indicators to a +100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence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

Figure 23: Responses to a shock on the policy rate, VAR(7)

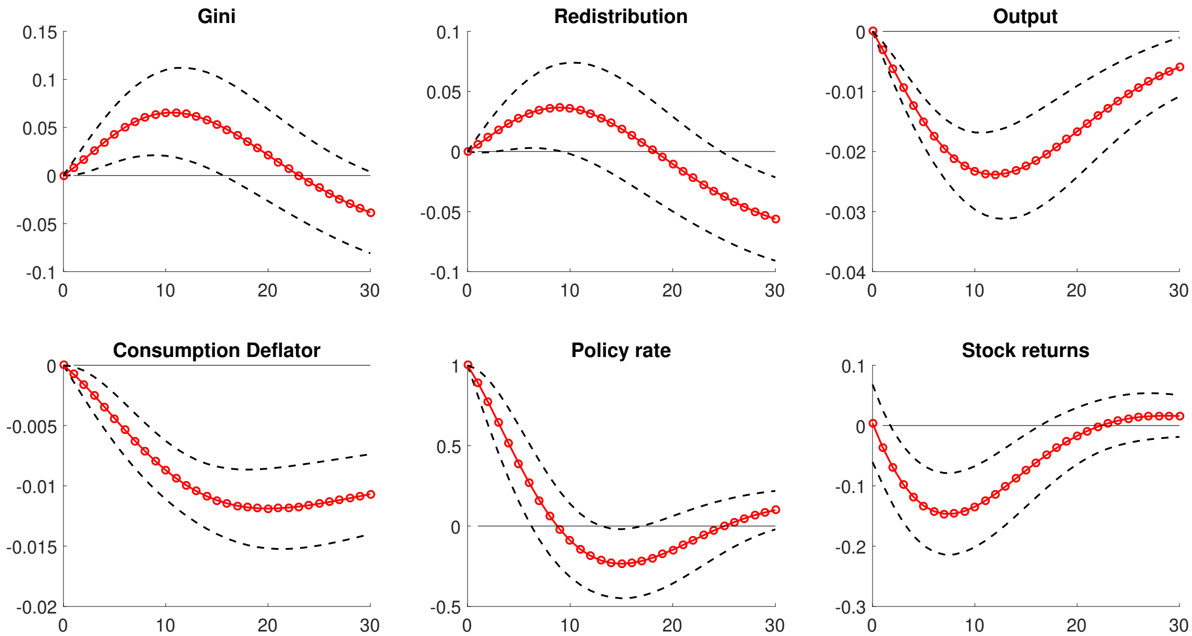

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 24: Responses to a shock on the shadow rate, VAR(7)



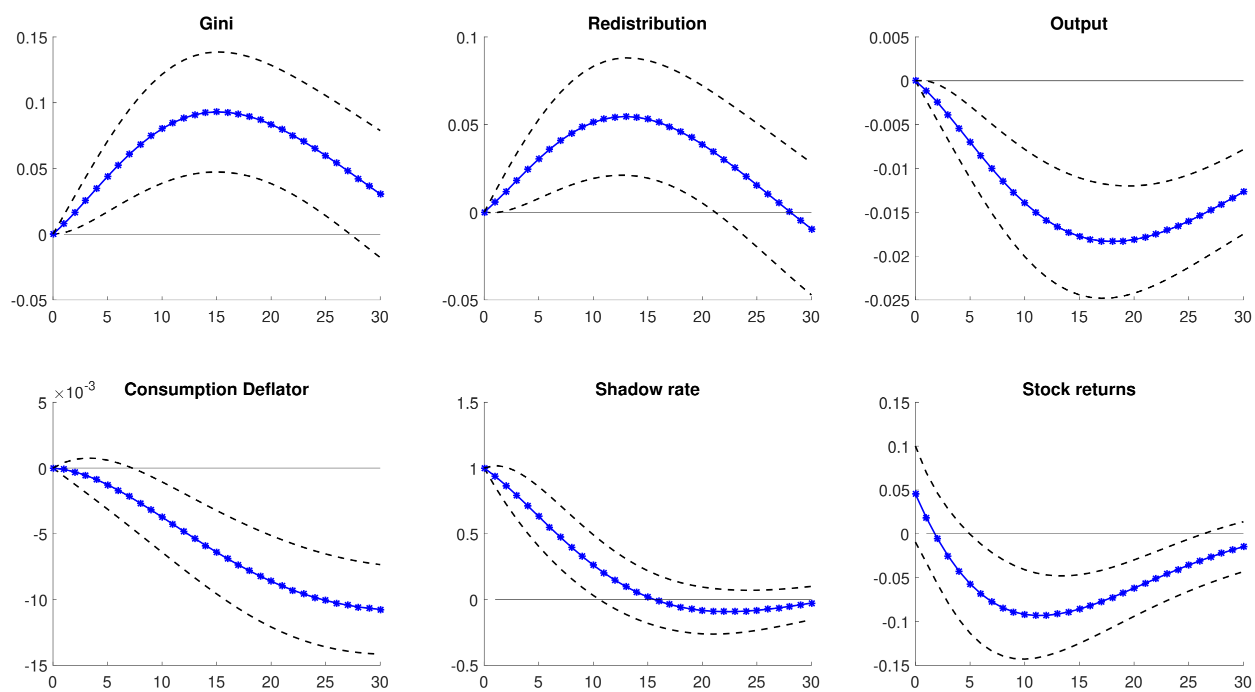

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 25: Responses to a shock on the policy rate, VAR(6)



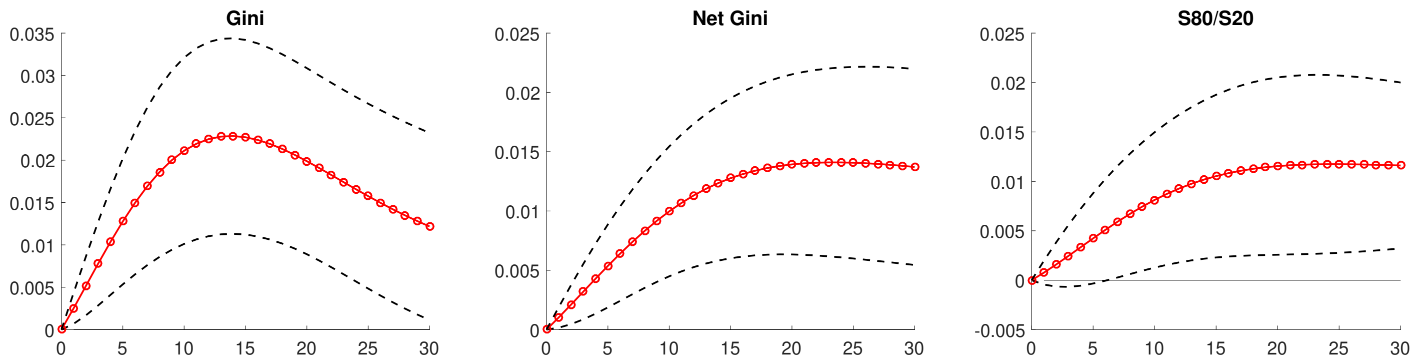

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 26: Responses to a shock on the shadow rate, VAR(6)



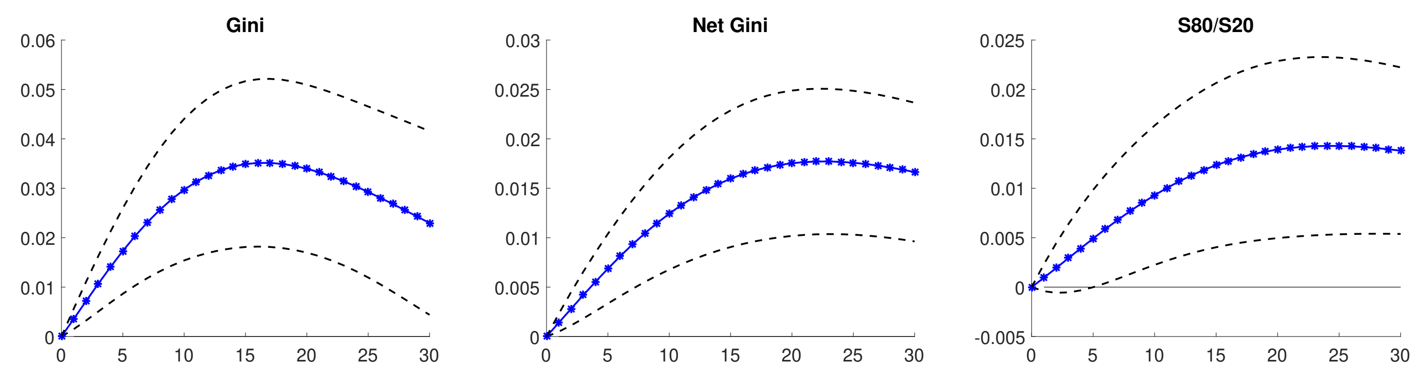

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 27: Responses to a shock on the consumption deflator (with the policy rate)




Note: The figure shows the impulse responses of income inequality indicators to one-standard deviation shock on the consumption deflator. The vertical axis denotes the percentage deviation of the variable after an inflationary shock. The solid line is the point estimate and the shaded lines are 90 percent confidence intervals.

Figure 28: Responses to a shock on the consumption deflator (with the shadow rate)




Note: The figure shows the impulse responses of income inequality indicators to one-standard deviation shock on the consumption deflator. The vertical axis denotes the percentage deviation of the variable after an inflationary shock. The solid line is the point estimate and the shaded lines are 90 percent confidence intervals.

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# 8 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 |
| Long-term interest rate | Government bonds maturing in ten years | OECD.Stat |
| 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 |

### 8.1 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:

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

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*

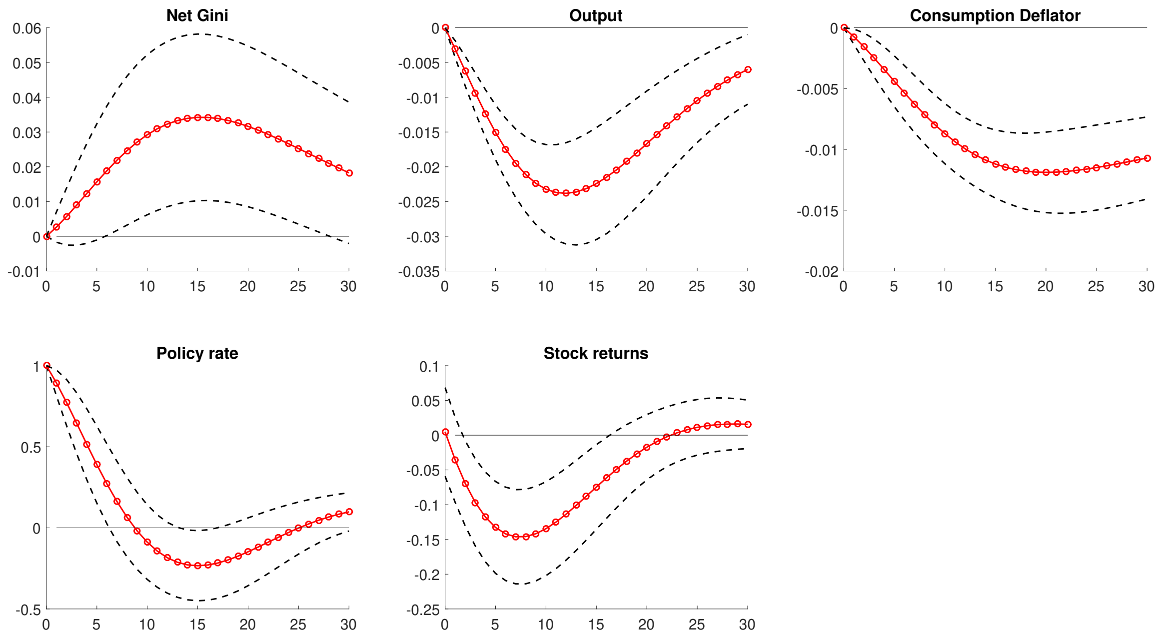



Figure 32: Responses to a shock on the shadow rate (Baseline model)
*Income inequality measure: net Gini*

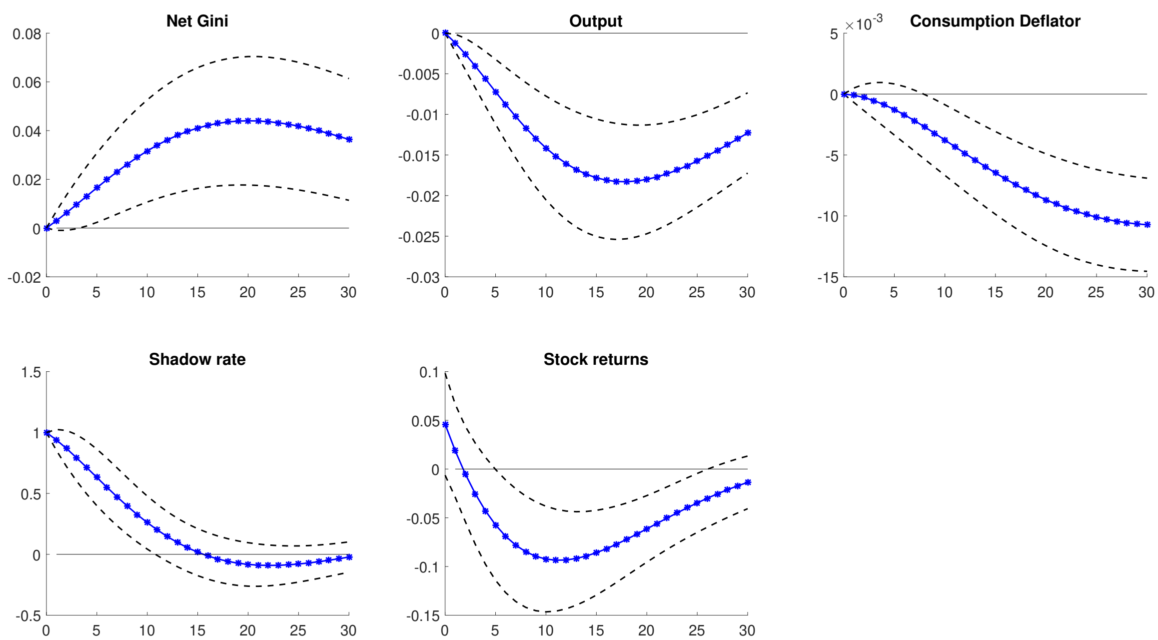


Figure 33: Responses to a shock on the policy rate (Baseline model)
*Income inequality measure: S80/S20*

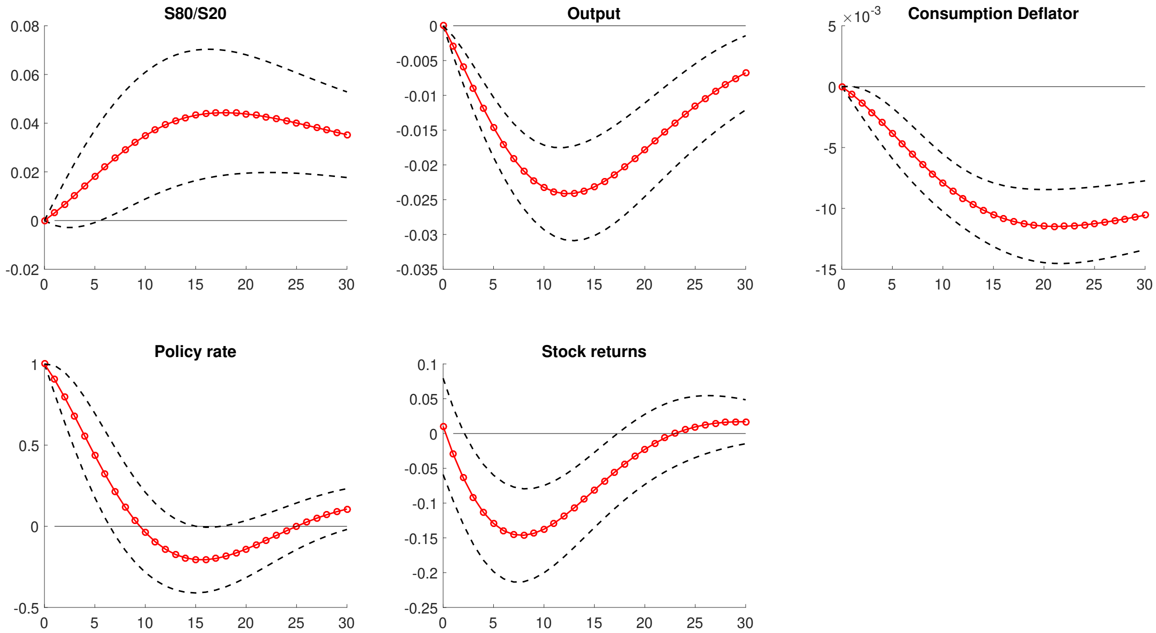



Figure 34: Responses to a shock on the shadow rate (Baseline model)
*Income inequality measure: S80/S20*

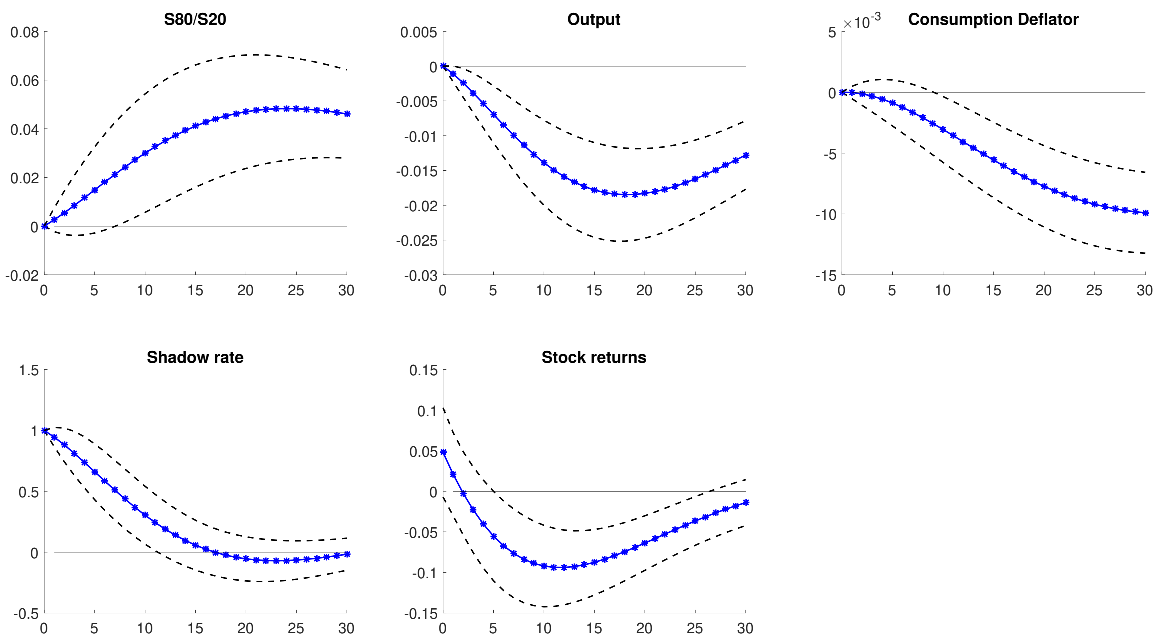


Figure 35: Responses to a shock on the policy rate (Ordering à la *Guerello*)
*Income inequality measure: net Gini*

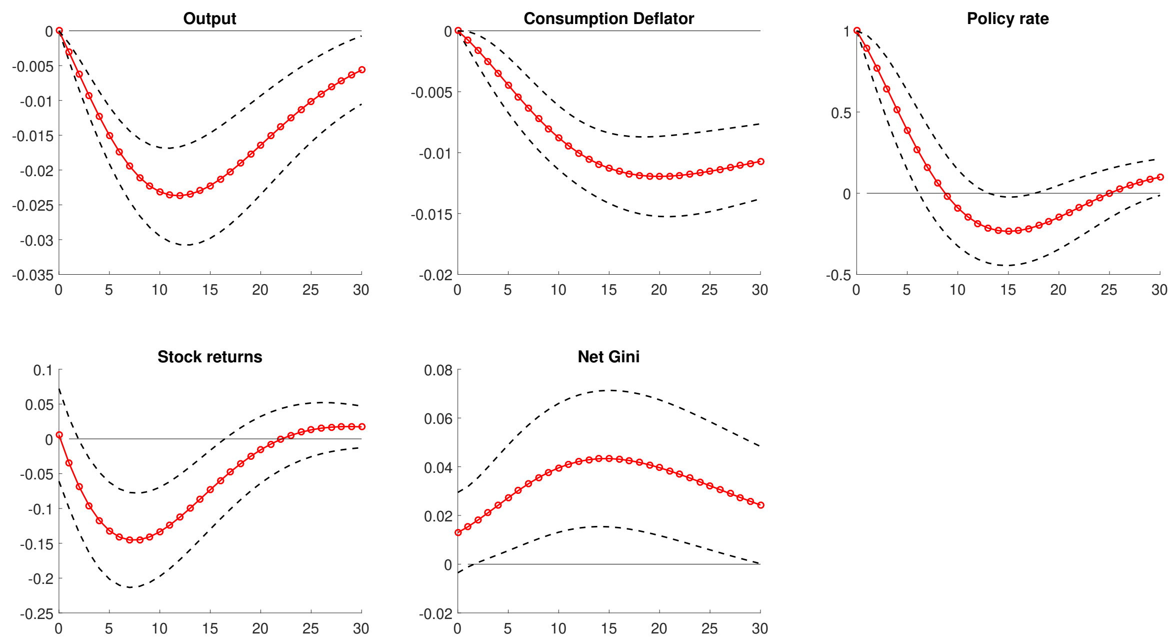



Figure 36: Responses to a shock on the shadow rate (Ordering à la *Guerello*)
*Income inequality measure: net Gini*

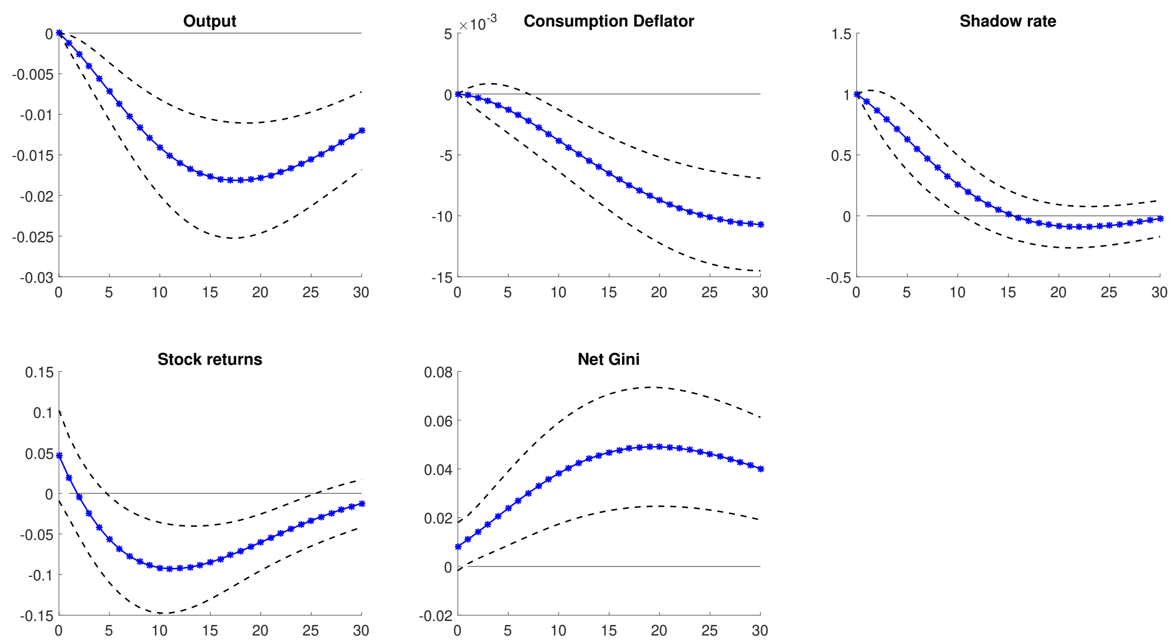


Figure 37: Responses to a shock on the policy rate (Ordering à la *Guerello*)
*Income inequality measure: S80/S20*

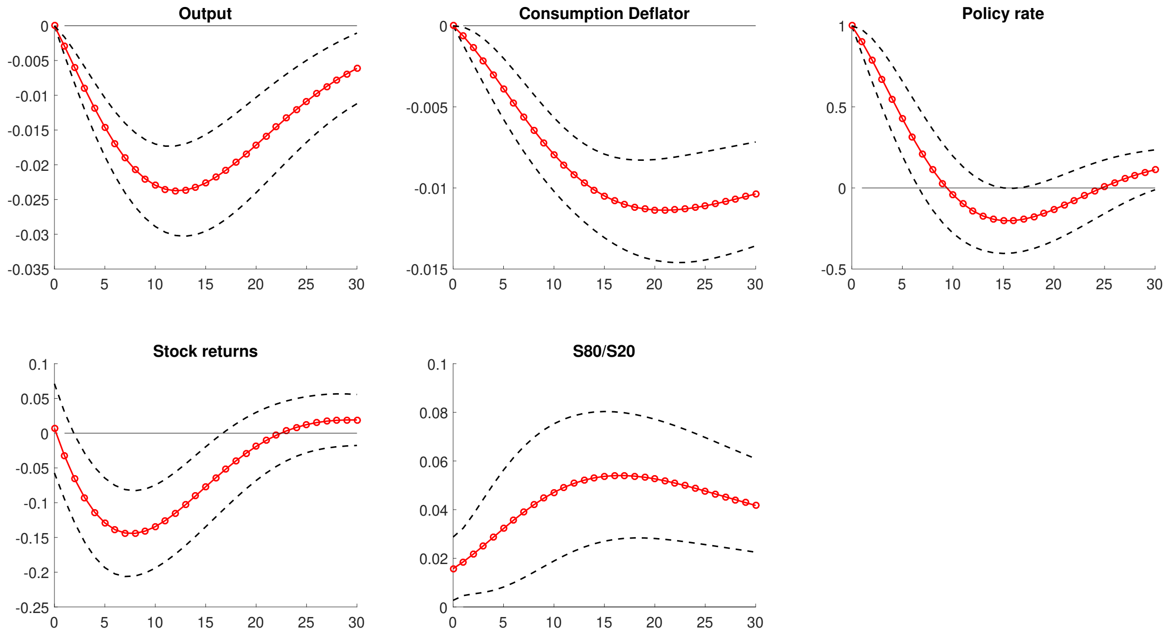



Figure 38: Responses to a shock on the shadow rate (Ordering à la *Guerello*)
*Income inequality measure: S80/S20*

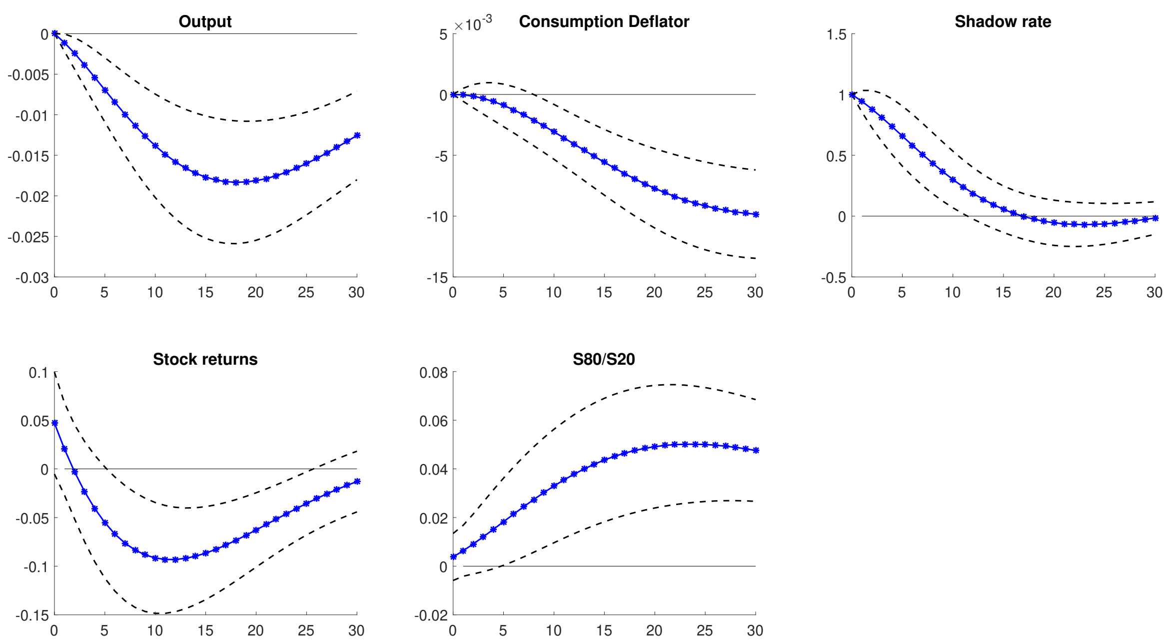


Figure 39: Responses to a shock on the policy rate (ordered last)
*Income inequality measure: net Gini*

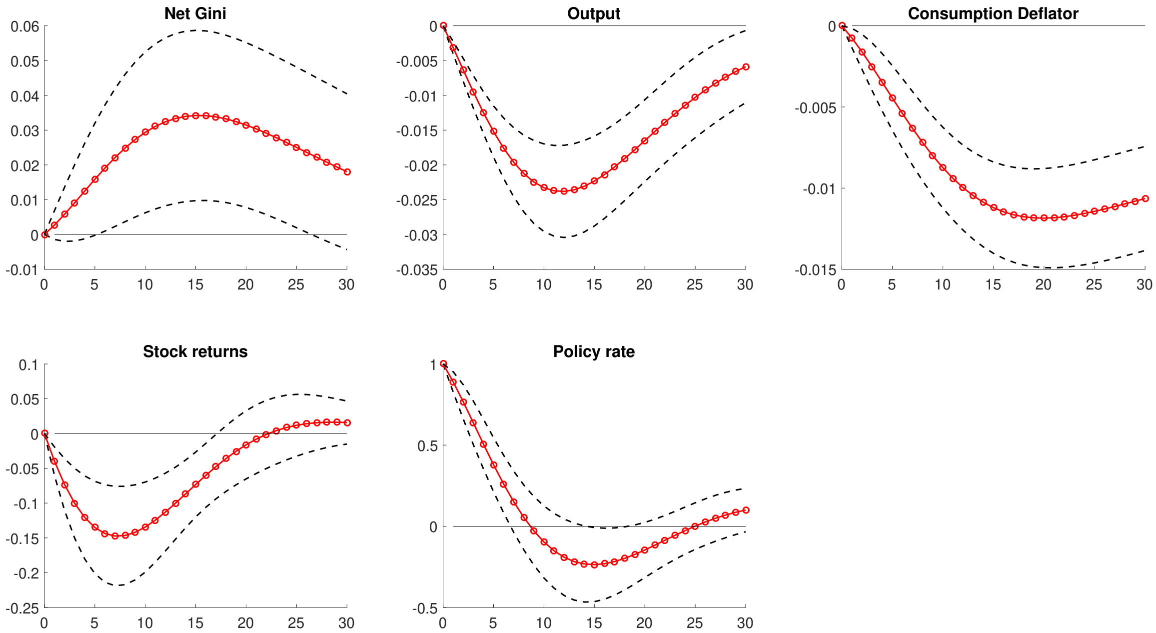



Figure 40: Responses to a shock on the shadow rate (ordered last)
*Income inequality measure: net Gini*

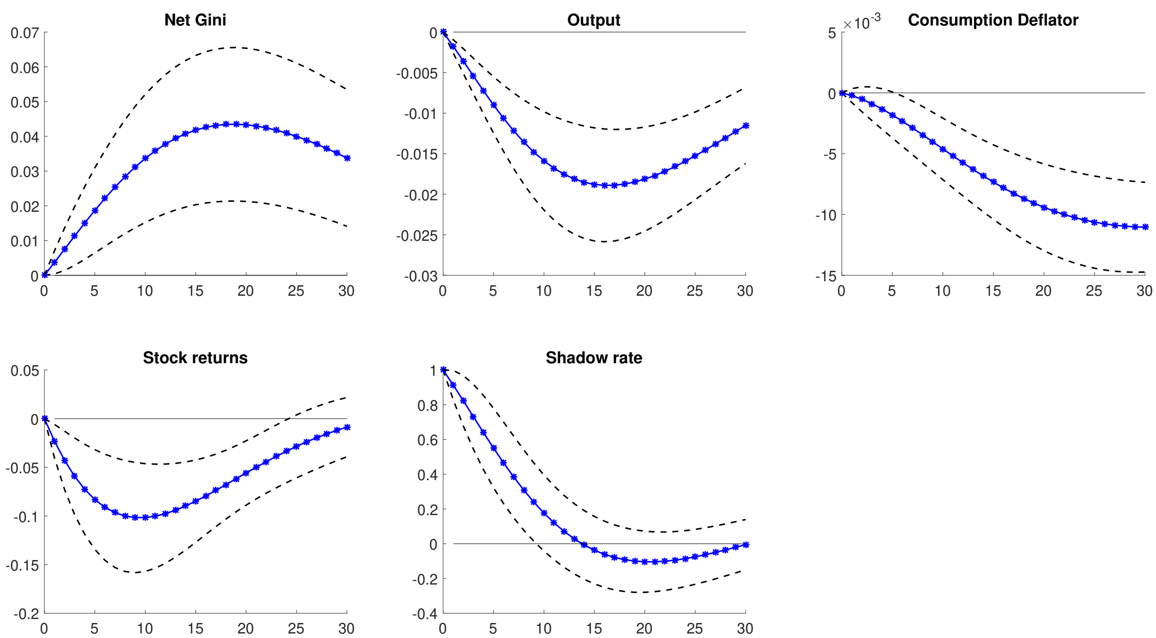


Figure 41: Responses to a shock on the policy rate (ordered last)
*Income inequality measure: S80/S20*

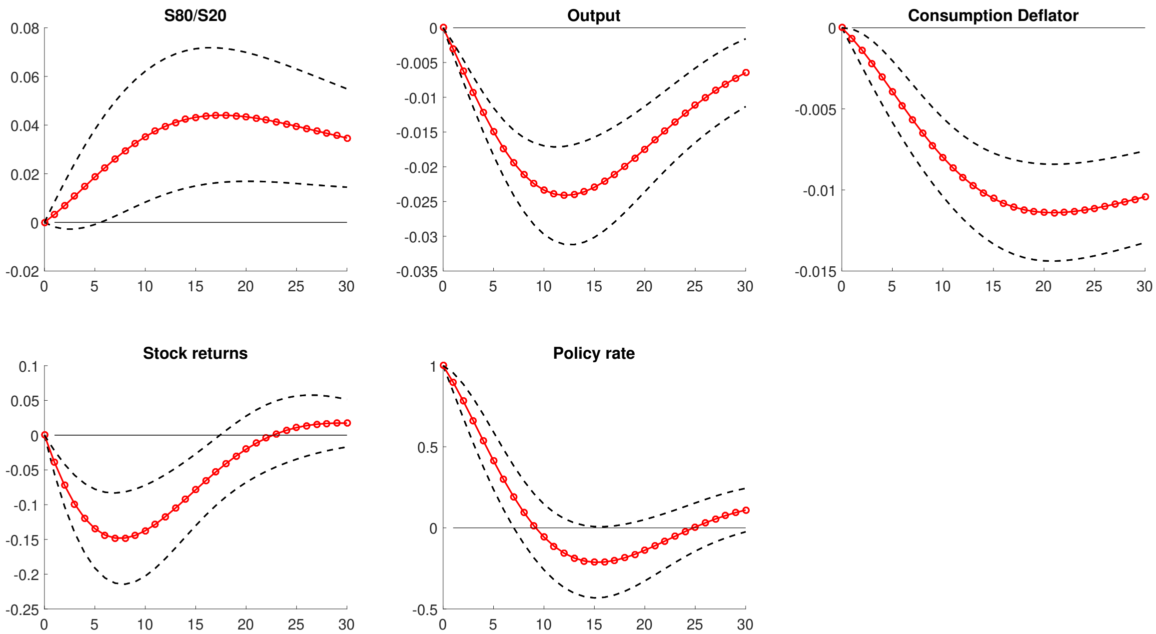



Figure 42: Responses to a shock on the shadow rate (ordered last)
*Income inequality measure: S80/S20*

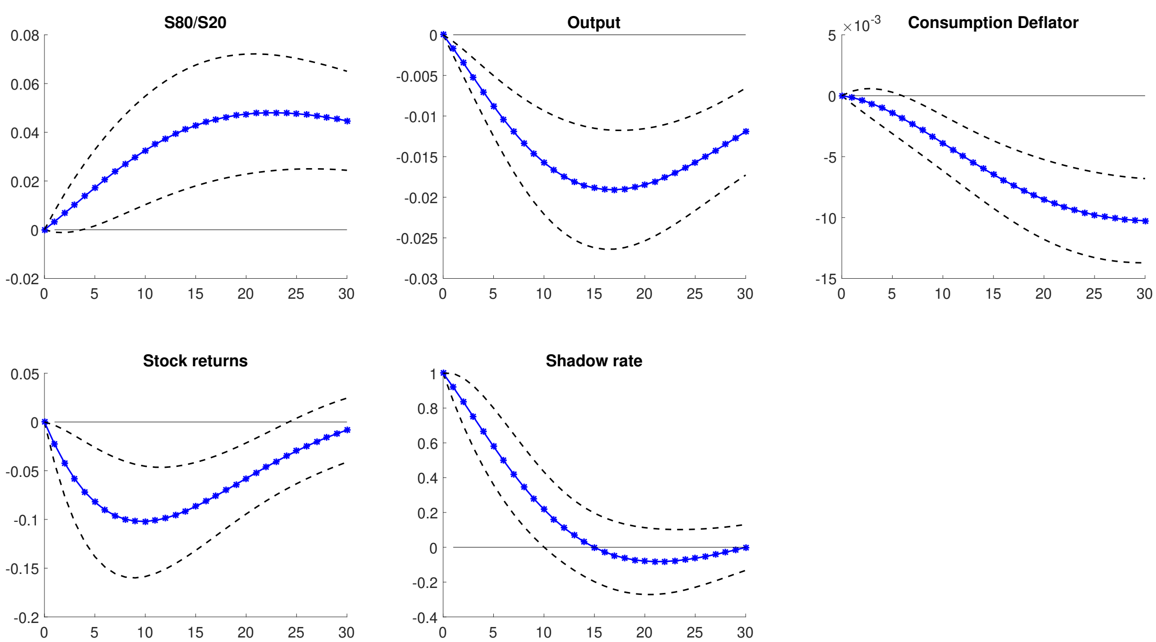
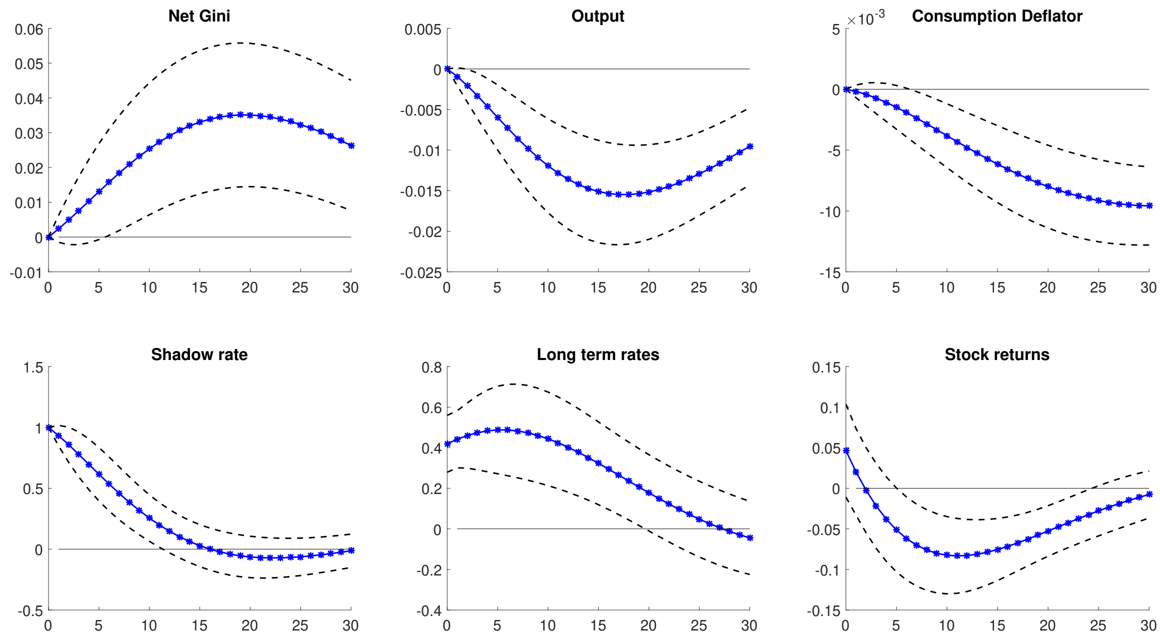
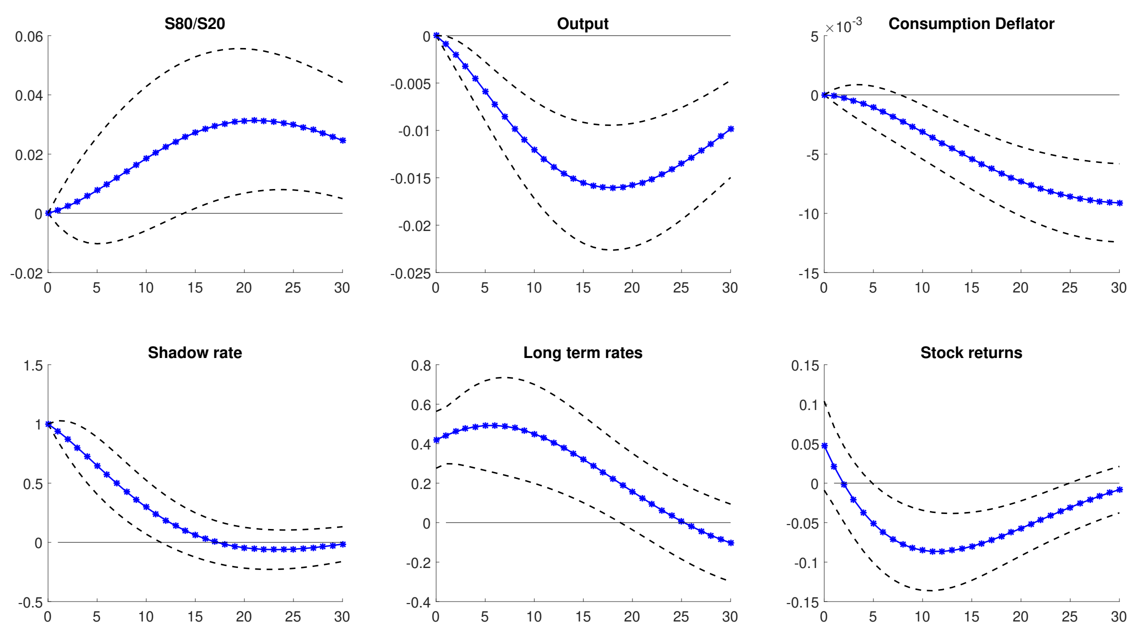


Figure 43: Responses to a shock on the shadow rate - net Gini




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 lines are 90 percent confidence intervals.

Figure 44: Responses to a shock on the shadow rate - S80/S20

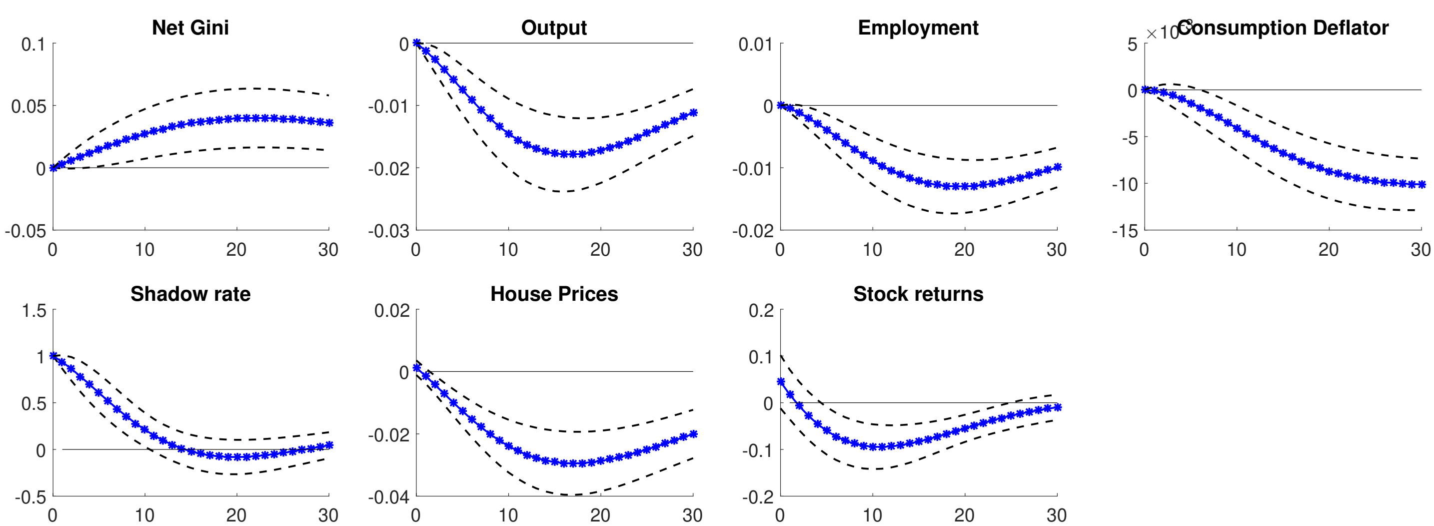



Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 45: Responses to a shock on the policy rate, VAR(7) - net 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 lines are 90 percent confidence intervals.

Figure 46: Responses to a shock on the shadow rate, VAR(7) - net Gini

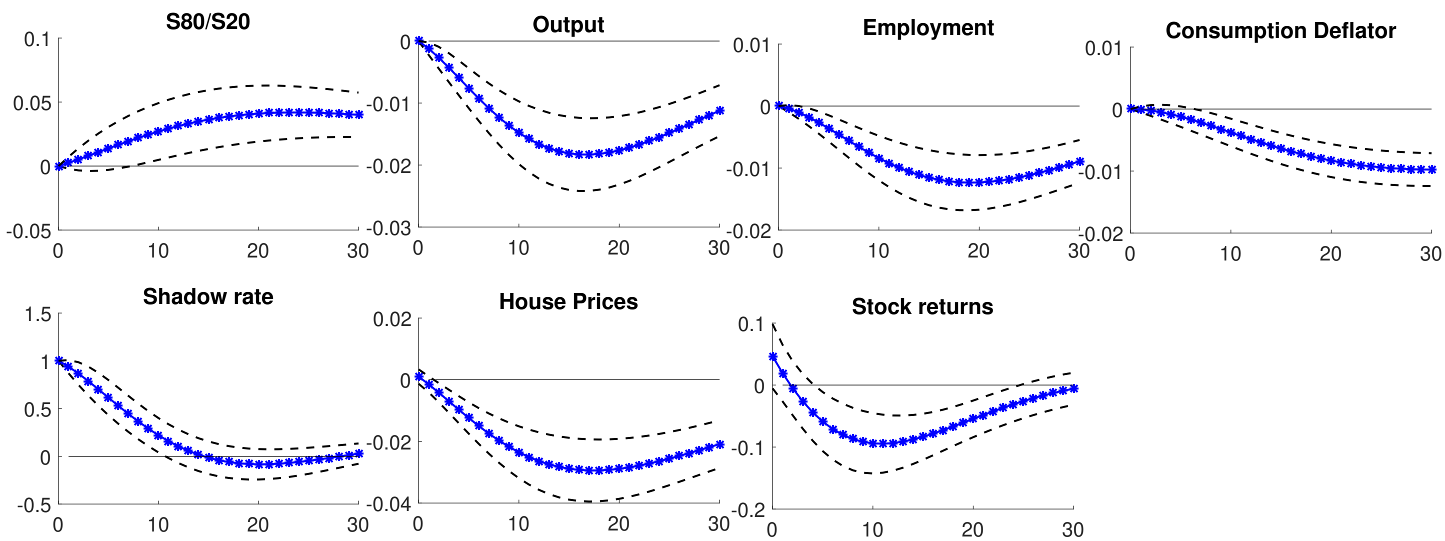



Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 47: Responses to a shock on the policy rate, VAR(7) - S80/S20

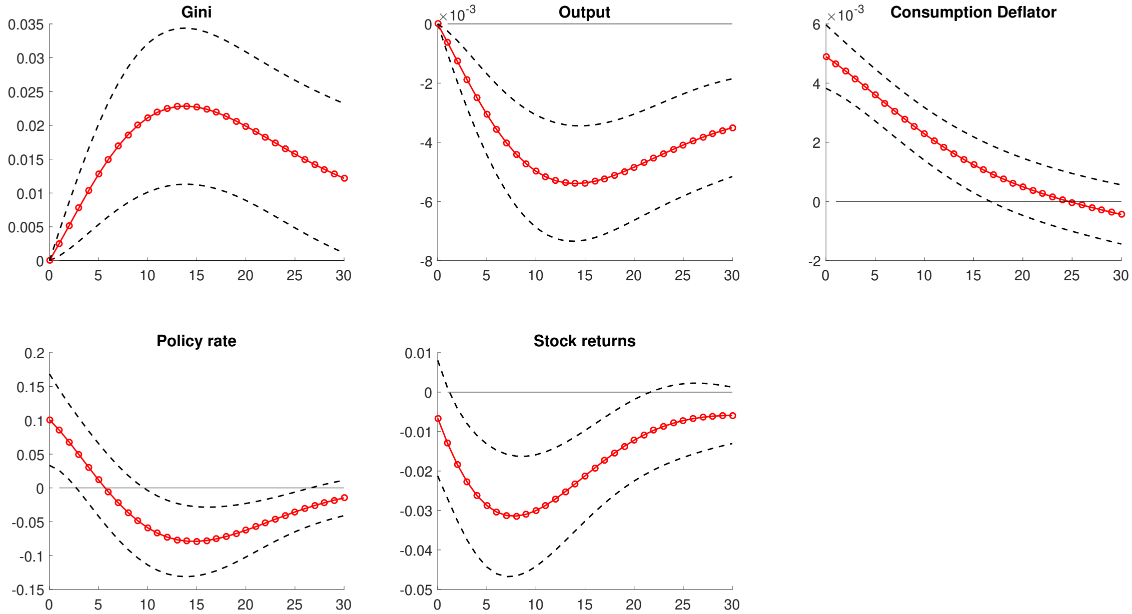

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the policy rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 48: Responses to a shock on the shadow rate, VAR(7) - S80/S20



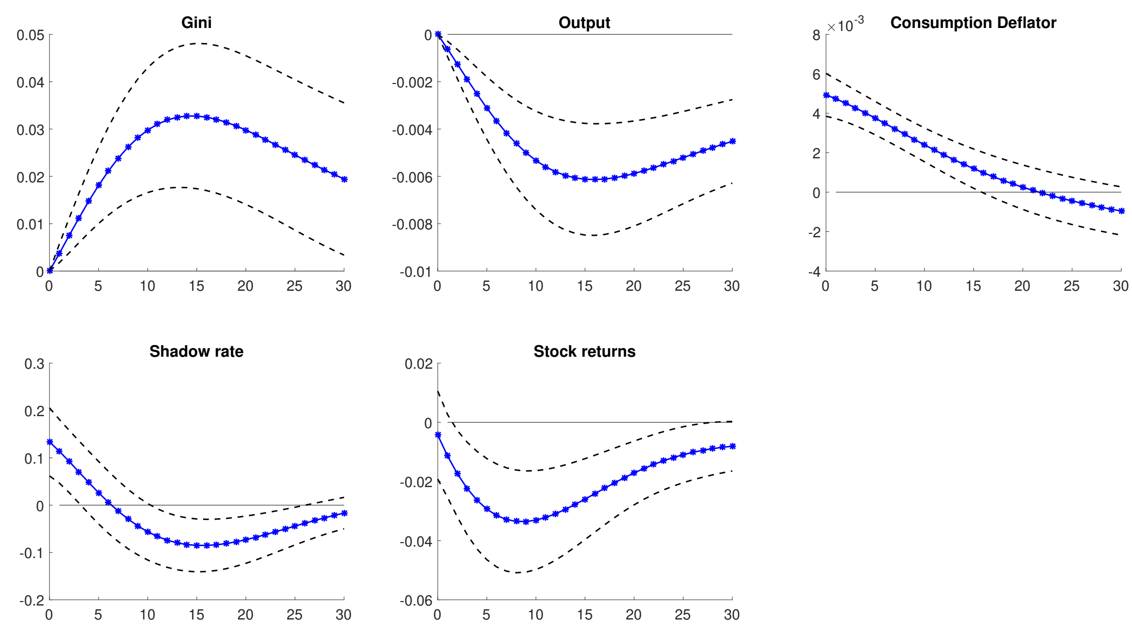

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to a +100 b.p. increase in the shadow rate. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are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

Figure 49: Responses to a shock on the consumption deflator - Gini



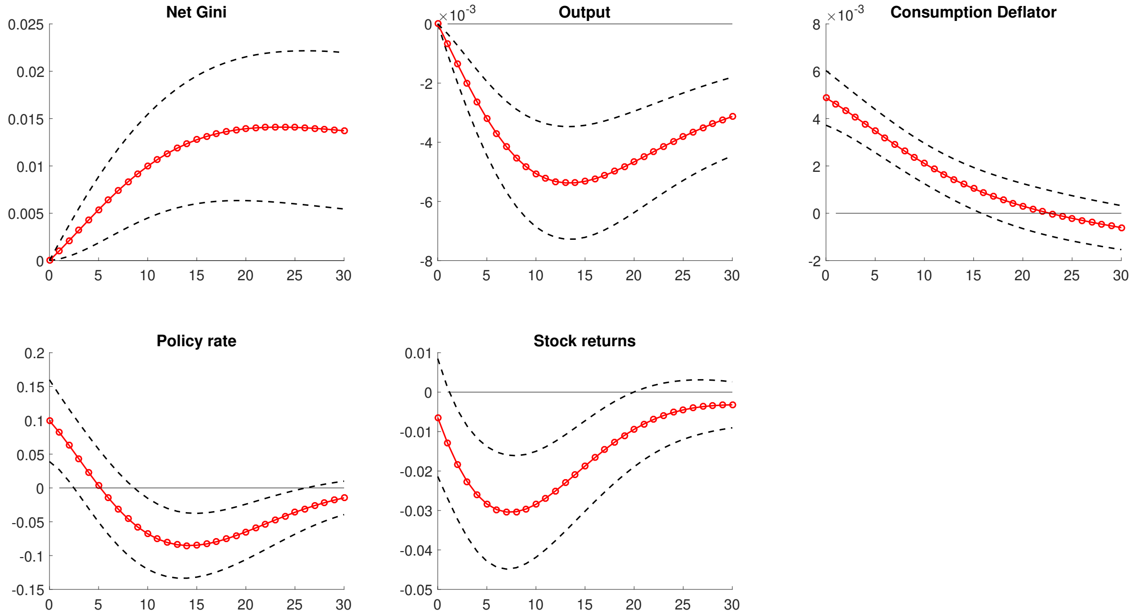

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to one-standard deviation shock on the consumption deflator. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence intervals.

Figure 50: Responses to a shock on the consumption deflator - Gini



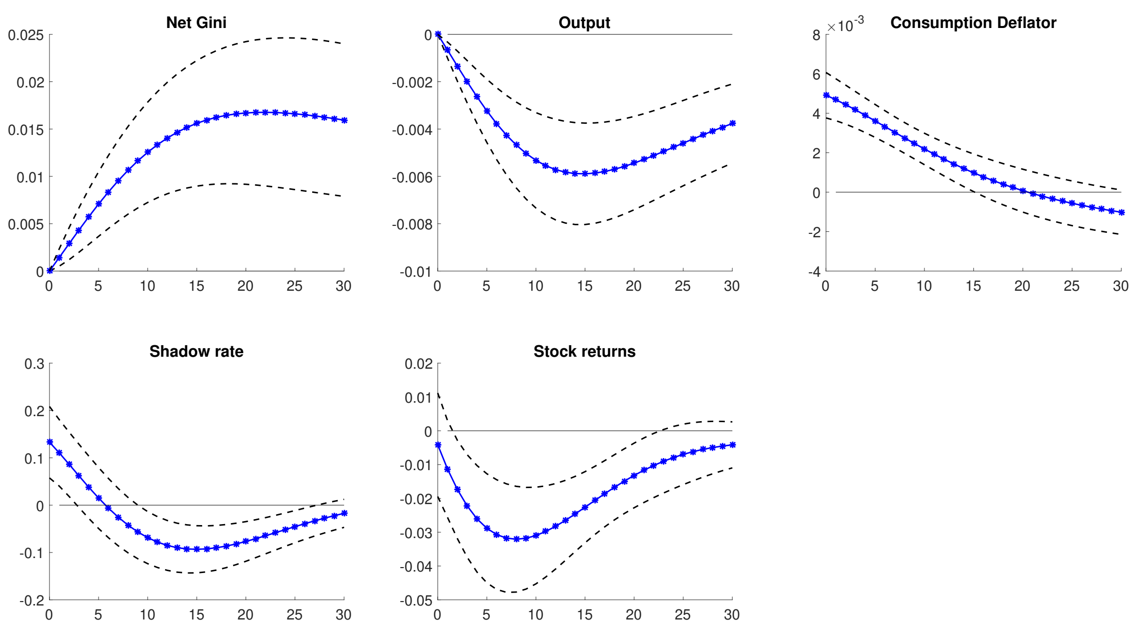

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to one-standard deviation shock on the consumption deflator. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence intervals.

Figure 51: Responses to a shock on the consumption deflator - Net Gini



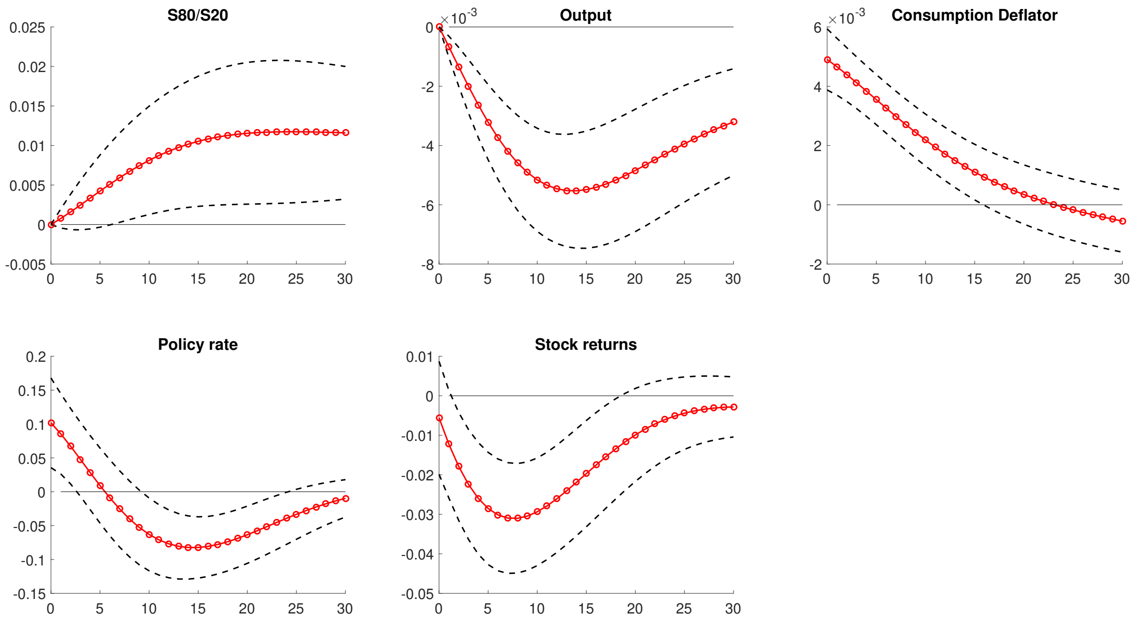

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to one-standard deviation shock on the consumption deflator. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence intervals.

Figure 52: Responses to a shock on the consumption deflator - Net Gini



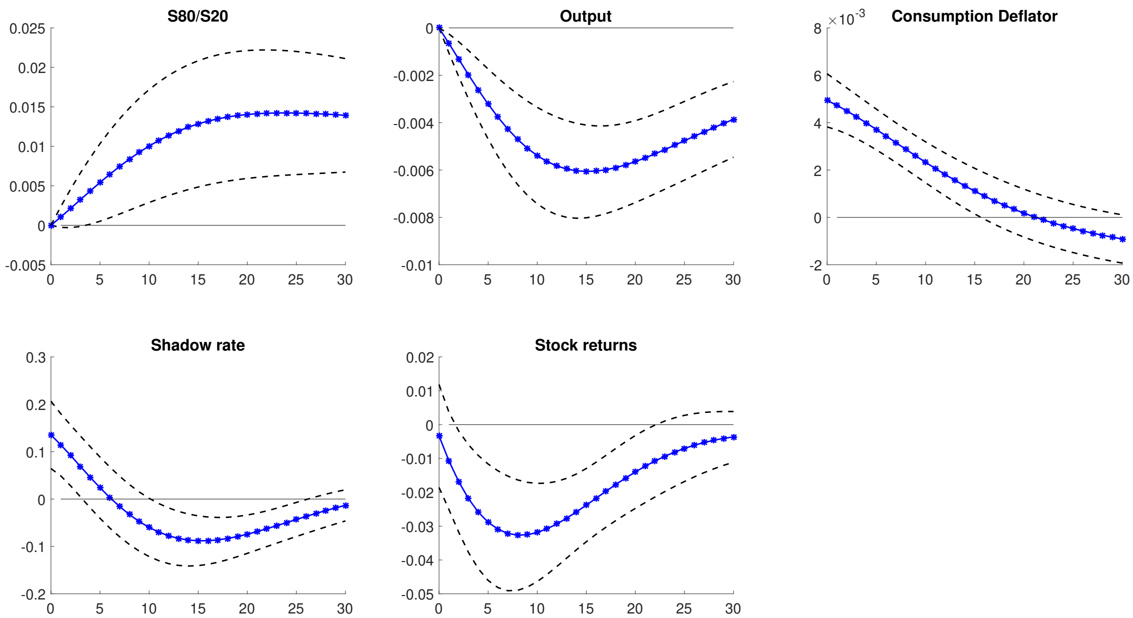

Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to one-standard deviation shock on the consumption deflator. The vertical axis denotes the percentage deviation of the variable after a monetary policy shock. The solid line is the point estimate and the shaded lines are 90 percent confidence intervals.

Figure 53: Responses to a shock on the consumption deflator - S80/S20




Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to one-standard deviation shock on the consumption deflator. 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 lines are 90 percent confidence intervals.

Figure 54: Responses to a shock on the consumption deflator - S80/S20




Note: The figure shows the impulse responses of income inequality and other macroeconomic variables to one-standard deviation shock on the consumption deflator. 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 lines are 90 percent confidence intervals.

## ABOUT OFCE

The Paris-based Observatoire français des conjonctures économiques (OFCE), or French Economic Observatory is an independent and publicly-funded centre whose activities focus on economic research, forecasting and the evaluation of public policy.

Its 1981 founding charter established it as part of the French Fondation nationale des sciences politiques (Sciences Po), and gave it the mission is to “ensure that the fruits of scientific rigour and academic independence serve the public debate about the economy”. The OFCE fulfils this mission by conducting theoretical and empirical studies, taking part in international scientific networks, and assuring a regular presence in the media through close cooperation with the French and European public authorities. The work of the OFCE covers most fields of economic analysis, from macroeconomics, growth, social welfare programmes, taxation and employment policy to sustainable development, competition, innovation and regulatory affairs.

## ABOUT SCIENCES PO

Sciences Po is an institution of higher education and research in the humanities and social sciences. Its work in law, economics, history, political science and sociology is pursued through ten research units and several crosscutting programmes.
Its research community includes over two hundred twenty members and three hundred fifty PhD candidates. Recognized internationally, their work covers a wide range of topics including education, democracies, urban development, globalization and public health.
One of Sciences Po’s key objectives is to make a significant contribution to methodological, epistemological and theoretical advances in the humanities and social sciences. Sciences Po’s mission is also to share the results of its research with the international research community, students, and more broadly, society as a whole.

## PARTNERSHIP