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Quantitative Easing's Effect on Income Inequality
A study on Sweden

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Abstract

This study explores if the first Swedish quantitative easing program conducted between 2015 and 2018 had an impact on the income distribution. In line with previous research, a structural vector autoregression is employed. As a metric of inequality, the linearly interpolated Gini coefficient, before taxes and transfers, is used. Furthermore, output, inflation, and equity prices are included in the analysis in line with Saiki and Frost (2014). QE is not found to have any significant impact on the income distribution despite allowing for several different specifications. This can be seen in the light of studies on other countries showing results in disparate directions.

Keywords: Income Inequality, Quantitative Easing, Income Composition Channel, Unconventional Monetary Policy

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1. Introduction

In the decade after the great recession, policymakers around the world struggled to get inflation back to target. In some countries, it became clear that conventional monetary policy did not suffice. As a response, central bankers around the world employed essentially unused methods or methods previously only employed in severe crises, such as; negative interest rates and quantitative easing (QE) (Borio & Disyatat, 2010). Simultaneously, Western countries have experienced a significant increase in income inequality (Chancel et al., 2021).

Considering that the use of unconventional monetary policy is relatively novel, the literature is also rather limited. Previous research on the subject can be deemed as unclear and at times contradictory. The initial study on the effect of QE on income inequality, examining Japan, concluded that there is a significant increase in income inequality (Saiki & Frost, 2014). However, a later research paper by Inui et al. (2017) found no significant effect on the income distribution caused by the use of QE in Japan. Country characteristics affect the potential consequences of policy implementations, and similar studies conducted in other regions conclude somewhat conflicting findings. Coibion et al. (2017) conclude that contractionary monetary policy in the US significantly increases income inequality due to income heterogeneity. In contrast, studies conducted in the UK found expansionary monetary policy to increase inequality through the income composition channel (Mumtaz & Theophilopoulou, 2017). Lastly, research by Lenza and Slacaclek (2018) on four ECB countries established that quantitative easing decreased income inequality due to a decrease in unemployment but simultaneously slightly increased wealth inequality, through the portfolio channel.

As demonstrated, the previous literature on the subject is relatively limited, contradictory, and seemingly heterogeneous in terms of country and region. There is one study examining the effect of monetary policy shocks on income inequality in Sweden (Amberg et al., 2022). The authors found a U-shaped effect on the income distribution, where the poorest and wealthiest households benefited, while the overall effect was deemed negligible. In comparison with Amberg et al. (2022), we will not focus on general monetary policy shocks but instead on the effects of the Swedish central bank's QE program on income inequality in Sweden. Similar research, as to our knowledge, has not yet been conducted.

The questions we aim to answer are: did the Swedish central bank's (Riksbanken) quantitative easing program affect income inequality in Sweden? If so, in which direction was income inequality affected? This is performed by using a structural vector autoregression with aggregate Swedish data on GDP, inflation, monetary base, stock market, and the Gini coefficient. Thereafter, we examine the interaction between variables using impulse response functions (IRF).

This paper is structured as follows. Section 2 describes unconventional monetary policy in general but with a focus on quantitative easing as well as income inequality. Furthermore, it also provides an overview of Swedish monetary policy. Section 3 contains relevant previous literature in the research area. Section 4 discusses the empirical strategy and model. Section 5 explains the data being used in the study while section 6 contains the results. Section 7 presents robustness checks and alternative specifications. Section 8 provides a discussion of our findings and the limitations of the study. Lastly, in section 9 concluding remarks are presented.

2. Background

This section of the paper will provide a comprehensive description of the fundamental macroeconomic terms used as well as a brief description of the country of Sweden. Thus, unconventional monetary policy and quantitative easing are presented first, which is followed by income inequality, and lastly an overview of Sweden.

2.1 Unconventional Monetary Policy and Quantitative Easing

Central banks in developed countries have for decades used a policy interest rate as their tool to conduct monetary policy. However, to avoid an even deeper recession after the great financial crisis in 2008 a new framework was born, called unconventional monetary policy (UMP). In general, the conventional approach can be seen as "interest rate policy" while the unconventional concerns "balance sheet policies". The introduction of UMP to central banking resulted in heated debates regarding its rather complex structure and potentially complex consequences (Borio & Disyatat, 2010).

Unconventional monetary policy can be summarized in four relatively broad categories:

(i) negative interest rate policies, i.e., setting the policy interest rate below zero.
(ii) lending operations, i.e., central banks expanding their liquidity facilities.
(iii) asset purchase programs or quantitative easing, i.e., expanding central banks balance sheet to lower long-term yields.
(iiii) forward guidance, i.e., explicitly communicating a commitment to low interest rates.

This study will focus on the third category of UMP, i.e., quantitative easing (QE). QE is conducted when central banks expand their balance sheet by purchasing securities, such as bonds and mortgage-backed securities, from the open market. This results in an increase of central bank reserves and the monetary base, as well as, higher bond prices and thus lower long-term yields. In turn, financial markets with improved liquidity and lowered borrowing costs are expected to stimulate aggregate spending (Potter & Smets, 2019).

Quantitative easing affects income and wealth inequality through various distributional channels. Its impact is dependent on the heterogeneity of agents, i.e., earnings and wealth are composed differently for different individuals. The main channels of impact, as discussed in the literature are the portfolio channel, income composition channel, within-component

heterogeneity channel, and job creation channel. Other distributive channels are the inflation-, and interest rate exposure channels (Coibion et al., 2017; Colciago et al., 2019). Considering that QE is a relatively novel monetary phenomenon, with relatively limited literature on its relation to inequality, we take a departure in two different strands of literature; one examining conventional monetary policy shocks on income and wealth inequality and one examining unconventional monetary policy's impact on income inequality.

The portfolio channel implies that when the central bank purchases government bonds demand increases which, all else equal, increases prices. Consequently, the yield decreases which leads to a decrease in the risk-free rate. This, according to conventional financial theory, suggests that the present value of future cash flows increases for all asset classes which leads to most assets appreciating in value. Moreover, as returns decline, investors invest even more in riskier assets which reduces returns further (Albertazzi et al., 2018). Thus, via the portfolio channel, the wealth distribution can be impacted by changes in asset values. Nonetheless, this outcome also depends on the existing dispersion of ownership across the wealth distribution (Coibion et. al., 2017).

The income composition channel entails that income sources vary along the income distribution. For the lowest decile in Sweden, for instance, transfers constitute almost half of the aggregate earnings whilst this share is virtually zero for the highest decile (Amberg et al., 2022). Another example is capital income which, as mentioned earlier, also differs significantly along the income distribution (Statistics Sweden, 2022). If different sources of income are impacted differently by monetary policy, it could serve as a source of inequality. For instance, if QE increases employment, it could serve as a means of reducing inequality since the lower parts of the income distribution rely relatively more on labor income and transfers, i.e., the job creation channel (Bernanke, 2015). Another example, relating back to asset prices is if the portfolios of households are composed differently. The richer households will then receive relatively greater capital gains if they own proportionately more of the stock of financial assets. The same reasoning could be argued for properties where property owners could receive higher capital gains than others.

Moreover, there is also within-component heterogeneity, meaning that different types of income from the same income group can be impacted differently. Examples of this would be

if wages for different income groups are impacted differently (earnings heterogeneity), or if the change to interest income differs to that of dividend income (capital income heterogeneity). Research on the labor market shows that expansionary monetary policy lowers the cost of capital. High-skilled labor, which usually earns more, could increase their earnings since they are paired with more capital. Low-skilled labor, on the other hand, is more substitutable to capital and can see their earnings decrease. These two opposing movements in wages can have distributional consequences (Dolado et al., 2021).

The interest-rate exposure channel constitutes the financial income effect of QE assuming that QE decreases interest rates. The lowering of interest rates will, cet. par, increase disposable income for net debtors while it diminishes that of net creditors. If the propensity of being a net creditor or net debtor differs along the income/wealth distribution, it suggests that this could have implications for income inequality (Auclert, 2019). Equally, inflation can have redistributive consequences since different types of wealth and income sources are nominally rigid to different degrees. For instance, cash balances are nominally rigid compared to equity holdings which can, in theory, appreciate in tandem with inflation (Colciago et. al., 2019).

2.2 Income inequality

Inequality can be categorized into several different metrics, such as lifetime inequality, inequality of opportunities, inequality of wealth, and the most frequently used metric, income inequality. The different metrics are associated and complementary which provide governments with information regarding the effects of certain policies. Hereafter, we will focus on the most common metric used which is income inequality (IMF, 2022).

Today, there are many ways to measure income inequality. There are metrics like the Gini coefficient which is a normalized metric taking the value of 1 if one person holds all income, i.e. perfect inequality, and the value of 0 when all income is exactly evenly distributed among the population, i.e. perfect equality. There are also other measures such as the Palma-ratio, which is the ratio of total disposable income received by the top 10% divided by the total disposable income received by the bottom 40%. All in all, they all rely on the same underlying distribution. Nevertheless, all different ratios cannot only be based on the underlying distribution of income but also wealth or consumption. (OECD, 2023).

According to a 2014 study, income inequality in most OECD countries is at its highest level in over 30 years. Furthermore, the increase in income inequality is not solely due to a significant income rise for the top earners but also a stagnation for the bottom share (Cingano, 2014). Moreover, similar evidence is found in the 2022 World Inequality Report. Although global inequalities between countries have declined during the last two decades due to globalization, most countries have experienced an increase in within-country income inequality (Chancel et al., 2021). The wider income gap leads to a significant decrease in economic growth through lower levels of education among the lower middle class and poor households (Cingano, 2014).

2.3 The steps into unchartered territory

Sweden, which has long been known as a strong welfare state, has since the 1980s witnessed the sharpest rise in market income inequality (income pre-tax and transfers) within the OECD. Even so, Sweden still counts as one of the 10 most egalitarian economies within the organization. The rise of Swedish inequality is attributed to higher entry levels for low-skilled jobs, compared to other countries, due to high starting wages (OECD, 2015). This implies that Sweden has more people than other countries with market incomes essentially equal to zero. The OECD (2015), therefore, proposed reforms promoting increased labor force participation in order to reduce Swedish income inequality.

Swedish inflation had persisted well below the 2 % - target after the great recession which made the Riksbank, the central bank of Sweden, open to take further measures to align inflation expectations with the target. Due to the small size and high degree of openness of the Swedish economy, policymakers closely monitored monetary policy deliberations at the European Central Bank. In January 2015, the ECB announced its first asset purchase program. Later on, in February, the Riksbank chose to cut its main policy rate below zero for the first time ever. Concurrently, the Riksbank launched its own program of quantitative easing with announced initial monthly purchases of SEK 10 Billion in government bonds. The purchases were conducted by crediting the Riksbank's monetary policy counterparties' reserve accounts at the bank. Thus, the Riksbank's balance sheet grew significantly. In late 2017, purchases ceased and only reinvestments were carried out. At this point, purchased nominal government bonds constituted 44% of the stock outstanding, equivalent to 7% of

nominal GDP in quarter 4 of 2014, the quarter preceding the announcement. As a point of comparison, the ECB purchases, during its QE period, constituted about 30% of the stock outstanding, equivalent to 25% of eurozone quarter 4 2014 GDP. (Di Casola & Stockhammar, 2021). By the same scale, the Bank of England purchases amounted to 37 % of British GDP during the same period and Japanese purchases during the period studied in Saiki and Frost (2014) accounted to 34 %[1] of GDP in the quarter preceding the Japanese QE-announcement.

Even if this was not the first time the central bank had bought securities from the open market, it was the first time the Riksbank did so as a means of achieving its inflation target. Previously, the bank had solely done so as a lender of last resort and as a way to provide liquidity to the banking system. The unprecedented measures were not accompanied by a substantial rise in inflation. Nevertheless, from the onset of quantitative easing until the start of the Covid-19 pandemic, the monetary base as a percent of GDP, increased by 48%. Concurrently the Swedish stock and housing markets increased by 46 % and 29 % respectively (Sveriges Riksbank, 2023b; Ekonomifakta, 2023; Nasdaq, 2023).

In retrospect, the Swedish QE program has been heavily criticized and debated. There have been concerns that the Board of Governors of the Riksbank conducted this novel monetary policy without taking the small size of the Swedish economy into account with a QE program merely having distortionary redistributive consequences through inflated asset prices (Andersson & Jonung, 2020; Waldenström & Åkerman, 2022). Here, it could also be noted that capital income in Sweden is heavily skewed along the income distribution; for instance, in 2020, the tenth decile with the greatest capital income received 95 % of the total capital income (Statistics Sweden, 2022). Nevertheless, in defense of the program, positive aspects such as increased GDP and sustained confidence in the inflation target have been emphasized by the then-governor of the Riksbank, Stefan Ingves (Megaw, 2017).

[1] Authors* calculations. Data for UK: Bank of England (2023); Office of National Statistics (2023). Data for Japan: Bank of Japan (2023); FRED Database (2023).

3. Past research

In this section past research about the effect of unconventional monetary policy on income inequality will be presented. The first part of this will focus on literature examining Japan which was the first country to conduct quantitative easing programs. The second part will encompass previous research on The United States as well as on different European countries. The final part will include our contribution to the field.

3.1 The case of Japan

One of the first studies undertaken empirically analyzing QE's effect on income inequality and one of the inspirations for this study, was that of Saiki and Frost (2014) on the Japanese economy. The Bank of Japan (BoJ), was the first central bank to initiate a QE program. The authors used aggregated household survey data in order to calculate a Gini coefficient representing income inequality and, monetary base as a percentage of GDP was used as a proxy for the QE program. The impact was measured by estimating a SVAR-model including variables for output, prices, QE, equity prices, and income inequality, with quarterly data spanning from quarter 4 of 2008 to quarter 3 of 2013. It was subsequently concluded that the use of QE increased the market-income Gini coefficient, with the income composition, and capital income heterogeneity channel having the greatest impact on income inequality in Japan. (Saiki & Frost, 2014).

The study was followed up with a new one spanning a longer sample period, with quantitative easing (QE) being primarily studied. However, Japan's implementation of large-scale quantitative and qualitative easing (QQE), including equity purchases in the forms of ETFs and J-REITs, in quarter 2 of 2013, was also covered. With more data, they investigate whether their original findings of increased inequality hold when including labor-market variables. Subsequently, it was concluded that QE and QQE had increased income inequality to a meaningful extent by increased capital income. It was argued that the findings for Japan could be unique due to the intensity of QE as well as economic structure in terms of demography and labor market. As opposed to Japan, which has experienced nominal wage stagnation since 2000, other advanced economies experienced relatively steady wage increases. The authors believed that these wage increases could have offset increased capital gains in other economies. (Saiki & Frost, 2020)

Unconventional monetary policy's impact on the income distribution in Japan has also been explored through local projections and DSGE-models (Inui et al., 2017). Contrary to Saiki and Frost (2014, 2020) it was concluded that QE has not had a significant impact on the income distribution. Nevertheless, they still found conventional monetary policy in the pre-QE era to have a significant redistributive impact. The study utilized the same income survey data as the other studies on Japan but differed in their estimate of QE. Instead of using the monetary base, they constructed a shadow-rate. The shadow-rate was based on the policy rate when it was positive and a proxy equating to what the policy rate should have been in the absence of the zero lower bound, existing in Japan during the period sampled. Considering that they could not find any significant results for the QE period, they constructed a DSGE-model to explore the diminishing impact of monetary policy on the income distribution after the turn of the millennium. With this model, it was predicted that labor market inflexibilities diminish the income (from labor) heterogeneity channel which is subsequently employed as an explanation for the decreasing impact of monetary policy on the income distribution. (Inui et al., 2017).

3.2 Evidence from the US and Europe

The National Bureau of Economic Research published a working paper studying the effects and historical contribution of monetary policy shocks to both consumption and income inequality in the US (Coibion et al., 2017). The research is not focused on UMP but instead on monetary policy shocks in general using a detailed micro-level dataset with observations dating back to 1980. When studying the impulse response functions, the authors can conclude that contractionary monetary policy seems to have significant long-run effects on increasing income inequality, due to heterogeneity in labor earnings. Furthermore, the authors suggest that keeping interest rates at the zero lower bound when negative rates are called for is conceptually similar to the economy being subject to contractionary monetary policy. (Coibion et al., 2017).

Researchers at the ECB have looked at the impact of QE on income and wealth inequality in four major economies in the eurozone. First, they construct a multi-country Bayesian VAR-model which includes variables with a potential impact on inequality such as unemployment, inflation, house prices, stock prices, and interest rates. Subsequently, they take the obtained

impulse responses (IRF) and apply micro-level data for households in the four countries and explore the changes in earnings and wealth that occur given the obtained impulse responses. They conclude that QE has boosted earnings of low-income households and has caused a negligible increase in wealth inequality and reduced the Gini coefficient of income. (Lenza & Slacalek, 2018).

Another study was that of Mumtaz and Theophilopoulou (2017). They explore the relationship between income inequality and monetary policy by gathering micro-data from surveys on consumption, disposable income, etc. from the United Kingdom, ranging from 1969 to 2012. They base the model on both the pre- and post-QE era and therefore draw conclusions based on both expansionary and contractionary monetary policy. The outcome of QE was forecasted by estimating a vector autoregressive model with data from quarter 4 2008 and onwards where the term-spread on Gilts is used as a proxy for QE. It is stated that inequality is primarily affected through the portfolio channel. Their VAR-model also included data for inflation, 3-month gilt rate, GDP/Capita, and growth of the nominal effective exchange rate. In their study, they found that QE increased income inequality in the 8 quarters following a monetary policy shock compared to the counterfactual of no QE. In contrast to this, it was concluded that conventional contractionary monetary policy also increases income inequality.

One study explored the response to income inequality from an expansionary monetary policy shock in the pre-QE era in Sweden. The authors examine changes to income across the entire income distribution, by using micro-data, after an expansionary conventional monetary policy shock. They find the relationship to be U-shaped with income being most affected in the highest and lowest income deciles. Their study was conducted through an instrumental variable analysis where they first regressed the main policy rate of the Riksbank on changes in the 1-month t-bill yield on the day of policy announcements. In this regression, they also exclude instances where the yield and daily stock return go in the same direction, at the time of the announcement, according to the so-called “poor man’s sign-restriction”. The fitted values from this regression then become the “monetary surprise” which is then regressed on changes in income for different income types of people in different income groups. From this, they conclude that an expansionary monetary policy shock increases income at the bottom and top tails. Moreover, they explore what happens if the income composition channel is

disregarded, i.e. all individuals are instead given the average income composition of the Swedish population. By doing this they demonstrate the shocks have a significant impact through the income heterogeneity channel even in the absence of the income composition channel (Amberg et al., 2022).

3.3 Contribution to the field

Although the scope and methods are not identical in the aforementioned studies, it can be concluded that expansionary monetary policy seems to have an ambiguous impact on wealth and income inequality. In the case of Japan, Saiki and Frost (2014) manifest a small increase in income inequality which is akin to the conclusions reached by Mumtaz & Theophilopoulou (2017) for the UK. As to Sweden, however, it is unclear whether there has been an aggregate impact. On the other side of the spectrum, Lenza and Slacalek (2018) manifest findings in stark contrast to those for Japan and the UK. It is debatable whether these differences are due to country-specific factors or the fact that their models differ in their specifications and fundamental assumptions.

Our study is the first, as far as we know, that explicitly explores the impact of quantitative easing on income inequality in Sweden, using aggregate data. The two main research questions this study aims to answer are:

1. Did the Swedish central bank's (Riksbanken) quantitative easing program affect income inequality in Sweden?
2. If so, in what direction was income inequality affected?

Table 1: Summary of findings in past research.

Country	**Authors**	**Channels**	**Impact on inequality** from QE/expansionary monetary policy
Japan	Saiki and Frost (2014, 2020)	Portfolio and Income composition	Income: increase
Japan	Inui et al. (2017)	Portfolio and Income composition	No impact found
Eurozone	Lenza and Slacaclek (2018)	Portfolio, Income Composition and Heterogeneity	Income: decrease Wealth: Increase
United States	Coibion et al. (2017)	Income heterogeneity	Income: increases from contractionary monetary policy
United Kingdom	Mumtaz and Theophilopiulou (2017)	Income Composition	Income: increase
Sweden	Amberg et al. (2022)	Income composition and heterogeneity	Income: negligible

4. Empirical strategy and method

In this section of the paper the selection of variables and their theoretical interaction will be discussed. Furthermore, the use of structural vector autoregression (SVAR) will be described as well as the use of impulse response functions (IRF).

4.1 Variables used in the model

As discussed, there are several ways in which QE has been empirically shown to impact wealth and income inequality. In short, QE drives inequality through four forces: changes in the value of real and financial assets, changes to employment and salaries, changes in inflation, and changes in the interest rate. Another potentially important driver of both wealth and income inequality is the public sector through its redistributive functions of transfers and taxation.

In many advanced economies, government spending has outright distributional consequences. In Sweden, for instance, there is a marginal income tax rate above a certain threshold. Simultaneously, less affluent people can get government grants, subsidized housing, etc. Therefore, in line with the OECD (2015), we believe government spending to have a clear distributional impact. For the purpose of our study, we find it necessary to take government spending into account since the size of transfers and tax structure should impact disposable incomes differently. However, by focusing on market-based measures of inequality, i.e. pre-tax and transfers, government actions and spending need not be addressed directly in the analysis.

Monetary base

In line with previous research from e.g. Saiki and Frost (2014) the monetary base as a share of GDP will act as a proxy for the Swedish quantitative easing program. The Riksbank's asset purchases were financed by increasing the reserves of the Riksbank's monetary policy counterparties (Di Casola & Stockhammar, 2021). These reserves, together with Riksbank Certificates (which the counterparties can buy with their reserves) in turn, together with cash and coins outstanding, constitute the monetary base (Sveriges Riksbank, 2009). In addition, as we are primarily interested in changes and not levels of our variables, we believe this to be

a suitable proxy for QE. All in all, for the purpose of our analysis, changes to the monetary base are analogous to the Riksbank's purchases of financial assets.

Income inequality

Considering that there is not any reliable Swedish wealth data, this study will solely focus on income inequality. More exactly, in line with Saiki and Frost (2014), the study will explore QE's impact on income inequality by focusing on the channels of income heterogeneity and income composition. Furthermore, we wish to explore the impact of these channels by changes in the stock market.

Stock returns

Appreciation in the value of real and financial assets, such as stocks, bonds, and property, could be an important factor impacting the wealth and income distribution (Albertazzi et al., 2018; Auclert, 2019). This could be the case since the asset portfolios of households are composed differently. Some hold a greater share of stocks, bonds, and property whilst others mostly hold cash and current account balances. If the value of asset classes is affected differently by QE, it could impact the wealth distribution. Analogously, QE could affect returns from assets differently which would generate different changes to capital income for individuals depending on their underlying asset composition, which we denote income heterogeneity channel. Moreover, individuals will have aggregate incomes that are differently reliant on different sources, i.e., the income composition channel. Analogous to Saiki and Frost (2014), stock returns on the Swedish market will be included in the model.

Inflation

On the one hand, inflation can also have an impact on inequality since capital gains can be more likely to catch up with inflation than wages. On the other hand, as an inflation shock also suppresses real wages, it can boost employment and have an opposing effect on inequality. Furthermore, inflation is also the target of the Riksbank and what they wished to achieve with the QE program. Therefore, inflation is also a variable that is included in the analysis.

Unemployment

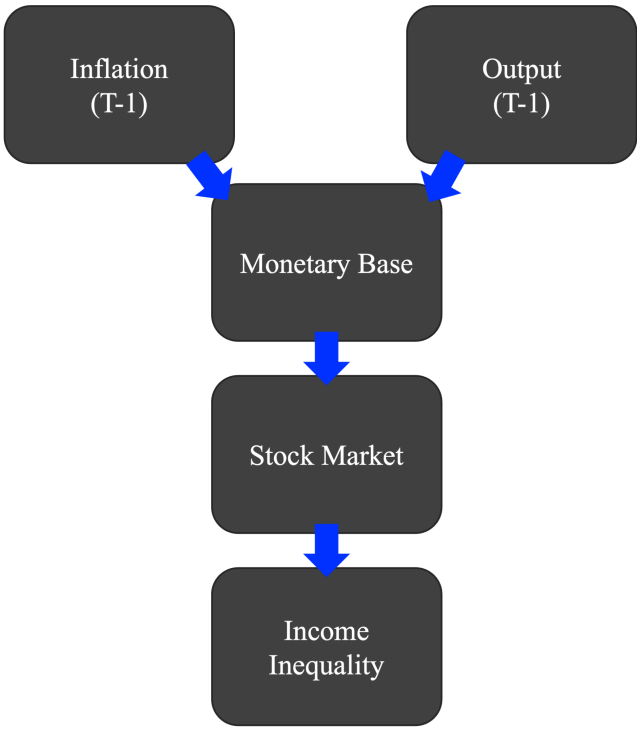
Changes in employment and the development of salaries can impact inequality since individual incomes depend differently on earnings from capital and salaries. Thus, on the one hand, improving labor market conditions may affect low-income earners relatively more as salary constitutes a greater part of total earnings which implies decreased income inequality, cet. par (Lenza & Slacalek, 2018). On the other hand, accommodative monetary policies can increase salaries of high-income earners relatively more given that the price of capital increases and that high-skilled workers earn more and are more complimentary than substitutable to capital compared to low-skilled workers (Dolado et al., 2021). Thus, employment can also be seen as a force impacting inequality via the income composition as well as the income heterogeneity channels. Nevertheless, considering the brief sample period of approximately 5 years, unemployment will not be addressed in the main model in order to preserve as many degrees of freedom as possible. Moreover, during the sample period, unemployment has changed significantly less than both the stock market and the monetary base (authors' calculations based on (Sveriges Riksbank, 2023b; Ekonomifakta, 2023; Nasdaq, 2023)). Furthermore, by disregarding unemployment, we arrive at the same specification used by Saiki and Frost (2014).

GDP

Finally, in line with previous research, such as Lenza and Slacalek (2018), GDP is also included in the analysis. Even if the Riksbank solely has an inflation-targeting mandate, according to the Riksbank Act enacted by parliament (SFS 1988:1385), it is assumed that they are also implicitly concerned with output. Moreover, output is a clear indicator of the real economy and could also have distributional consequences (Cingano, 2014).

Thus, in order to identify the impact of quantitative easing on income inequality we will look at the interrelation between output, inflation, quantitative easing, stock returns, and income inequality. Our identifying assumption is thus that the Riksbank observes developments in prices and output and then decides its monetary policy. This can subsequently have an impact on stock prices which then affects the income distribution via the income composition and income heterogeneity channels.

Figure 1: Simple illustration of the variables used in the model and their initial interaction.



4.2 Structural Vector Autoregression

In line with previous research, we employ a structural vector autoregression (SVAR). Some other studies in the field instead use a dynamic stochastic general equilibrium model (DSGE) in order to study the effects of monetary policy on income inequality, such as Inui et al. (2017). During the 1990s policymakers were hesitant to use DSGE-models for quantitative data analysis, but over the years the models have improved (Del Negro & Schorfheide, 2006). Due to the more complex nature of the DSGE-model as well as the reliance on rigid assumptions and restrictions, we have opted to use a structural vector autoregression.

The SVAR, as proposed by Sims (1980), is suitable since it allows for endogeneity between the variables of the model and is a methodology broadly used in modern macroeconomic research. It also allows for all variables to affect each other both contemporaneously and with a predetermined set of lags. In other terms, it allows for feedback between the variables across time (Enders, 2015). Nevertheless, in order to identify all parameters of the model, it

needs to be restricted in such a way that all variables cannot affect all others contemporaneously as this would yield too few equations with too many unknowns.

In a SVAR-model there will be as many multi-linear regressions as there are endogenous variables. In each equation, one variable is regressed on its own lags and present forms of the other variables, depending on the specification. The regressions are subsequently estimated by ordinary least squares. Given that the contemporaneous effects have been sufficiently restricted, all parameters can be identified. Then, in order to see how a shock to one variable affects the others, impulse response functions (IRF) are computed. IRFs are computed by transforming the SVAR-equations into vector moving averages which entails expressing the endogenous variables as a function of past and present shocks to the variables themselves. This transformation is consequently utilized to map out the effects of a shock to one variable on all the others over time. (Enders, 2015).

IRFs also include confidence intervals obtained via bootstrapping methods. Bootstrapping is suitable in the case of this study due to the short number of observations. This is performed by first extracting the estimated residuals and reducing them by their mean. Secondly, these values are randomly drawn into a subsample and then replaced. Thirdly, bootstrapped confidence intervals are calculated, in a recursive manner, based on fitted values of the endogenous variables. The coefficients of the model are then recalculated based on the obtained time series. The new parameters are then used to arrive at a point estimate for the IRF. Finally, These steps are subsequently repeated N number of times. (Lutkepohl, 2005) For this study, N is set to 500.

In this case, we estimate a model akin to that of Saiki and Frost (2014), based on Swedish data, with the following vector of endogenous variables:

$$Y_t = [\partial \ln(\text{GDP})_t, \partial(\text{Inflation})_t, \partial \ln(\text{Monetary Base})_t, \partial \ln(\text{OMXSPI-Index})_t, \ln(\text{Gini})_t]'$$

where ∂ denotes the first difference and ln denotes the natural logarithm. These measures were taken in order to ensure data absent of unit roots.

In order to restrict the contemporaneous effects in the model, we assume that QE affects asset

prices, as measured by the OMXSPI index, contemporaneously. We also impose the restriction that the Riksbank cannot observe and react to output and inflation in real time. This is in line with a similar study on Japan (Saiki & Frost, 2014) and suggested in macroeconomic theory (Bernanke & Mihov, 1998). It is also assumed that monetary policy only affects output and inflation with a lag.

Finally, we impose the recursive restriction that the income distribution, as measured by the Gini coefficient, does not impact any of the other variables contemporaneously. Conclusively, from our ordering, it follows that the Riksbank observes developments in output and inflation and then decides on the size of its asset purchases which affects the monetary base. Changes in the monetary base then affect the stock market which impacts capital gains and thus alters the Gini coefficient.

Under these assumptions, our model becomes:

$$B_0 Y_t = A_{t-p} Y_{t-p} + u_t$$

$$u_t \sim N(0, \Sigma)$$

where:

$$B_0 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ x & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ x & x & x & 1 & 0 \\ x & x & x & x & 1 \end{pmatrix}$$

A_{t-p} is a vector of estimated coefficients at lag length p.
u_t is a vector of structural innovations which are used to obtain the impulse response functions. u_t is assumed to be white-noise disturbances which are normally distributed with Σ, the variance-covariance matrix.

In the SVAR-model the lag length is set to 8 months in accordance with the Schwarz, Hannan-Quinn, and the Akaike Information Criteria. The information criteria are employed to determine the optimal lag length in accordance with common SVAR-analysis.

5. Data

This section of the paper provides an overview of what types of data is being used as well as their sources.

Monetary base

In line with Frost and Saiki (2014) the monetary base as a share of GDP is considered a proxy for QE. Sweden commenced its QE program in February 2015. The program formally ended in 2018 but all proceeds continued to be reinvested. (Di Casola & Stockhammar, 2021). Considering that it is widely known that monetary policy affects the real economy with a lag we have chosen to include data up until early 2020 when the Riksbank initiated a novel QE program to mitigate the economic impacts of the Covid-19 pandemic (Sveriges Riksbank, 2023a). The Riksbank's balance sheet (Sveriges Riksbank, 2023b) is published on a weekly basis and weekly values have been averaged to arrive at the monthly figures used. The monthly figures are then divided by the GDP (Statistics Sweden, 2023d), as measured in current prices, in its corresponding quarter to arrive at the monetary base as percent of GDP, in line with Saiki and Frost (2014).

GDP

Due to the short sample period (January 2015 to February 2020) it was desirable to use monthly figures as opposed to quarterly ones. Therefore, the GDP Indicator published monthly by Statistics Sweden (2023a) was used in contrast to the official quarterly GDP figures published in the national accounts. The indicator represents preliminary figures until the national accounts have been reconciled at each quarter and therefore serves as a suitable output metric. It has also been used in monetary policy studies at the Riksbank (Di Casola & Stockhammar, 2021), and is measured based on fixed prices.

Inflation

Inflation is measured as changes in the core consumer price index with fixed interest (CPIF) published monthly by Statistics Sweden (2023b). It can be argued for different measures of inflation such as the GDP deflator, the standard CPI, etc. However, CPIF was elected due to it being the formal target variable of the Swedish monetary policy regime (Sveriges Riksbank, 2017).

Stock market

Stock returns are measured by monthly averages of the OMXSPI index, an index of all listed Swedish equities (Nasdaq, 2023).

Income inequality

The primary income inequality metric used in this study is the Gini coefficient. The data collection of inequality is complicated. Preferably, we would have liked to look at the Swedish wealth distribution since that could be believed to be more strongly impacted by changes in the stock market and the portfolio composition channel. However, as for Sweden, only gini-coefficients based on income and not on wealth are published which is due to the abolishment of wealth taxation in 2013. This lack narrows down the options available and has also been to the detriment of Sweden's macroprudential authorities (Ingves, 2018). Nevertheless, we still believe the Gini coefficient of income to be relevant since it still captures realized capital gains. The Gini coefficient of market income, retrieved from the OECD (2022) was therefore chosen since this metric measures income pre-tax and transfers. Thus, as stated, there is no need to account for government spending or taxation in our model. The OECD calculates its Gini coefficient based on both its own surveys and data collected from the national statistical agencies. This is subsequently harmonized in order to be comparable across countries (ibid).

Moreover, in the case of Sweden, data is only assembled on an annual basis. To remedy this, we linearly interpolate the yearly values into monthly ones. This methodology has already been used for gini-data in the United States in how it is affected by monetary policy (Davtyan, 2017). Moreover, it has also been employed to adjust the frequency of data in studies of QE at the Bank of England (Joyce et al., 2011). However, with linear interpolation, there are still issues since the true underlying data-generating process is lost. Even so, doing this leaves the study with more degrees of freedom and can be justified due to the low variance in the coefficient to start with. Moreover, the annual data which does exist is to some extent reliant on surveys. Surveys of income also tend to be biased and subject to measurement errors (Moore & Welniak, 2000). In income surveys, the very top and bottom percentiles in the income distribution are usually underrepresented which implies inherent issues with any sort of reported income, regardless of frequency.

The annual data for the gini-coefficient is concluded to be stationary at the 5% level, according to an Augmented Dickey-Fuller test. After interpolation, the null hypothesis of the interpolated series containing unit roots could not be rejected at any significance level. Nevertheless, including variables in levels despite unit-roots has been done for other studies examining QE and is therefore undertaken in this study (Weale & Wieladek, 2016; Di Casola & Stockhammar, 2021). In line with their methodology, we subsequently also conduct the same SVAR but with all variables in levels.

6. Results

This section presents the summary statistics and the results of the main specification.

6.1 Summary Statistics

Here follows an overview of the non-transformed variables used in our model together with data for unemployment since it is mentioned in the background and is subsequently used in the robustness checks.

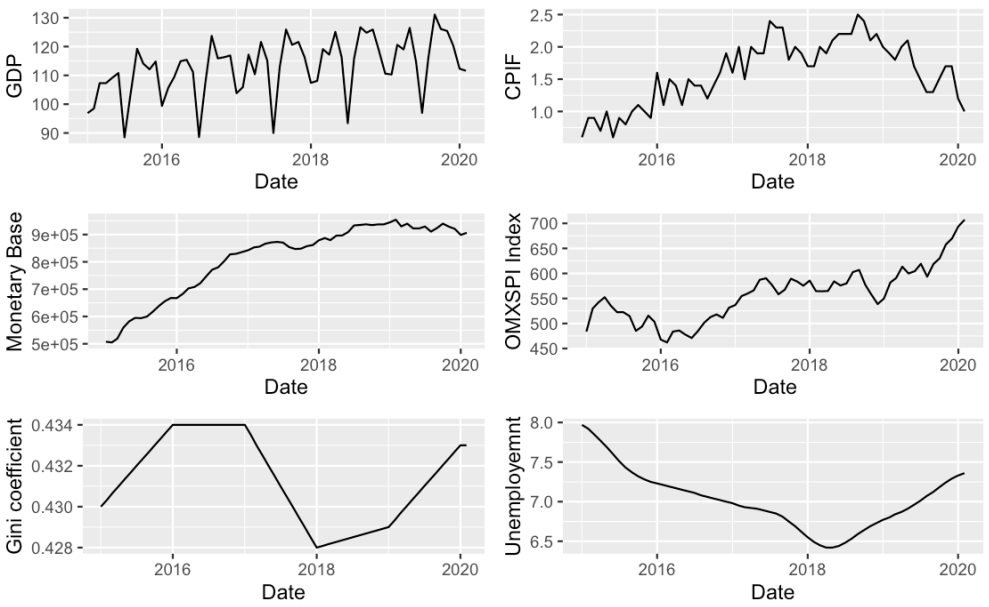
Table 2: Summary statistics of variables used in all specifications.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
GDP	62	113.048	9.788	88.500	107.575	119.175	131.100
CPIF	62	1.597	0.499	0.600	1.200	2.000	2.500
Monetary Base	62	812,152.200	132,015.900	504,924.800	711,463.800	922,063.900	954,355.200
Monetary Base Share	62	0.693	0.080	0.482	0.650	0.745	0.777
OMXSPI Index	62	557.870	54.478	462.089	516.217	588.830	707.324
Gini coefficient	62	0.431	0.002	0.428	0.429	0.433	0.434
Unemployemnt	62	7.027	0.376	6.420	6.777	7.238	7.970

Note. OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

- *GDP* denotes the value of the GDP Indicator Index.
- *CPIF* denotes the yearly change in the CPIF-Index in percent.
- *Monetary Base* denotes the value of the Monetary Base in million SEK.
- *Monetary Base* denotes the value of the Monetary Base Share denotes the Monetary Base as a Share of GDP.
- *OMXSPI Index* denotes the index value of the OMXSPI Index.
- *Gini coefficient* denotes the value of the Gini coefficient.
- *Unemployment* denotes the unemployment rate in percent.

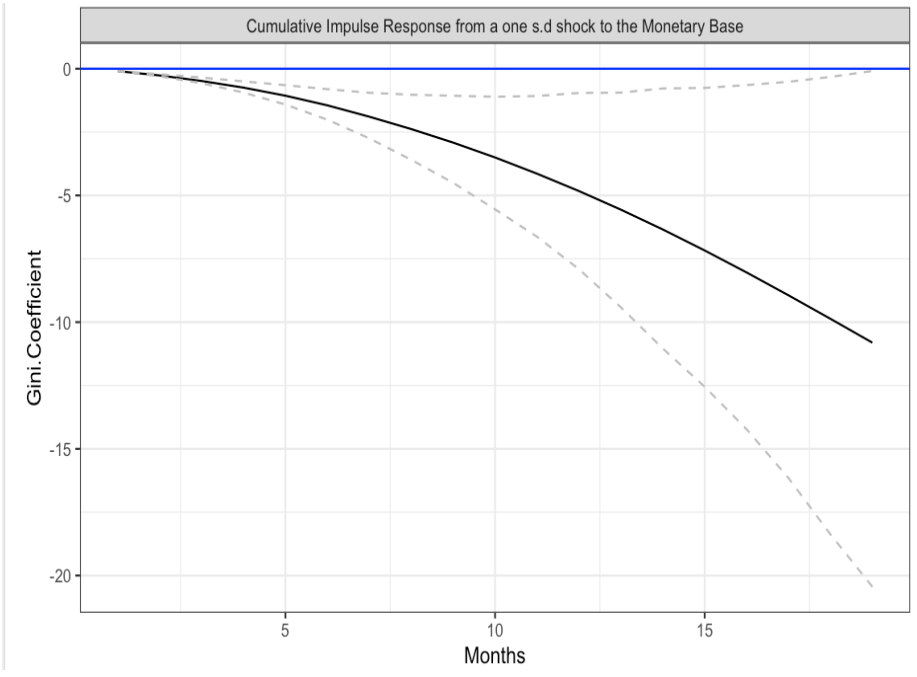
Figure 2: Summary of variables used in the model, from January 2015 to February 2020.



Note. OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

6.2 Impulse response functions from the main specification

Figure 3: Impulse response function to the Gini coefficient from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Table 3: Corresponding confidence interval bounds of responses in the Gini coefficient from a one s.d shock to the monetary base, at 95 % confidence level.

Months	Lower CL	Upper CL
1	-0.094	-0.090
2	-0.299	-0.215
3	-0.579	-0.353
4	-0.996	-0.495
5	-1.546	-0.652
6	-2.247	-0.786
7	-3.104	-0.930
8	-4.090	-1.046
9	-5.241	-1.117
10	-6.528	-1.099
11	-7.939	-1.053
12	-9.439	-0.966
13	-11.026	-0.879
14	-12.682	-0.721
15	-14.409	-0.501
16	-16.210	-0.216
17	-18.095	0.081
18	-20.005	0.481
19	-21.901	0.942

Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

From **Figure 3** and **Table 3**, it can be concluded that a one standard deviation shock to the monetary base, corresponding to 8 % of GDP in the sample, generates a decrease in the Gini coefficient, which is statistically significant at a 95 % confidence level up until 16 months after the shock. However, the confidence intervals are broad, ranging between a 1 and 16 percent decrease in the Gini coefficient, at the last point of significance. Impulse responses for the other variables can be found in the appendix.

7. Robustness Checks

This section presents testing of our assumptions as well as alternative specifications that alleviate potential issues with the interpolated Gini-coefficient.

7.1 Testing of assumptions

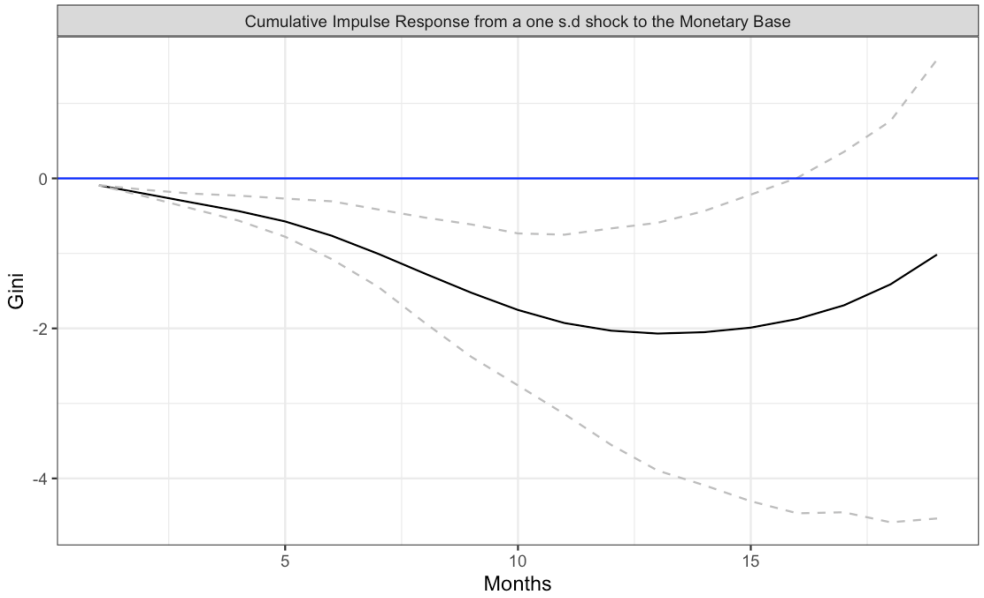
One commonly used practice in SVAR-analysis is to ensure that all variables do not contain unit-roots, i.e. the variables are stationary (Enders, 2015). For this study, this was tested by Augmented Dicky-Fuller (ADF) tests where the null, of the series containing unit-roots, could be rejected for all variables, except the the interpolated Gini-coefficient and the stock market variable at the 1% level. The null hypothesis for ADF-test of the stock variable could be rejected at the 5% level. Due to the relatively short sample period, one drawback of hypothesis testing for stationarity is that the power of the test, concluding that the series is stationary when that is the case, tends to be low even if the sampling frequency is high (Mills, 2019). Even if the monthly frequency in this study is higher than most others who use quarterly series, this could be an issue. However, considering that the null of the ADF-tests was rejected at the 1 % level for all variables but for the stock and gini-variables, the probability of committing a type 2 error is negligible.

In addition, if common trends between the variables are suspected, i.e. cointegration, then the SVAR can be run in levels in its entirety, even if this entails the variables containing unit-roots. This suggests no first-differencing of the variables as done by Di Casola and Stockhammar (2021) and Weale and Wieladek (2016). Thus, the following specification is used:

$Y_t = [\ln(GDP)_t, Inflation_t, \ln(Monetary\ Base)_t, \ln(OMXSPI\text{-}Index)_t, \ln(Gini)_t]'$

Doing this, does not materially alter the results but generates narrower confidence intervals, as shown by below **Figure 4**.

Figure 4: Impulse response function to the Gini coefficient from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Furthermore, potential misspecification of the model could entail issues with serial correlation. As a check to ensure that the model was specified with a sufficient number of lags, the model was tested for serial correlation in the residuals by the Breusch-Godfrey LM-test. The null hypothesis could not be rejected for the BGLM-test at the 5 % significance level indicating that the alternative hypothesis of serial correlation could not be accepted.

7.2 Alternative Specifications

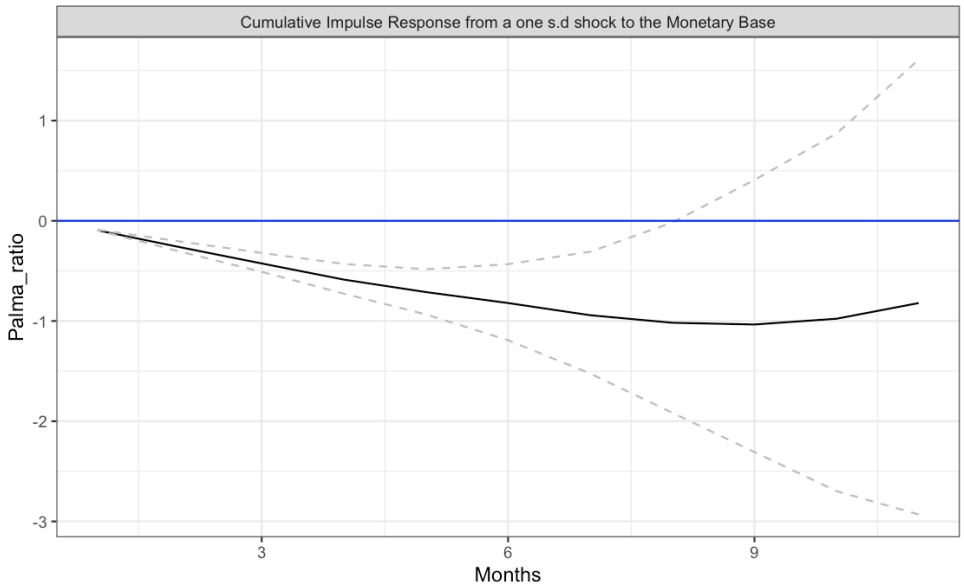
7.2.1 Another metric of inequality

As previously stated, the Gini coefficient is just one metric of income inequality. In order to check the robustness of the results, the Gini coefficient is exchanged in favor of the Palma ratio. The Palma ratio is a ratio of total disposable income received by the top 10% divided by the total disposable income received by the bottom 40%. This metric for Sweden is published annually by the OECD (2022). Considering that the ratio is based on disposable income, i.e. post-tax and transfers, it has some drawbacks compared to market income measures. Even so, we employ the Palma ratio as other market measures are arduous to come by. Following the main specification, the Palma ratio is linearly interpolated from yearly to

monthly values. The lag length was set to 8 months according to the Schwars, Hannan-Quinn, and Akaike information criteria. Thus, the following specification is estimated:

$$Y_t = [\partial \ln(\text{GDP})_t, \partial(\text{Inflation})_t, \partial \ln(\text{Monetary Base})_t, \partial \ln(\text{OMXSPI-Index})_t, \ln(\text{Palma-ratio})_t]'$$

Figure 5: Impulse response function to the Palma ratio from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

This gives an IRF, shown in **Figure 5**, with a still statistically significant decrease in income inequality but the impact is significant for a shorter time period.

7.2.2 Accounting for the labor-channel.

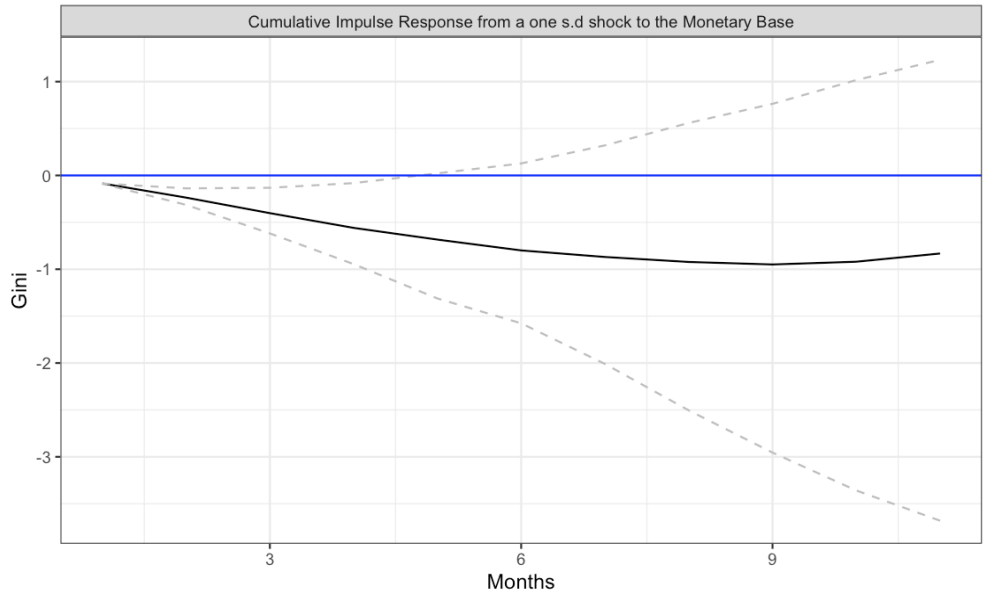
One drawback of having an analogous specification to that of Saiki and Frost (2014) is that developments in the labor market could be relevant due to different labor market dynamics. Moreover, even if it was argued that unemployment could be omitted due to its relatively low variation, it has still shifted somewhat. Therefore, we introduce an alternative specification where it is instead assumed that the Riksbank observes unemployment and inflation and sets the monetary base which moves stock prices and changes the income distribution. As with the former specification, it assumed that the central bank cannot observe unemployment and inflation in real time. Furthermore, it is assumed that unemployment precedes inflation in the Cholesky ordering which allows for contemporaneous effects of changes to employment on inflation but not the other way around. Despite this being a rather strong assumption, a

Granger-causality test corroborates this by concluding, at the 5 % significance level, that unemployment granger-causes inflation and not vice versa. The Granger test is conducted by regressing inflation on its own lags and lags of unemployment. Subsequently, an F-test is conducted to see if coefficients on unemployment are jointly statistically significant from 0. The unemployment rate, defined as the proportion of people between 15 and 74 in the labor force searching for a job, is collected from Statistics Sweden (2023c) and published on a monthly basis.

Thus, a SVAR-model with the following vector of endogenous variables is estimated with the following IRF. Lag length is set to 5 months according to the Akaike and Schwarz information criteria.

$Y_t = [\partial(\text{Unemployment})_t, \partial(\text{Inflation})_t, \partial\ln(\text{Monetary Base})_t, \partial\ln(\text{OMXSPI-Index})_t, \ln(\text{Gini})_t]'$

Figure 6: Impulse response function to the Gini coefficient from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), CPIF, Unemployment from Statistics Sweden (2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

In **Figure 6** it is shown that a shock to the monetary base still yields a reduction in the Gini coefficient. Albeit, at a lower magnitude and for a lower duration of time.

7.2.3 Removing potential issues of interpolation

Considering that our model relies on interpolated data for the Gini coefficient, we propose an alternative SVAR-specification, excluding this variable. Furthermore, since the Gini coefficient cannot give any insights into the decomposition of different channels, this specification attempts to emulate both changes to capital and labor earnings, by focusing on income composition and income heterogeneity and their respective components.

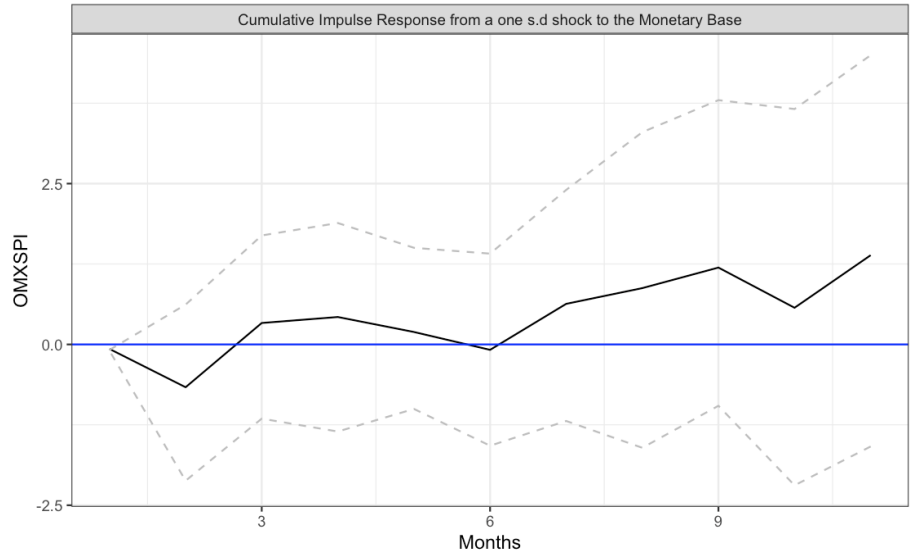
In the alternative specification, the focus is turned on the key variables that can impact the income distribution. First, we estimate a model to see if QE has driven Swedish stock returns, which could potentially increase capital gains and thus prove to be inequality-enhancing. Secondly, the model aims to see if QE has impacted unemployment since obtaining a job has been considered an important driver of income for the lower parts of the income distribution (Lenza & Slacalek, 2018).

For this specification, it is assumed that the Riksbank observes output, unemployment, and inflation, and then decides the degree of QE that they undertake which in turn impacts stock prices. An original Cholesky decomposition with a lower triangular matrix is employed but with the same assumption as in the original specification, proposed by Bernanke & Mihov (1998); the central bank cannot observe inflation, output, or unemployment in real time. The ordering of the variables is akin to that of Saiki and Frost (2020) where macroeconomic variables precede monetary policy in the Cholesky ordering. The same period as before is studied; from January 2015 to February 2020. In short, the following vector of endogenous variables is used:

$Y_t = [\partial \ln(\text{GDP})_t, \partial(\text{Unemployment})_t , \partial(\text{Inflation})_t, \partial \ln(\text{Monetary Base})_t, \partial \ln(\text{OMXSPI-Index})]'$

The lag-length was set to 5 months according to Schwarz- and Hannan-Quinn and Akaike Information criteria.

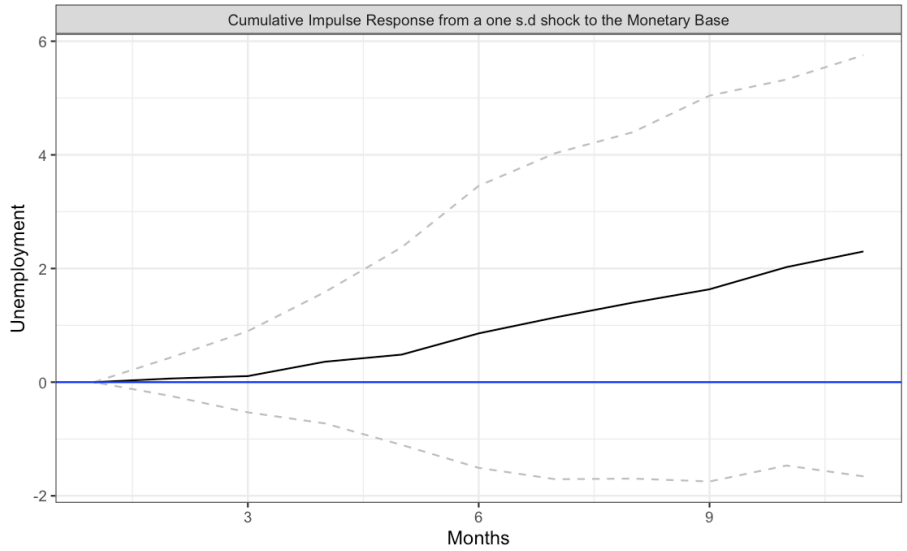
Figure 7: Impulse response function to OMXSPI from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

As seen in **Figure 7**, it cannot be concluded that QE has had a statistically significant impact on share prices, at a 95% confidence level.

Figure 8: Impulse response function to unemployment from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

As seen in **Figure 8**, it cannot be concluded that QE has had a statistically significant impact on unemployment, at a 95% confidence level.

8. Discussion

In this section, the main model as well as the alternative specifications with its ensuing implications will be discussed.

8.1 Main model and other specifications with non-stationary variables

The main specification shows that QE reduces the Gini coefficient of income to a statistically significant extent. Even so, we believe these results should be interpreted with caution due to several reasons. First of all, considering that the coefficient was interpolated from a yearly to monthly series, there is a risk that too much of the underlying data-generating process was lost which could indicate spurious results. Compared to, for instance, Davtyan (2017), who interpolated from yearly to quarterly, we did it from yearly to monthly making this study more susceptible to losing out on the true data-generating process. Even so, instead employing quarterly series for this study could have been problematic in terms of a small sample size.

Secondly, since the null hypothesis of the interpolated gini-series containing unit-roots could not be rejected at any significance level, even when taking the logarithm or first difference, the coefficient was as stated included in levels. As previously mentioned, this has been done in prior research when there is a suspicion of cointegration between the variables. Potentially, in this study, it could be the case that the prerequisites of including a variable in levels are not fulfilled. Finally, since both the monetary base and the OMX-index increase significantly and the Gini coefficient increases marginally, during the sample period, it is questionable how a decrease in the coefficient, as our model shows, could be explained. To sum up, there are several reasons why the results in the main specification could be erroneous which necessitates the need for alternative specifications.

Nevertheless, by looking at the actual data it is clear that the Gini coefficient has not moved entirely in tandem with all the variables. Whilst the OMX index increased by approximately 46 %, during the sample period, the Gini coefficient of market income increased by less than 1 %. Therefore, even in the presence of monthly income data which could be converted into a stationary series, it is unlikely that this would have yielded results showing a large upswing in income inequality. This poses the question of why larger movements have not been

witnessed, in spite of the significant rise in asset prices. One potential explanation for this could be the dynamics of Swedish capital income. In Sweden, capital income is classified as interest, coupons, dividends, and capital gains from real and financial assets like property, stocks, bonds, etc. Capital income has been heavily skewed along the income distribution (Statistics Sweden, 2022); even so, only half of capital income stems from financial income, with the rest being attributable to capital income from property.

Considering our specification, it was initially assumed that QE would impact stock prices which would impact gains which in turn would affect the Gini coefficient. However, in the case of Sweden, even if people made massive profits by selling stocks during the sample period, this need not translate into capital gains due to ISK. ISK, or Investment savings account, is an account type in which capital gains are not taxable. Instead, from the holdings in ISKs a standard income is calculated which equals the higher of 100 basis points above the government borrowing rate or 1.25% (Skatteverket, n.d.). According to Statistics Sweden (2022), this standard income constitutes part of capital income which subsequently feeds into the Gini coefficient. This suggests that if a substantial part of realized stock gains occur within an ISK it would not necessarily translate into significantly higher capital income.

Furthermore, as for the stock holdings of Swedish shares not in ISKs, any gain would have to be realized in order to yield capital income feeding into the overall income distribution. Thus, as this manifests, even if quantitative easing were to impact asset prices, it is not evident that this would have significant implications for the overall income distribution in the Swedish case. Even so, relaxing these specific circumstances of Sweden entails that other factors, having potentially redistributive consequences, could be looked at directly which we did in the robustness checks. As for the specification with the Palma ratio and the one with employment instead of output, they presented similar results but should be similarly interpreted due to their interpolated nature.

8.2 Alternative specification

The alternative specification did not yield any significant results even when considering that all variables included were considered stationary at a statistically significant level. This could be due to several factors.

As for the response of a monetary base shock to the OMXSPI-index, QE cannot with statistical significance have impacted capital income via share prices since no impact of QE on stock prices could be found at any confidence level. Assuming that capital income is skewed along the income distribution, this suggests that no impact of QE on the income distribution via the income composition and heterogeneity channels can be concluded, via stocks. This could be due to various factors.

One factor is the effect of forward guidance in monetary policy decisions. It might not be the actual realized purchases by the Riksbank that moves asset prices. It could also be the announcement of QE that drives investors to rebalance their portfolios, which drives asset prices. Thus, the sheer expectation of QE could have been significant while the transacted purchases, as measured here, were not. In contrast to Saiki and Frost (2020), this suggests that Swedish stock markets could be potentially more reliant on forward guidance than Japan.

A shock to the monetary base did not showcase any significant impact on unemployment on a 95% confidence level. In turn, this suggests that it cannot be concluded that employment, via the income composition channel, has affected the income distribution. As for income heterogeneity with respect to labor income, nothing can be deduced since the specification did not include changes in salaries for different income groups. This could potentially have been relevant and also a source of omitted variable bias, in this study, but is disregarded due to lack of data. Another omitted variable bias could be developments of labor-market policies or other movements in the real economy not captured by the GDP-Indicator.

Regarding all alternative specifications, the relatively short sample period implies few degrees of freedom. This suggests that relatively high magnitude and low-standard errors would be required in order to produce significant results. Nevertheless, the sample period was deemed as sufficiently long since it included more or as many observations than similar studies on the topic, such as those of Saiki and Frost (2014, 2020) and Lenza and Slacaclek (2018).

Finally, it should also be noted that one reason why the alternative specification fails to give significant results could also be that the QE program did not impact asset prices or unemployment in the same ways as established in for instance the eurozone or Japan

suggesting that different dynamics, such as the role of the small-scale economy, could prevail in Sweden.

8.3 Identification issues with monetary policy and characteristics of the Swedish Economy

A drawback of all the specifications is the chosen identification strategy of monetary policy. Throughout the study, a change to the monetary base was elected to represent quantitative easing akin to Saiki and Frost (2014). Yet, during the sample period, the Riksbank did not only purchase assets but also changed the main policy rate, the repo-rate. Considering that the policy rate was not included in the analysis, this could present issues biasing the results.

Regarding studies examining Japan, the Japanese policy rate was at 0 % for the entire period removing the need of taking it into account (Saiki & Frost, 2014). As for the Eurozone, changes to the term-spread on government bonds (the difference in yield of a 10-year to maturity and a 3-month to maturity government bond) were utilized instead since it was considered to reflect both changes in the policy rate (short-term rate) and asset purchases (long-term rate). Nevertheless, considering that the monetary base is determined at the Riksbank's sole discretion, we found it to be a more suitable metric than the term-spread since the term-spread could be susceptible to change from many other factors, such as risk appetite, economic outlook, inflation expectations, etc. Moreover, as the study's aim was to focus on the Swedish QE program, the inclusion of the policy rate would be problematic in the SVAR framework since it is cumbersome to theoretically motivate which monetary policy should take precedence in the Cholesky ordering. Including it would also risk running into "the curse of dimensionality" which can occur if too many parameters are to be fitted with too little data (Lenza & Slacalek, 2018).

Other fallacies of the model could be how Sweden, as a small country, differs compared to its larger peers of Japan, United Kingdom, the Eurozone, etc. As a small and export-dependent economy, Sweden. One such variable could be the Swedish Krona (SEK) exchange rate since many Swedish listed enterprises are export-reliant and thus, all else equal, will earn more, in SEK terms, if the currency depreciates. This could consequently lead to higher prices. Moreover, during the sample period, the krona depreciated by 20 % against the dollar and by 12 % against the euro. Even if the exchange rate is not exogenous vis-à-vis monetary policy,

it can still be impacted by other factors. All in all, this could suggest that asset prices are affected by other macroeconomic factors than domestic monetary policy. In addition to exchange rates, developments in unemployment and output are likely to a greater extent be reliant on the economic development of our major trading partners than in other countries studied. This could be the case since Sweden is a large exporter of goods with a small domestic market.

Finally, equity prices could also be impacted by international risk appetite which could be affected by foreign monetary policy. This line of thought was followed by Di Casola and Stockhammar (2021), in their study on the Swedish QE program, by letting Eurozone QE precede the Swedish one in the Cholesky ordering. To summarize, it would have been desirable to include more variables to better account for various potential omitted variable biases. Even so, more variables could also entail even less probability of obtaining significant results due to the curse of dimensionality and the short time period sampled.

9. Concluding Remarks

Due to the sharp increase in inflation and interest rates as well as quantitative tightening during the last year, the time of quantitative easing is over, for now. However, monetary policy and income inequality are policy issues that are still highly relevant. Our main specification suggests that the initial QE program decreased income inequality in Sweden but due to potential biases, interpolation problems, and our insignificant alternative specification, it is not a result we confidently can claim. Even though Sweden differs significantly from Japan in terms of the labor market, demographics, and sheer size, opposing results from Saiki and Frost (2014, 2020) cannot be determined with certainty despite that the same specification was employed.

The use of market income in order to isolate monetary policy from fiscal policy could have affected the results. During the last decades, Sweden has seen a substantial change in terms of fiscal policy, reducing redistributive policies. Even though direct consequences of such policies in terms of taxes and transfers are removed, underlying and non-QE related factors, like labor-market policies, could unobservably affect the income distribution. Furthermore, Sweden provides an extensive social safety net and large transfers for the unemployed which could suggest job creation would entail a drop in market income inequality whilst disposable income inequality would be relatively unaffected. Assuming that an egalitarian society is desirable, then this poses the question of whether unemployment is even desirable to look at in the Swedish case since output is a better determinant of transfers and taxation. Nevertheless, the state should not be indifferent to job creation even if the income of the individual remains unaffected since being employed serves other ulterior motives.

In addition, one reason inhibiting comparability between Sweden and other countries could be the size of countries' respective quantitative easing programs. The Riksbank’s program was not even half of the size, when scaled by GDP, of that of the ECB, BoE, or BoJ. This could partly serve as an explanatory reason as to why our conclusions differ from those reached in previously discussed studies.

The numerous fiscal policy reforms, such as the abolishment of wealth taxation, in the last decades, in combination with the use of unconventional monetary policy can not only affect income but also wealth. Considering that there exists a large discrepancy in income taxation

and tax on wealth, examining the effects of QE on wealth inequality would be relevant. However, due to the non-existence of wealth data on Swedish citizens such studies are, as of today, impossible. This carries significant implications for evaluating future fiscal and monetary policy implementations' effects on economic inequality in Sweden. Regardless of political stance, knowing if QE impacts the wealth distribution could be beneficial for making informed policy decisions. Even if inequality per se is well beyond the scope of the Riksbank's core responsibilities, this type of information would not only be advantageous for the government but also for the central bank due to its potential ramifications for growth and financial stability. From a research perspective, it would also be desirable with higher-frequency surveys such as those employed by the studies of the UK and the US. Therefore, we propose that the National Institute on Economic Research includes queries on assessed wealth and liabilities in their monthly Economic Tendency Survey on Swedish households (Konjunkturinstitutet, 2023). This data would be subject to measurement bias due to deficiencies in self-reported data. Nevertheless, it would still be a revelation compared to the current situation. Finally, the current Schrodinger-esque set-up does not serve politicians opposing wealth taxation either. Denmark can serve as a leading example where wealth and liability are collected on the individual level whilst there is no tax on wealth.

As previously mentioned, the effects of the use of expansionary monetary policy are heavily debated. Mature economies are currently experiencing record-breaking inflation in the 21st century, resulting in higher interest rates, quantitative tightening, and overall contractionary monetary policy. Coibion et al. (2017) suggested that contractionary monetary policy could come to the detriment of the poorer parts of the income distribution. This could suggest that the current state of the economy if it is not met with redistributive policies from the fiscal side, could have redistributive consequences. Furthermore, the QE program carried out during the COVID-19 pandemic was comparatively larger than the program this study concerns. Simultaneously, Saiki and Frost (2020) argue that the quantitative and qualitative easing used in Japan from 2013, which is arguably more similar to the COVID-19 QE program in Sweden, increased income inequality further. Thus, when more data is available, these countervailing paradigms could serve as a possible route for further research.

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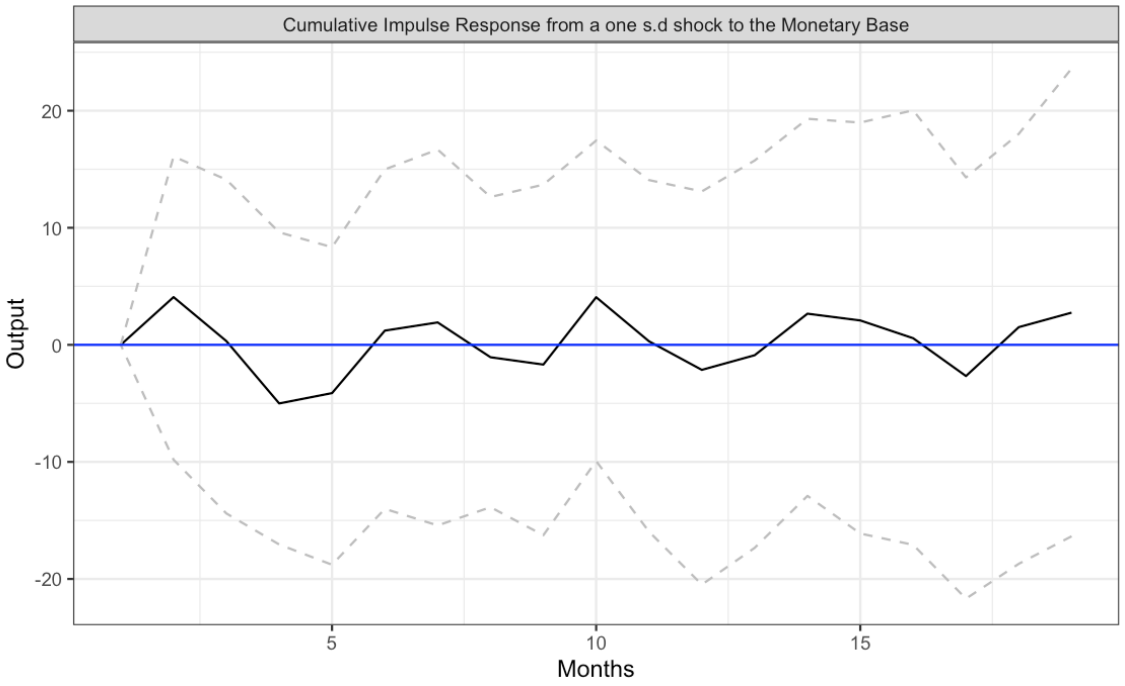
Appendix

Appendix 1: IRFs from the main specification

In appendix 1, additional impulse response functions from the main specification are presented.

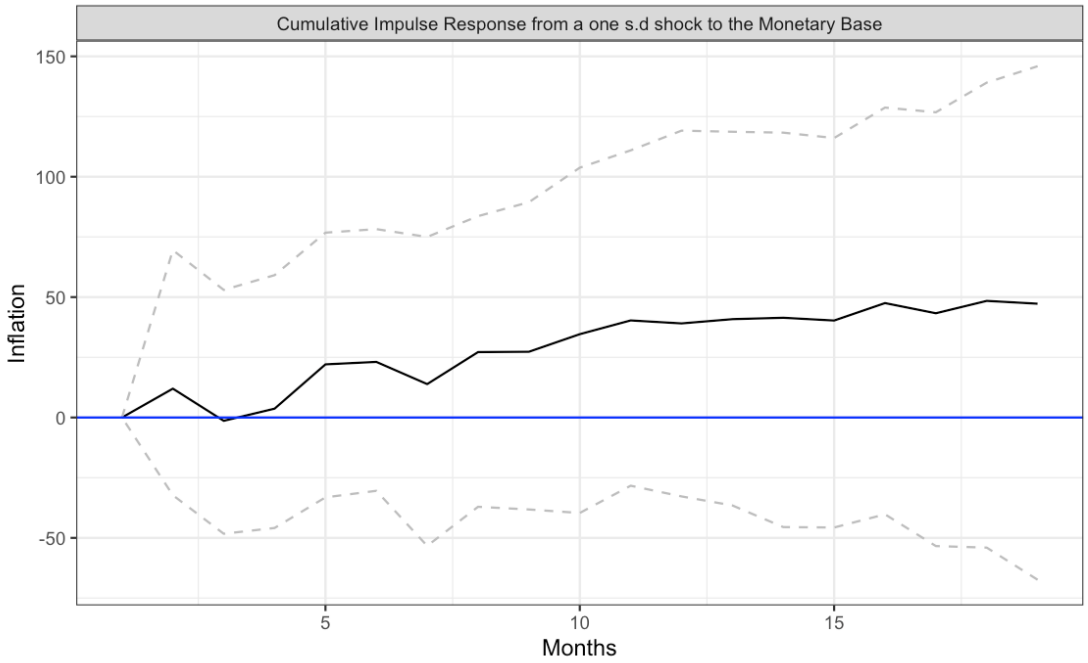
Specification: $Y_t = [\partial \ln(GDP)_t, \partial(Inflation)_t, \partial \ln(Monetary\ Base)_t, \partial \ln(OMXSPI\text{-}Index)_t, \ln(Gini)_t]'$

Figure 9: Impulse response function to GDP from a one s.d shock to the monetary base.



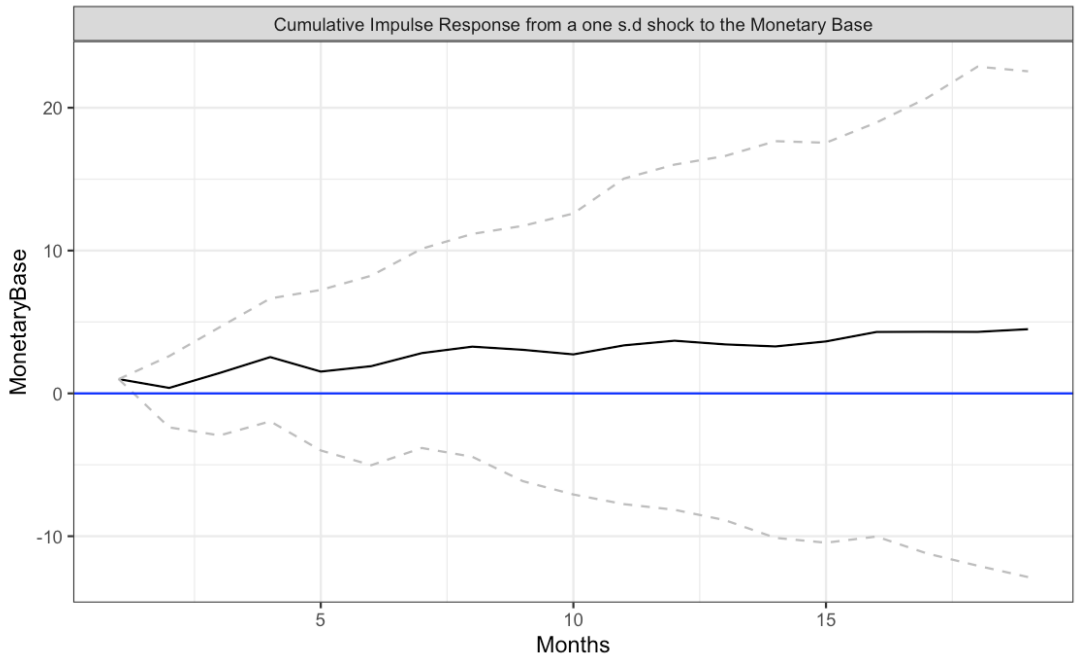
Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Figure 10: Impulse response function to inflation from a one s.d shock to the monetary base.



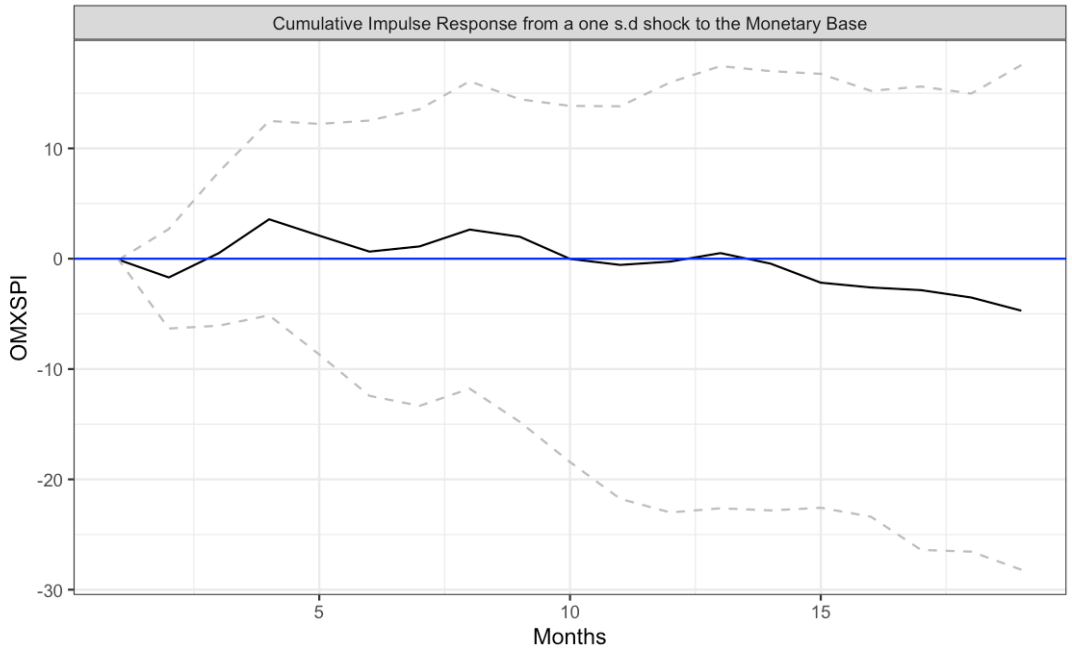
Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Figure 11: Impulse response function to monetary base from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Figure 12: Impulse response function to OMXSPI from a one s.d shock to the monetary base.



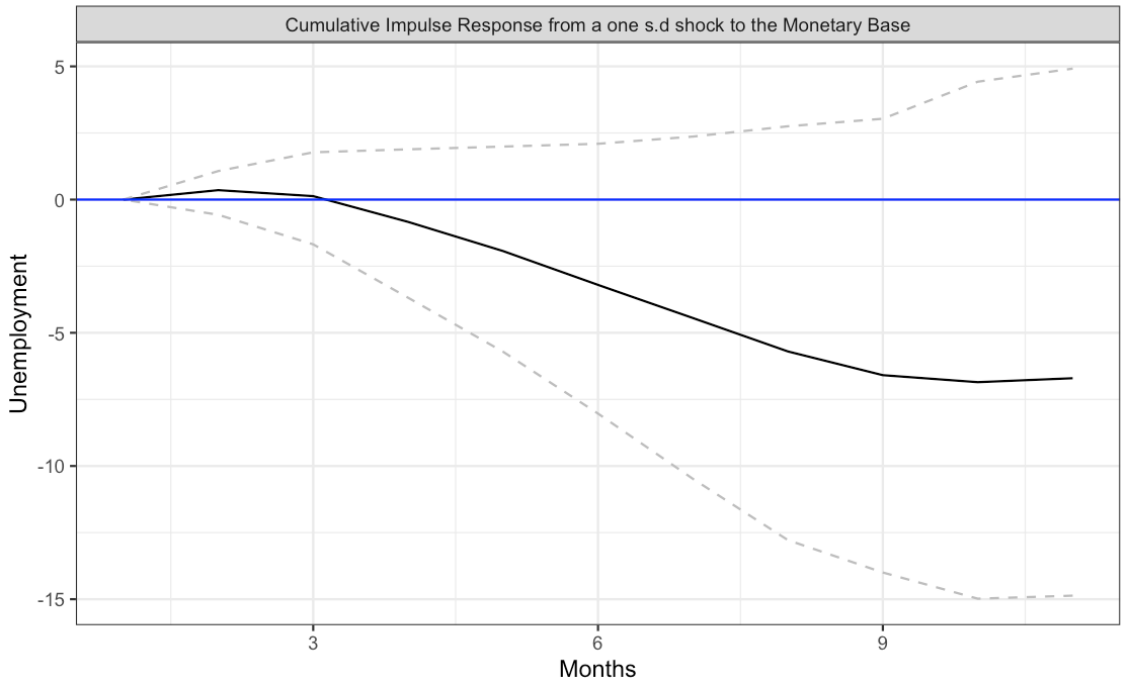
Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Appendix 2: IRFs from the second specification

In appendix 2, additional impulse response functions from the second specification, where output is subsided in favor of unemployment, are presented.

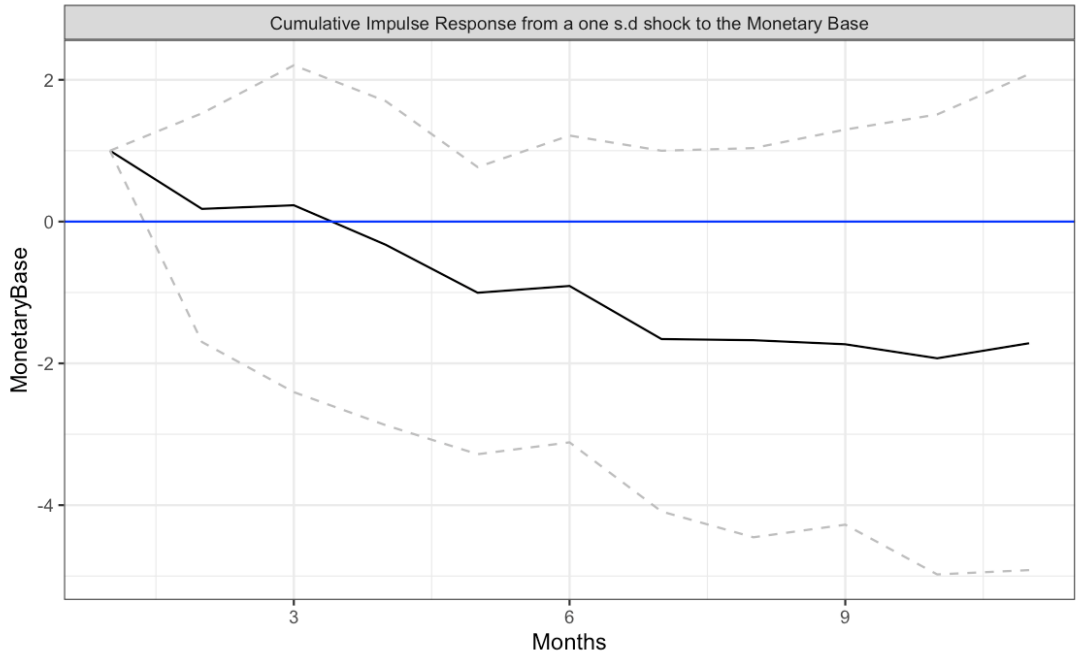
Specification: $Y_t = [\partial(\text{Unemployment})_t, \partial(\text{Inflation})_t, \partial\ln(\text{Monetary Base})_t, \partial\ln(\text{OMXSPI-Index})_t, \ln(\text{Gini})_t]'$

Figure 13: Impulse response function to unemployment from a one s.d shock to the monetary base.



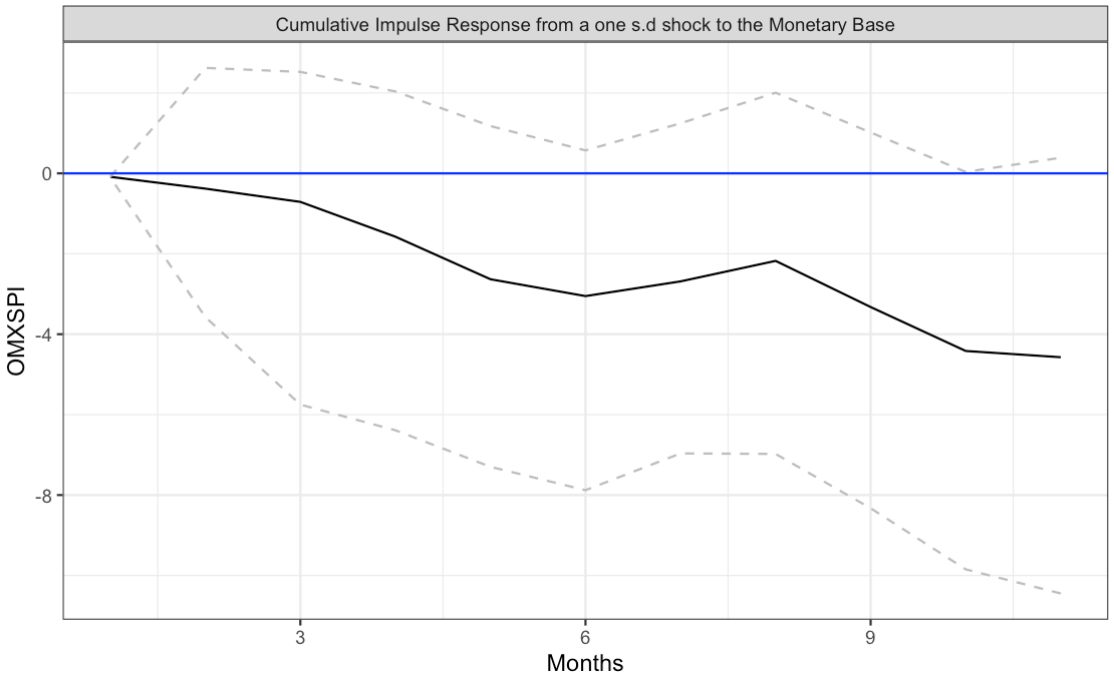
Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), CPIF, Unemployment from Statistics Sweden (2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Figure 14: Impulse response function to monetary base from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Figure 15: Impulse response function to OMXSPI from a one s.d shock to the monetary base.



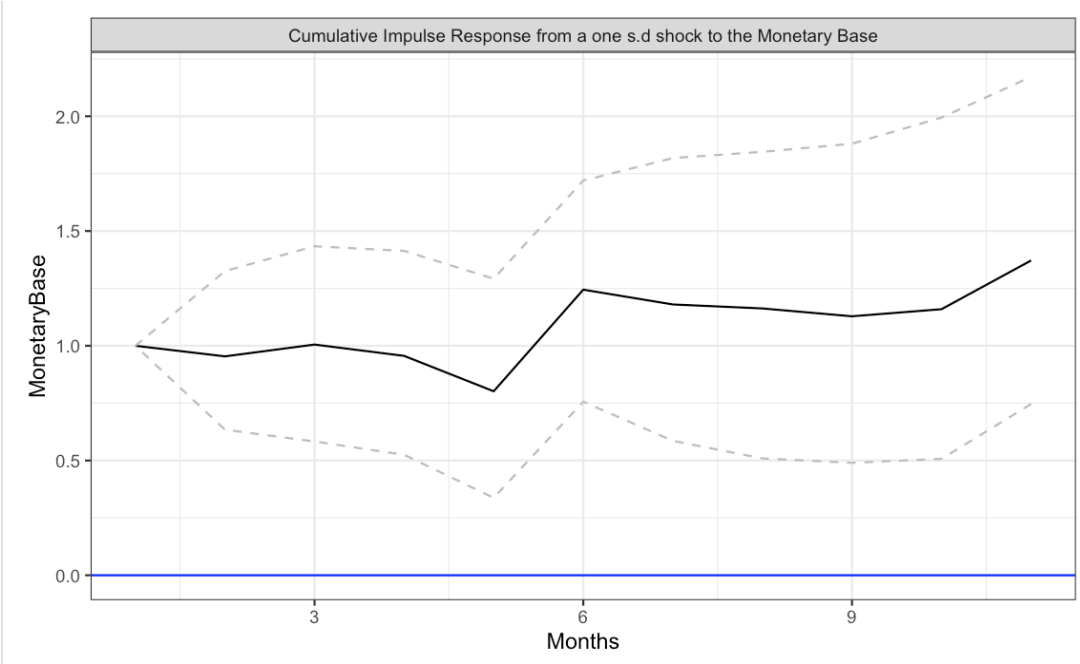
Note. authors' computations; OMX-Index from Nasdaq (2023), Gini Coefficient from OECD (2022), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Appendix 3: IRFs from the alternative specification

In appendix 3, additional impulse response functions from the alternative specification where the interpolated Gini coefficient is removed, are presented.

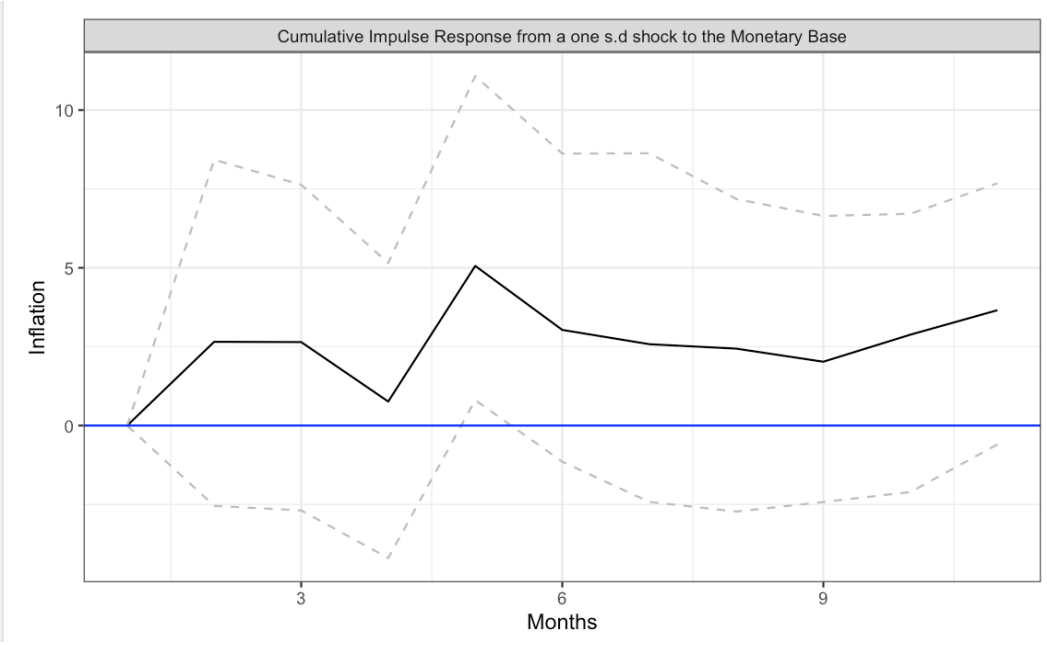
Specification: $Y_t = [\partial \ln(GDP)_t, \partial(Unemployment)_t, \partial(Inflation)_t, \partial \ln(Monetary\ Base)_t, \partial \ln(OMXSPI\text{-}Index)]'$

Figure 16: Impulse response function to the monetary base from a one s.d shock to the monetary base.



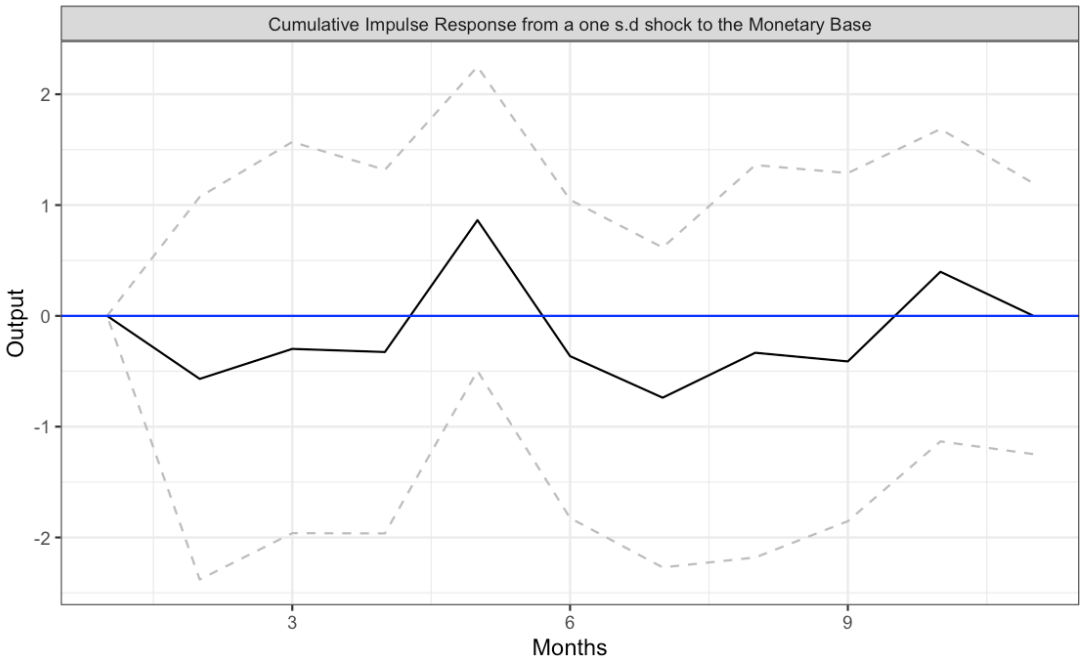
Note. authors' computations; OMX-Index from Nasdaq (2023), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Figure 17: Impulse response function to inflation from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).

Figure 18: Impulse response function to output from a one s.d shock to the monetary base.



Note. authors' computations; OMX-Index from Nasdaq (2023), GDP-Indicator, CPIF, Unemployment from Statistics Sweden (2023a, 2023b, 2023c). Monetary Base from Sveriges Riksbank (2023b).