Quantitative easing's impact on inflation

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Abstract

This paper estimates the effects of quantitative easing (QE) policies on consumer inflation in Sweden, the United States, and the euro area. Furthermore, the effects of QE policies on additional macroeconomic variables have also been investigated. To study the effects, quarterly data was used in a local projections impulse response function (IRF). The results implies that QE increased consumer inflation in the euro area, but not in Sweden. No clear result could be inferred for the United States. In the case of Sweden, QE caused deprecation of the exchange rate. A link between QE policies and inflation expectations was also found for the euro area, a link not found for Sweden. This paper contributes to a broader comprehension of QE policies, especially for small open economies as Sweden.

Keywords: quantitative easing, inflation, Sweden, United States, Euro area

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1 Introduction

Since the global financial crisis of 2008/9, many central banks have expanded their toolset to include so-called unconventional monetary tools. One of the most talked about have been quantitative easing (QE). It entails large-scale asset purchases by the central banks, which increases the monetary supply and is used when the short-term interest rate is close or under zero (Williamson, 2017). QE has emerged as a crucial tool of monetary policy and is seen as an unconventional policy tool that can be employed when the short-term interest rate might fail. The Federal Reserve was early in their implementation of QE, as they in the end of 2008 started their expansionary unconventional monetary policy (The Federal Reserve, 2008), including large-scale asset purchases of government bonds in the beginning of 2009 (Borio & Zabai, 2016). Later, the European Central Bank (ECB) started their asset purchase programme in mid-2014 to stimulate the economy and to increase the inflation (European Central Bank, 2014). While the Swedish central bank, the Riksbank, started their asset purchase programme of government bonds in the beginning of 2015 (Riksbank, 2015). The Riksbank introduced QE during a boom, making the Riksbank the only central bank to do so.

Previous empirical research on the impact of QE has mostly been focused on the United States, the United Kingdom, and Japan. An early study by Baumeister and Benati (2013) explored the impact of QE on inflation in the United States and the United Kingdom, with the result that QE is a feasible policy tool to influence inflation in a zero-bound environment. Kapetanios et al (2012), using three different vector autoregressions (VAR) models, showed that early rounds of QE by the Bank of England increased consumer inflation, and that QE is a viable policy tool during financial crisis. Chung et al (2012) conducted simulations and assessed that the large-scale asset purchase programmes by the Federal Reserve during 2009-10 gave a similar effect as a 2% reduction in the short-term interest rate. The research on the effect of QE on inflation in Sweden is limited. The evaluating of QE’s effects on a small open economy, as Sweden, is especially difficult as a result of the spill overs of QE by other central banks (Di Casola & Stockhammar, 2021). Still, the result from Di Casola and Stockhammar (2021) shows that the effects of domestic QE on inflation in Sweden is not clear. Additionally, Andersson and Jonung (2020) posit that monetary policy by the Riksbank has not influenced consumer inflation in Sweden, but asset prices. As the efficiency of QE is not definite, the theory is inconclusive, and the empirical evidence is ambiguous.

The purpose of this study is to examine the effect of QE on inflation in the United States, Sweden, and the euro area. In addition, the effects of QE on other macroeconomic variables will be investigated. This thesis have an extra focus on the effects in Sweden, as there exist a lack of research of the impact of QE on Sweden. The study was done by a local projections impulse response function (IRF). Several macroeconomic variables are used: consumer price index (CPI), CPI with fixed interest rate (CPIF), harmonised index of consumer prices (HICP), short-term policy interest rate, exchange rate, unemployment rate, expected inflation, government debt, and QE purchases. Quarterly data is used, and the time period ranges are 1998-2021 for Sweden, 2002-2021 for the United States, and 2000-2021 for the euro area.

The result of this paper contributes additional evidence that QE policies by the Riksbank does not increase the domestic consumer inflation rate. This might be the result of the Riksbank using QE during an economic boom. In addition, this study shows that QE by the Riksbank causes a depreciation of the currency of Sweden. This is line with previous studies as Andersson and Jonung (2020) and Di Casola and Stockhammar (2021). Both studies shows that QE have caused depreciating of the Swedish krona. For the euro area, the result implies increased consumer inflation as an effect of QE. This gives further confirmation of the result of the study by Hohberger, Priftis and Voge (2019), who shows an increase of the CPI inflation in the euro area of 0.6% as a result of QE policies by the ECB. Another finding of this study is that the expected inflation of the euro area increases as a result of QE policies. This link was absent for Sweden.

This study contributes additional evidence of the efficacy of QE policies in a zero-bound environment. Further, it highlights the differences of the effects of QE between a large economy as the euro area, and the effects of QE in a small economy as Sweden. The results could assist in the decision to conduct further QE programmes, or in the decision to start conducing QE.

The rest of the thesis has the following disposition. In section 2 the background for the monetary policy is presented that explains why unconventional monetary policy, like QE, was introduced in several countries. This is together with an introduction of QE and theories for and against the efficacy of QE. Section 3 reviews previous literature in the research of this area. Section 4 present the data used and section 5 presents the method for the study. Section 6 presents the results from the models and a discussion of the results. Lastly, section 7 concludes the thesis.

2 Theory

Inflation targeting became the favoured monetary policy framework by most advanced central banks during the 1990s. By altering the short-term policy rate, the central banks aimed to neutralize economic shocks and stabilize inflation around the inflation target. The efficacy of this approach to conducting monetary policy was supported in both theory and empirical evidence. As the global financial crisis of 2008/09 emerged, central banks lowered the interest rates towards zero in order to meet their inflation targets. However, as the interest rate approaches the zero lower bound, a point for the interest rate where the further cutting of the rate is less effective, this instrument alone was proven to be ineffective (Joyce, et al., 2012). The global financial crisis therefore drove central banks to move away from only conducting conventional monetary policy towards the implementation of unconventional monetary policy that lacks the same support in theory and empirics.

2.1 Conventional monetary policy and inflation targeting

The decision to set the interest rate was made by studying a broad range of macroeconomic signals, but it was set in a way that could be approximated with the Taylor rule (Joyce, et al., 2012). The Taylor rule is a model that explains the relationship between the central bank's policy rate and the rate of inflation and the output gap (Taylor, 1993). When inflation is higher (lower) than the inflation target, or when the output is higher (lower) than the potential output, the central bank's policy rate is increased (decreased). Central banks could also regulate the real interest rates for the short-term and medium-term, and through the real interest rate, the central banks could affect asset prices (Fawley & Neely, 2013). Banks, firms, and households are affected via this asset price channel in their decisions to lend, invest, and consume. Central banks can also affect the economy through the expectation channel. The expectations of the central banks influence economic decisions. Signalling also affects the real economy, and the signalling channel reflects the new information. Such as the central banks' future policy rates which influences decisions in the present. The monetary policy, through the channels, influences the prices and thereby the inflation. For mature economies, the period that preceded the global financial crisis can be explained of a mostly foreseeable and an effective use of monetary policy in the aim for low and stable inflation.

As a consequence of the global financial crisis, central banks were presented with new challenges. The first challenge was the effective lower bound on nominal interest rates.

During the crisis, the Taylor Rule suggested for many central banks that the nominal interest rate to be negative (Joyce, et al., 2012). The problem is that the public can always hold non-interest-bearing cash instead of depositing their money in a bank, leading to that the nominal short-term interest rate cannot be set much lower than zero (Fawley & Neely, 2013). In an environment with already low interest rates, which several economies found itself in during the global financial crisis, the effect of changing the interest rate was limited. Thus, interest rate cutting was not enough to produce consumer inflation. The second challenge was the broadening of focus for central banks. From mainly focusing on inflation targeting, to also focus on the greater financial stability (Joyce, et al., 2012). Unfortunately for central banks, they are constrained by their policy instruments. One of the most documented constraints are explained by the Tinbergen's Rule. The rule claims that each policy instrument can only fulfil one policy target at a time (Michl, 2009). Because the number of achievable policy goals are equal to the number of policy instruments, the short-term interest rate is not sufficient to achieve both inflation targeting and any other goals, such as greater financial stability. The third challenge was the lack of liquidity as a consequence of commercial banks seizing to lend. Lowering the liquidity decreases the supply of loans and hence limiting the credit available for borrowers. Thus, leading to a lower money supply. QE can in turn affect bank liquidity on lending during periods of financial stress, more so in weaker banks (Bowman, et al., 2015).

Due to these facts, combined with the inability of current monetary policy to stimulate the economy, conventional monetary policy was deemed to be inadequate. The following period was therefore characterized with the use of unconventional monetary policy by several central banks. These new instruments could be negative interest rates, as in the case of Sweden and several other economies. Negative interest rates work through the requirement of commercial banks to hold reserve ratios, as commercial banks most hold and pay interest to hold reserve ratios, the banks unsuccessfully seek to avoid the interest, and therefore the negative interest rate spreads to other rates in the economy by arbitrage relationships (Borio & Zabai, 2016). This does not imply that the interest rate can be lowered in perpetuity, because there exist a technical constraint. Commercial banks will try to maintain their profitability by limiting losses, this leads to enforcements of negative interest rates on their customers, and at some undefined point the customers will prefer cash (Borio & Zabai, 2016). Without funding of the banks' future operations, their future is in jeopardy. A more prevailing instrument was the enormous expansion of the central banks' balance sheets. Balance sheet policies impacts financial conditions beyond the policy rate by adjusting the size and/or composition of the central banks' balance sheets (Borio & Zabai, 2016). One example of balance sheet policies is when the Federal Reserve increased their balance sheet during the policies of credit easing. These policies provided the market with liquidity, lowered the interest rates for mortgages, and opened credit lines to the economy (Joyce, et al., 2012).

2.2 What is Quantitative Easing and how does it work?

QE policies involves large-scale asset purchases by central banks and are used when short-term nominal interest rates are close to zero. QE increases the monetary base in unorthodox ways through asset purchases and lending programmes (Fawley & Neely, 2013). Generally, long-term government debt is purchased, but private assets as corporate debt or asset-backed securities can also be purchased (Williamson, 2017). The first instance of QE in modern times was in Japan in the beginning of 2001. Japan experienced a falling inflation rate and policy rates that had approached the lower bound. This led to the Bank of Japan to start purchasing government bonds financed by creating central bank reserves (Haldane, et al., 2016). During and after the global financial crisis, the use of QE become more prevalent, and have been used by central banks in the United States, the United Kingdom, Sweden, Switzerland, and the euro area, for example. The implementation of QE shifts the focus from short-term interest rates towards the quantity and price of money. When the interest rate is close to zero, QE can provide stimulus to spending and provide the necessary assistant to meet the inflation target, through the impact on expectations, the accessibility of credit, and the impact on asset prices (Benford, et al., 2009).

The Federal Reserve started their initial QE1 programme (mainly mortgage-backed securities) in late 2008. The ECB started their asset purchase programmes in mid-2014. The QE programmes by the ECB was not implemented to combat the global financial crisis, instead they were introduced several years after to combat the sovereign debt crisis. The programmes was not truly effective in increasing the inflation in the euro zone from 2015 to 2019 (Draghi, 2017; Canofari, et al., 2019). But they were effective in removing the risk of unsustainable public debt in the most exposed euro member states (Canofari, et al., 2019). The Riksbank started their expansionary government bond purchase programme in the beginning of 2015. This was during a boom, therefore not making the implementation of QE a crisis tool. According to De Rezende (2017), the main goal of the Riksbank's government bond purchase programme was to lower the interest rates in several markets to avoid a quick appreciation of the currency and to increase the bank lending. This would in turn increase economic activity and move inflation closer to the inflation target.

To explain the theoretical effects of QE different channels needs to be identified and explained. These are signalling channel, portfolio balance and asset prices channel, liquidity and credit risk premium channel, and expectation channel.

2.2.1 Signalling channel

The signalling channel reflects the new information for participants in the market. The channel incorporates the expectations of the central bank's future policy rates, the future term premia, and an array of other financial variables (Urbschat & Watzka, 2020). For the central bank to be perceived as time consistent, they can implement the strategy of signalling. Direct asset purchasing will signal consistency of the central bank's commitment to hold the announced policy rate. This is done by the change of the central bank's consideration through the balance sheet. Since when a central bank holds considerable amount of long-term bonds when the long rates are low, their interest is aligned to keep the long-term rates low (Fawley & Neely, 2013).

2.2.2 Portfolio balance and asset prices channel

One of the solutions to model an effect of QE, is to incorporate the portfolio balance channel. This is done by dropping the assumption that portfolio balance shifts are considered indifference for investors (Joyce, et al., 2012). The portfolio balance channel requires the assumptions of frictions through two assumptions, first the absence of arbitrage between short and long expected rates, and second the change of maturity composition of government debt to impact the asset prices (Fawley & Neely, 2013). Asset purchases by central banks can affect the long-term real interest rates by a reduction of the term premia. By buying assets of a certain risk, the term premia will be reduced, and therefore less compensation is paid to hold the remaining assets. By affecting the yield, investors will be affected in their investments decisions. This is because the central bank's purchases increases the funds for the sellers, and this will lead to a rebalance for investors by buying additional assets. This will directly lead to higher asset prices. As higher asset prices means lower yields, households and companies are experiencing a lower cost of borrowing, and this leads to higher consumption and investments (Benford, et al., 2009). Higher consumption and investments should transform to higher spending, higher output, and higher employment retention. An additional effect of increased asset prices, would be the increased wealth of holders of assets, which furthermore should increase their spending (Benford, et al., 2009). Altogether, this should lead to higher inflation.

2.2.3 Liquidity and credit risk premium channel

Liquidity premium is additional compensation for assets that is neither simply nor swiftly convertible to cash. The central bank can improve the function of the bond markets by being a major buyer of bonds, thereby decreasing the risk premia from illiquidity. Further, the central bank's purchase of assets is increasing the liquidity in the economy, and therefore making households and companies more inclined to hold less liquid assets (Benford, et al., 2009). A famous example of this channel is Mario Draghi's "Whatever-it-takes" speech, which made investors certain that the possibility of selling bonds to the ECB was always on the table (Urbschat & Watzka, 2020). Another effect of the central bank's willingness to be a buyer of assets, is that yields decrease to normal levels during periods of financial stress, thereby increasing market participation and increasing the amount of funding in the financial system (Benford, et al., 2009).

2.2.4 Expectation channel

Another channel for QE that can affect inflation is the expectation channel. If market participants believe that the central bank will be willing to do anything to reach the inflation target, the inflation expectations could be anchored at the inflation target when there exists a risk that the expectations might decrease (Benford, et al., 2009). This could depress real interest rates and increase spending. If households and companies believe that the economy in the future will improve, the spending and investment should also increase in the present. Additionally, as long as QE is expansionary, the inflation expectations will increase, but there exists some risk that QE might increase uncertainty for the outcome of inflation (Krishnamurthy & Vissing-Jorgensen, 2011).

2.3 Theoretical counter evidence against QE

The study by Eggertsson and Woodford (2003) question the efficiency of QE. They argue that expanding the monetary base through asset purchases by the central bank should have a neutral effect on inflation. Their result is based on standard New Keynesian model, with the assumptions that the private sector, represented by a representative household, is rational, lacks credit constraints, and have an infinite time horizon. These assumptions are coupled with that the private sector considers assets held by the government and the central bank to be identical to their own. Consequently, the change of one asset to another with the central bank cannot elicit an effect. Furthermore, the authors claims that QE will lack efficacy if households do not understand the central bank's commitments for future interest rate policies. These assumptions for the representative household are debatable in normal times, especially as agents have different preference for assets. During financial crisis the assumptions are even more doubtful as markets are not operating ideally. In cases with credit constraints, the results do not hold.

Another study by Curdia and Woodford (2011), uses a standard New Keynesian model that assumes heterogeneity, which introduces different preferences for households, and credit imperfections, which removes the lack of credit constraints. In this model, the interest rate is the same in equilibrium for government bonds and bank reserves, leaving the households with the decision problem to be *how* much to borrow or deposit. In this model QE, defined as the purchase of government bonds, is still ineffective. Even when the interest rate reaches the zero lower bound. The basis of this result is that bank reserves and government bond are treated as perfect substitutes, as both have the same interest rate, and the change from one to the other, QE, does nothing (Joyce, et al., 2012).

2.4 Summary

As a result of the global financial crisis, unconventional monetary policies have been implemented by several central banks. The policies was mostly untested, and therefore the efficiency was undetermined. QE is no exception; purely theoretical it exist hypotheses for both in support and in opposition for the effectiveness of QE. In the possibility of QE polices working as intended, several channels which it would work through have been introduced. These channels have different size of influence, and some only work as long as QE is implemented, while others work with different size of lags. On the other side, the theoretical study by Eggertsson and Woodford (2003) shows that QE should have a neutral effect on inflation. This result only holds with stringent assumptions, assumptions that would be highly debatable during financial crisis. But it is precisely during financial crisis many QE programmes was adopted. Curdia and Woodford (2011) relaxes the assumptions, and the result is the same: QE policies would still be ineffective. With the implementation of QE programmes by several central banks, researchers now have the possibility of examining data to move the arguments from solely theoretical grounds to the empirical.

3 Empirical evidence

According to Borio and Zabai (2016), the empirical research of the impact of large-scale asset purchase programmes can be divided into three approaches. The first approach is the measurement of the direct impact on macroeconomic variables, as inflation. Typical a small model consisting of a few equations that traces the changes in the data. For example, a few equations measure the impact on inflation of the expansion of the balance sheets. The problem with these types of studies is that the relationships between variables are unstable, and that any patterns before the expansion of balance sheets are changed with the execution of balance sheets policies. One of the earlier studies in this field, Baumeister and Benati (2013), used this approach. They investigated the macroeconomic impact of a compression in the spread of the long-term bond yield during the recession of 2007-09 in the United States and the United Kingdom, using a time-varying parameter structural VAR model. The first result was that the compression of the spread for the long-term yield strongly affected both output growth and inflation. This effect was present in both countries of the study. The second result was from counterfactual simulations and showed that the asset purchase programmes deflected deflation in both countries during the financial crisis and its aftermath. They argue that QE was crucial in negating the threat of deflation. Their result shows that the effect was persistently positive of the large-scale asset purchases by the Federal Reserve. The effect had a delay and the effect was largest in the third quarter. The peak effect on inflation was 0.5% for the United States, and about 2% for United Kingdom. The authors asserts that QE enables price stability and is a feasible policy tool for price stability and financial stability in a zero-bound environment. Another study that used this approach was Kapetanios et al (2012). They estimated the impact of the first rounds of QE by the Bank of England on output and inflation. In the study, three different VAR models: a Bayesian VAR, a change-point structural VAR, and a time-varying parameter VAR was all used to incorporate different combinations of structural shocks and was used to generate counterfactual simulations. The authors preferred average estimate from the three different models indicates the peak effect of QE on annual CPI inflation to be about 1.25%, and the peak effect of QE on real GDP of around 1.50%. This study also shows that QE works with a delay, and that the effect is greatest after two to four quarters. Kapetanios et al argues that their study suggest that QE can be a viable policy tool during financial crisis, even while the degree of efficiency varies wildly across the models, and the specific assumptions made to create the counterfactual simulations creates uncertainty of the result.

The second approach is the theory-based approach, where the studies start with a predetermined outcome of the balance sheets polices in a general equilibrium model. Thereafter, the effects of policies are traced through the economic system. The models depends on outside information to set the sizes of the parameters, also known as calibration. The models are to show guidance of the transmission channels and does not report the true size of the effects. They can be regarded as the first step to more thoroughly research. An example of this approach is the study by Gertler and Karadi (2013). They estimated the impact of the Federal Reserve's large-scale assets purchases on the economy of the United States. This was done by a dynamic stochastic general equilibrium (DSGE)-based counterfactual exercise for QE1 (first wave of asset purchases from September 2008), and DSGE-based simulation of QE2 (second wave of asset purchases from October 2010 until September 2011). The findings shows that QE does have a positive effect on inflation: in QE1 the inflation increased by 4%, and in QE2 the inflation increased by 1.5%. The peak effect of the large-scale asset purchase programmes was immediately and thereafter decreased, and after ten quarters the effect was around zero. They also showed that the transmission of QE to real output and inflation is similar to conventional monetary policy. The advantage is that QE is an option when the zero lower bound is binding. Even more, QE is the most effective option in a situation with a binding zero lower bound.

The third approach is the two-step approach. The first step is to map measurements into variables or shocks, and to include these variables or shocks into the models. The second step is based on the mapping in the first step, and it is to trace the effect on the variable of interest, for example inflation. This is for example how QE purchase programmes have been mapped to a synthetic short-term policy interest rate. Hence, it is possible to show that a certain QE programme has the same effect on inflation as a certain change of the short-term policy interest rate. The problem with this approach lies with the quality of the mapping, and the result is more reliable if the mapping is simple. This approach was applied by Chung et al (2012). Their study consisted of simulations using the Federal Reserve's FRB/US (large-scale rational-expectations model of the United States economy). Where of the effect of the two first rounds of large-scale assets purchase programmes, LSAP1 and LSAP2 were estimated. They found that the asset purchase programmes together raised the inflation by 1%. The results implies that the asset purchases programmes kept inflation from dipping below zero.

Furthermore, the asset purchases programme by the Federal Reserve during 2009-10 gave a similar effect as a 2% reduction in the short-term interest rate.

Table 1. The effect of large-scale asset purchase programmes on inflation

Study	Country	Maximum impact on inflation
First approach		
Baumeister and Benati (2013)	The United States	0.5%
	The United Kingdom	2%
Kapetanios et al (2012)	The United Kingdom	1.25%
Second approach		
Gertler and Karadi (2013)	The United States	QE1: 4% QE2: 1.5%
Third approach		
Chung et al (2012)	The United States	1%

3.1 Summary

The implementation of QE polices by several central banks have provided new data. This has made further empirical research on the effectiveness of large-scale asset purchase programmes possible. The studies can broadly be divided into three approaches (Borio & Zabai, 2016). The first approach is to measure the direct impact on macroeconomic variables. Examples of these kinds of studies are Baumeister and Benati (2013) and Kapetanios et al (2012). Baumeister and Benati posits that QE increased inflation and was crucial in negating the threat of deflation during 2007-09 in the United States and the United Kingdom. The preferred average estimate of Kapetanios et al (2012) indicates peak effect of QE on annual CPI inflation to be about 1.25%. Their result also shows that QE works with a delay of two quarters, and the maximum effect is at three to five quarters in. The second approach is theory-based, and the study by Gertler and Karadi (2013) is an example of this. Their findings shows that QE have a positive effect on inflation. Their model indicates that the peak effect of QE occurred immediately and thereafter decreased. They also showed that the transmission of

QE to real output and inflation is similar to conventional monetary policy. The third approach is to map measurements into variables or shocks, and thereafter to include these into the models. This is what the study by Chung et al (2012) did. They found that the asset purchase programmes by the Federal Reserve together raised the inflation by 1%. Furthermore, the asset purchases programme during 2009-10 gave a similar effect as a 2% reduction in the short-term interest rate. Table 1 summarises the results from previous studies.

4 Data

The data used in this study is quarterly data from 1998 to 2021 for a diverse set of macroeconomic variables. Choosing a start point earlier than the period of QE policies will give more observations. More observations may give a more robust statistical inference. The precise start point of 1998 for Sweden was chosen because low inflation targeting was already implemented for many advanced central banks, as the Riksbank and the ECB, during this time. The start point for the United States is the second quarter of 2002, and the start point for the euro area is the first quarter of 2000. Their start point was chosen because the limitation of the availability of data. The endpoint was selected as the last available data at the time of this study. The precise time periods for each model is 95 observations in 1998-2021 for Sweden, 77 observations in 2002-2021 for the United States, and 87 observations in 2000-2021 for the euro area. The variables used is CPI, CPIF, HICP, the central banks' short-term policy rates, nominal effective exchange rate represented by a currency basket, the harmonised unemployment rate, expected inflation, nominal consolidated general government debt, nominal gross domestic product (GDP), and finally the sizes of QE purchases. All variables in the models are in natural logarithms, expect for the short-term policy interest rates and the unemployment rate.

For inflation in Sweden the index CPIF has been used, which is the target variable for monetary policy by the Riksbank. CPIF is CPI with fixed interest rate, and therefore omits the effect of changes in the mortgage rate. The drawback of using CPI is that changes in the central bank's interest rate affects the interest rate for mortgages. So, when the central bank's rate is lowered to increase inflation, the mortgage rates decline, and this cause the CPI to decrease in the short-term. HICP is used within the euro area by the ECB to measure inflation. It enables comparison between member states of the European Union. The HICP excludes the mortgage rates and therefore, similar like the CPIF, omits the effect on inflation of a change in the central bank's interest rate. The measurement HICP was also used for the United States.

This measurement is not the Federal Reserve's preferred measurement for inflation, that is the personal consumption expenditures price index. But by using the same index for both the euro area and the United States, the possibility for a clearer comparison emerges. Furthermore, no database that provided a CPIF was found for the United States. CPIF was provided by Statistics Sweden (SCB) for Sweden. HICP was provided by the ECB for the euro area, and by Eurostat for the United States. The data was provided in monthly indexes and was calculated from monthly indexes to the mean value for each quarter. When the variables are used in the models, they have been expressed in natural logarithm.

The short-term central bank-rate was chosen as the central banks' policy rates: the repurchase (repo) rate for Sweden, the interest rate for the main refinancing operations (MRO) for eurozone, and the federal funds effective rate for the United States. The policy rates were included, because this conventional monetary instrument is the main tool to influence inflation when the lower bound has not yet been reached. The central banks provided the short-term interest rates. The Swedish repo rate was provided as the mean for each quarter. The federal funds effective rate was provided as the daily rate and was calculated to the mean of each quarter. The ECB's MRO was provided as the rate of each date when the rate was changed and was calculated to the mean of each quarter when several changes in the rate occurred during the same quarter. When the variables are used in the models, the interest rates have been expressed as percentage points.

The Bank for International Settlements (BIS) provided the data for the exchange rates. BIS effective exchange rate was used to incorporate international trade. The exchange rate influences a country's international competitiveness, and therefore its imports and exports. It directly impacts the prices of items coming from abroad, and currency movements have a significant links to inflation (Forbes, 2015). The currency basket includes 52 economies, and in 2004 these 52 economies accounted for 93% of the world trade (Klau & Fung, 2006). The data was provided as nominal monthly index and was calculated to the mean of each quarter. When the variables are used in the models, they have been expressed in natural logarithm.

Harmonised unemployment rate was chosen as a better measurement than the different governments self-reported unemployment rates. Unemployment is classified differently by different governments, and this measurement make it possible to compare unemployment rates between countries. Organisation for Economic Co-operation and Development (2020) defines the harmonised unemployment to be the working age population that are without work, prepared to work, and have taken certain activities to find work. It is expressed as percentage of unemployed of the total civilian labour force. Unemployment influences inflation through (1) the Phillips curve, which states that inflation and unemployment have an inverse and stable relationship, (2) inflation expectations, and (3) the empirical evidence of a positive relationship between unemployment and inflation (Friedman, 1977). Organisation for Economic Co-operation and Development (OECD) provided the data as the mean value for each quarter. When the variables are used in the models, they have been expressed as percentage points and the data was seasonally adjusted.

Expected inflation, or inflation forecast, is projections based on the current economic development in both the individual country and the world economy. This data was also provided by the OECD. OECD uses both expert judgement and a model-based approach for their forecast. Inflation expectations influence actual inflation. For example, if labour unions believe that the inflation next year will be 5%, the labour unions will at least want a similar raise. The same is for business that want to raise prices. The data was provided as monthly percentage points. But when used in the models the data have first been transformed to a monthly index, and secondly to the mean value for each quarter. Lastly, the indexes have been expressed in natural logarithm when used in the models.

General consolidated government debt was used for government debt. Maastricht debt was used for Sweden and the euro area and is the consolidated gross debt, and covers all government debt, including local government debt. When the government increases their debt, their interest rate for the debt also increases. This will in turn also lead to a higher interest rate for companies. Companies will increase their prices and the result is higher inflation. The government debt for Sweden was provided by SCB. The euro area's government debt was provided by ECB Statistical Data Warehouse, and the government debt for the United States was provided by the Board of Governors of the Federal Reserve system. The debt was provided in nominal amounts and when used in the models they have been expressed as natural logarithm.

QE is the variable of interest for this study. The QE purchases was provided directly by the central banks for Sweden and the euro area. While for the United States no data was available directly from the central bank. The QE purchases in the United States was mainly focused on United States Treasury Securities and Mortgaged-Backed Securities, and therefore *Assets: Securities Held Outright: U.S. Treasury Securities: All: Wednesday Level* and *Assets: Securities Held Outright: Mortgage-Backed Securities: Wednesday Level* was used as proxies. This measurement will not give the true sizes for the QE purchase programmes and they will include changes that are not a part of QE. This noise will make the result less clear in relation to the other two models. This data was provided by the Board of Governors of the

Federal Reserve System. For all three models, the data was provided in monthly commutive amount. The data was first converted to be the last monthly value for each quarter. Then the commutive purchases was divided by the quarterly GDP to better measure the relative size of the purchases. This is by dividing the QE purchase for that quarter divided by the nominal GDP for the same quarter, and thus giving a fraction that better represents the relative sizes of the QE purchases. The GDP was seasonally adjusted and was provided by Eurostat for Sweden and the euro area, and for the United States by U.S. Bureau of Economic Analysis. When used in the models, the fraction was expressed in natural logarithm.

Lastly, Germany's CPI was used for Sweden as an additional control variable. The inflation in Sweden follows the economic development in the euro area (Andersson & Jonung, 2020). Therefore, Germany's CPI is included in the model for Sweden. CPI is the most common index to measure inflation. The index chosen excludes food and energy and is more commonly known as core inflation. The reason to exclude food and energy from the index, is that their prices are considered to be more volatile. The data was provided as an index and when used in the model for Sweden it was expressed in natural logarithm.

Table 2 summarizes the transformation of the data, presents the variable names, and provides the sources of the data.[1]

Table 2: Description of data and variables

Variable	Description	Source
CPIF	Log of CPIF (index)	Sweden: SCB
HICP	Log of HICP (index)	Euro area: ECB Statistical Data Warehouse United States: Eurostat via FRED
GerCPI	Log of Germany's CPI (index). Only used for Sweden	Sweden: OECD
CBR	The central banks' policy rates. Note that the ECB used fixed rate tenders from 1991-01-01 to 2000-06-09 and 2008-10-15 to present time, and	Sweden: Riksbanken Euro area: ECB Statistical Data Warehouse United States: Board of

[1] Descriptive statistics for the variables can be found in the Appendices.

	variable rate tenders (minimum bid rate) during the time in between	Governors of the Federal Reserve System (US) via FRED
ER	Log of nominal index	BIS
U	Harmonised unemployment rate	OECD
ExpInf	Log of index	OECD
GD	Log of the general consolidated government debt. The Maastricht debt, debt defined by the Maastricht Treaty, is used for Sweden and the euro area	Sweden: SCB Euro area: ECB Statistical Data Warehouse United States: Board of Governors of the Federal Reserve System (US) via FRED
GDP	Nominal GDP. Seasonally adjusted. Note that GDP was not used directly in the models	Sweden and the euro area: Eurostat via FRED United States: U.S. Bureau of Economic Analysis via FRED
QE	Log of the commutative QE purchases that was divided by the nominal GDP	Sweden: Riksbanken Euro area: ECB United States: Board of Governors of the Federal Reserve System (US) via FRED

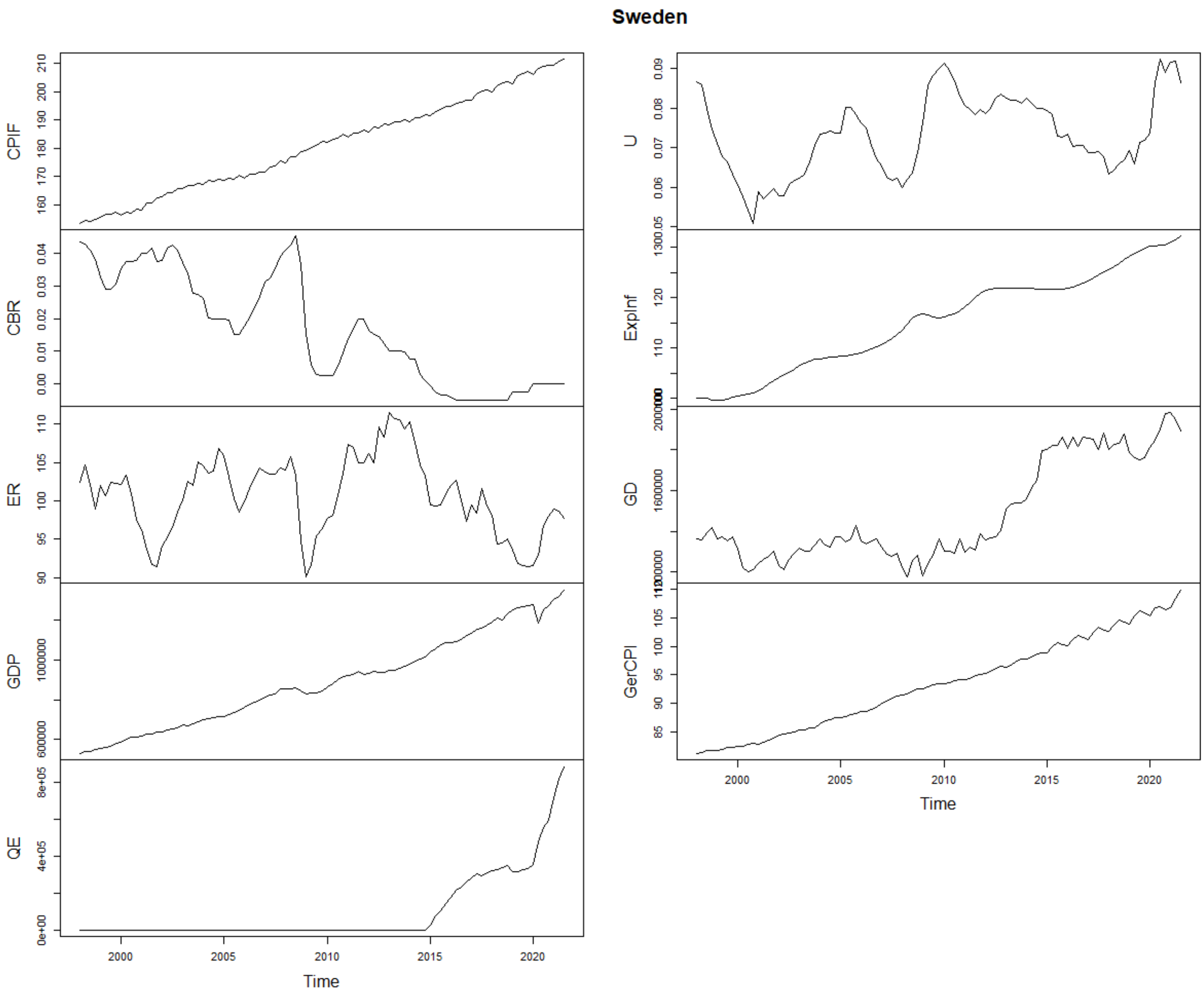
Note: "Log" indicates natural logarithms

The data used is level data and is similar to the study by Haugh and Smith (2012). Therefore, this study has the same concerns as Haugh and Smith: the possibility of both cointegration and unit roots for the variables. Cointegration is when there is correlation between data and it might lead to misleading statistical relationships. Unit root is a trend for time series. A time series with a unit root displays unpredictable systematic patterns. This can cause problems for inference in time series models. Still, cointegration and the existence of unknow unit roots can perform better with direct forecasting when using models with vector error-correction models (Lin & Tsay, 1996). This might be beneficial as local projections regressions are common to the methods of direct forecasting (Jordà, 2005). The result from Lin and Tsay (1996) was however based on Monte Carlo results. The performance with real data sets was mixed.

Therefore, the use of level data might affect the results, and cautious need to be displayed when inferring any conclusions.

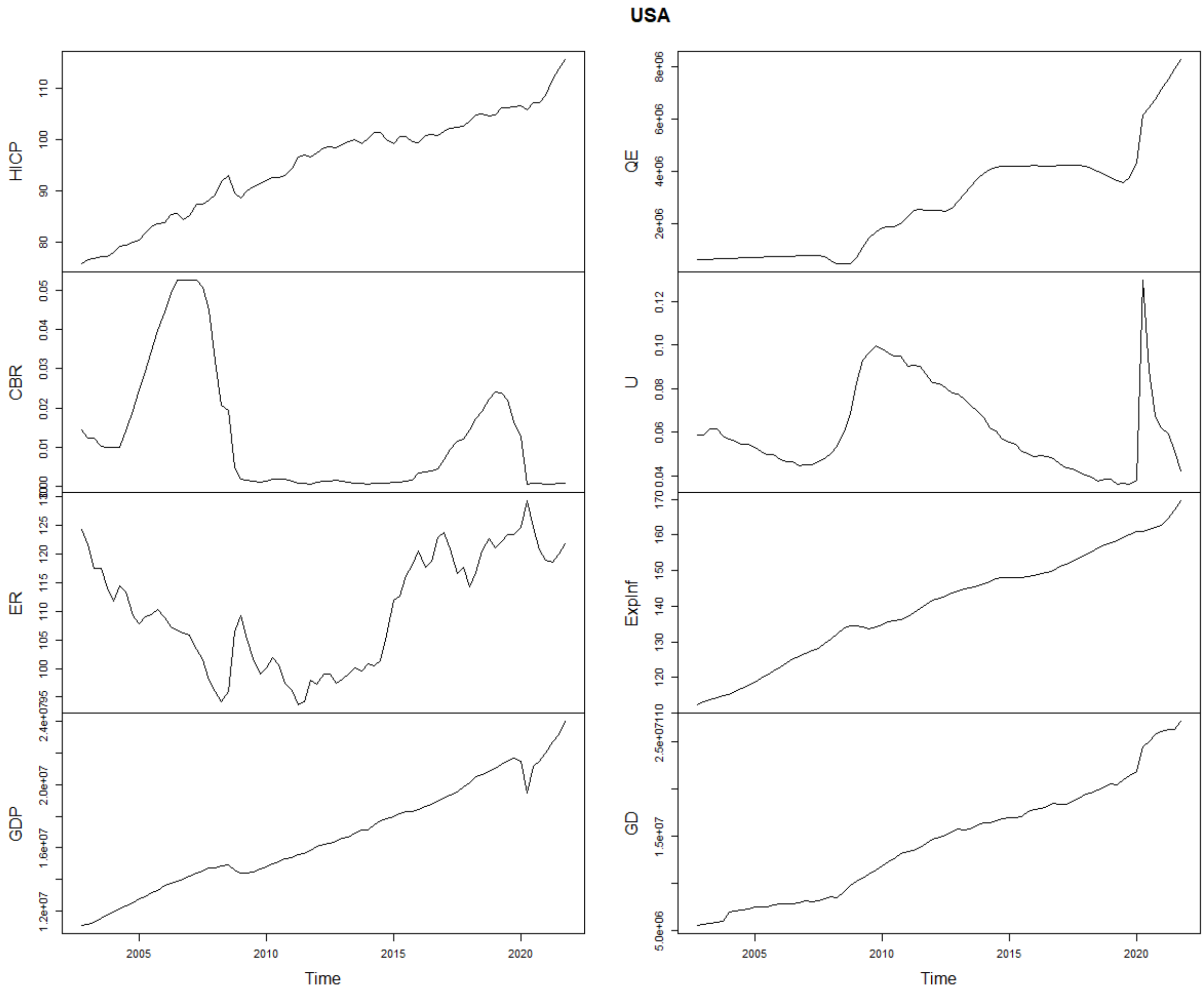
Time series plots for the variables in the models are presented in the following figures.

Figure 1. Time series plot for Sweden



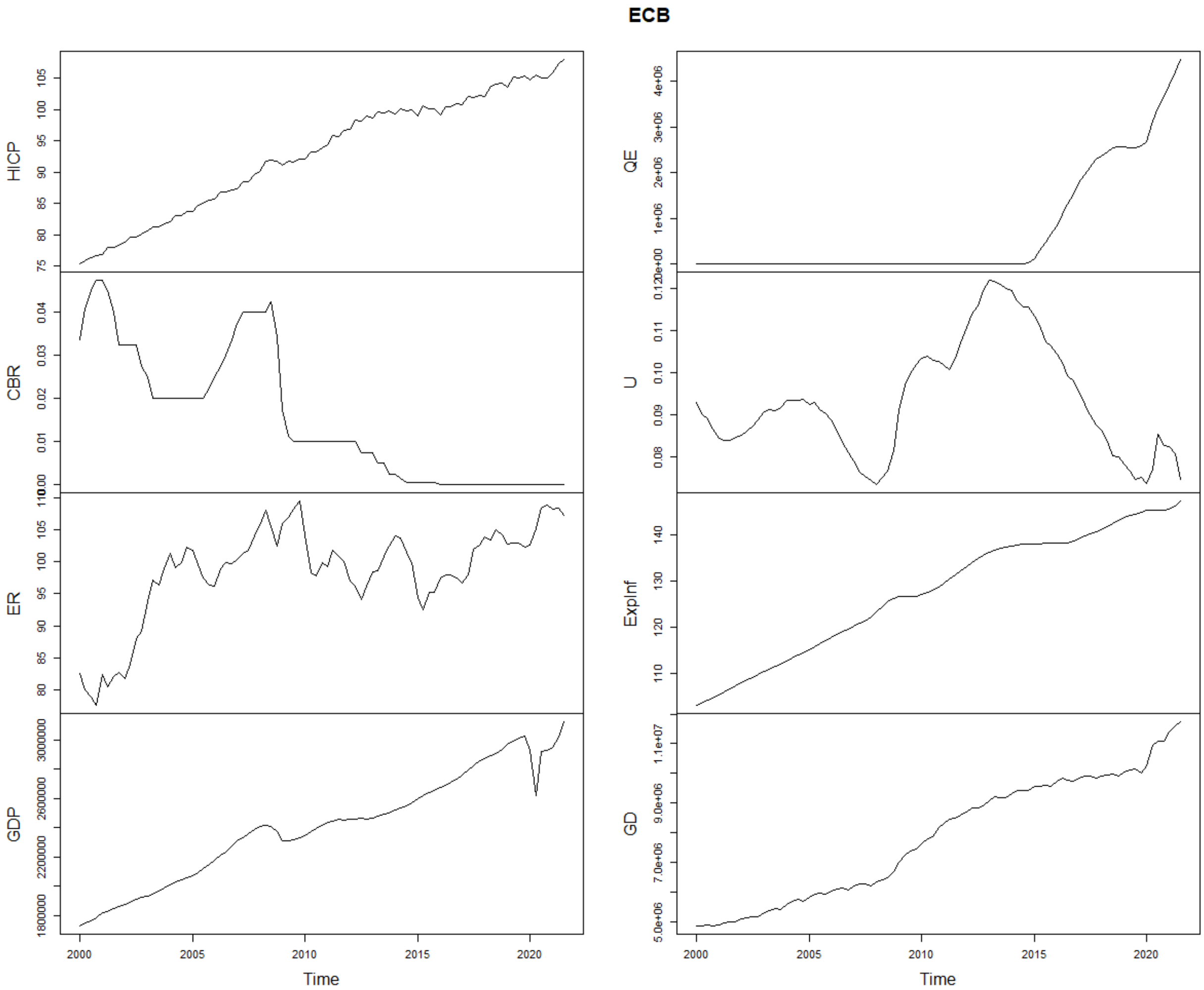
Time trends can be observed in many variables. CPIF, GerCPI, GDP, GD and ExpInf shows trends upwards. The CBR shows a downward trend. Additionally, GerCPI might display some patterns of seasonality in the later period. It might also be a seasonally pattern for GD and CPIF. During the global financial crisis and the COVID-19 pandemic GDP as anticipated decreases. Naturally, the QE variable is zero until the implementation of the QE policies. The QE variable is the nominal cumulative amount in this figure, and this also shows an upward trend. There is a large increase of QE during the COVID-19 pandemic, starting in the beginning of 2020. This increase is larger than the cumulative purchases just until this period.

Figure 2. Time series plot for the United States



Time trends can be observed in several variables. HICP, GDP, QE, ExpInf and GD all have a trend upwards. CBR have two large bumps, the first one between 2005 to 2009, and the second one during 2017 to 2019. GDP decreases during the global financial crisis and during the COVID-19 pandemic. Because proxies are used as measurement for QE, the variable QE is never zero as it should be before the implementation of QE policies. The Federal Reserve started their purchase programmes during late 2008, but before this period an upward trend can be observed. As for Sweden, the period for the COVID-19 pandemic shows a large increase in QE. The period preceding the COVID-19 pandemic shows that QE is decreasing slightly.

Figure 3. Time series plot for the euro area



In figure 3 upwards trends are present for HICP, GDP, QE, ExpInf and GD. CBR indicates a negative trend. GD might also show a seasonally pattern. QE is as for Sweden zero before the implementation of QE policies. In contrast to both Sweden and the United States, the cumulative QE purchases are larger for the period before the start of the COVID-19 pandemic than the period after. During a short period before the start of the pandemic, QE purchases had halted and had started to decrease very slightly. But the pandemic started the QE purchases a second time.

5 Empirical model

To examine if domestic QE affects domestic inflation, an econometric impulse response model has been used. This was done using a local projections IRF, first presented by Jordà (2005). The estimations of the impulse responses are calculated by univariate equations that are replicated for each period. Impulse responses have historically commonly been calculated with VARs. A downside of using an estimation based on a sample, as VARs, is that this method is optimal for forecasting only one period ahead (Haug & Smith, 2012). Jordà (2005) argued against using VARs, and rather use local projections to generate an IRF. Jordà (2005) presents several advantages of using local projections: simple least squares can be used to estimate the projections, increased robustness to misspecification, inference is straightforward for joint or point-wise, and can be used for nonlinear and flexible specifications. Additionally, as an impulse response is a function of forecasting for a growing length of horizons, VARs may lead to misspecification errors that are increasing with each horizon (Jordà, 2005). Instead, with the local projections method, the main idea is to estimate projections that are local at every period of interest. Therefore, with the use of local projections that are local to each horizon, the IRF will better match the real impulse response. Local projections also have fewer restrictions and the estimates are less accurate than VARs, but they are more robust for misspecification (Ramey, 2016). A potential weakness of local projections are that local projection point estimates can be biased, especially for small samples (Herbst & Johannsen, 2021). Additionally, small samples may also lead to sampling uncertainty for the standard errors that can change the inferences (Herbst & Johannsen, 2021). The use of local projections to analyse monetary policy has become more common and have been used by Carcel, Gil-Alana and Wanke (2018), Aastveit, Natvik and Sola (2017), Ramey and Zubairy (2014), and Haugh and Smith (2012).

The models contains seven variables for the euro area and the United States, and eight variables for Sweden. The variables that represent monetary policies are the short-term policy interest rate and QE. The rest of the variables are control variables and are the inflation, the effective exchange rate, the unemployment rate, the expected inflation, and the government debt. Additionally, for the model of Sweden a further control variable has been used: Germany’s CPI. Further, an exogenous shock is used in the models. A true exogenous shock originates from outside the economic model and is unexpected. By classifying the global financial crisis and the COVID-19 pandemic as exogenous shocks in the model, the effects of the central banks’ monetary policies can be estimated more clearly. Through the removal of the cyclical variations that are unrelated to QE policies.

To start with, the first step is to regress every forecast horizon with ordinary least squares, as introduced by Jordà (2005):

$$\boldsymbol{y}_{t+h} = \boldsymbol{\alpha^h} + \boldsymbol{B_1^h y_{t-1}} + \cdots + \boldsymbol{B}_p^h \boldsymbol{y_{t-p}} + \boldsymbol{u_{t+h}^h} \quad h = 0, 1, 2, \dots, H-1 \qquad (1)$$

where $\boldsymbol{y}_{t+h}$ is the variable of interest, $\boldsymbol{\alpha^h}$ is the vector of constants, $\boldsymbol{B_i^h}$ are matrices of coefficients for the lag p and forecast horizon h. The residuals $\boldsymbol{u}_{t+h}^h$ are heteroscedasticity and/or autocorrelated. This is how the impulse response of $\boldsymbol{y_i}$ at the horizon h can be estimated with only one equation. The group of equation (1) are called local projections.

The estimates of the impulse responses are from the following:

$$\widehat{IR}(t, h, \boldsymbol{d}_i) = \boldsymbol{\widehat{B}_i^s d}_i \quad h = 0, 1, 2, \dots, H-1 \qquad (2)$$

where $\boldsymbol{\widehat{B}_i^s}$ is the impulse response coefficients. $\boldsymbol{d}_i$ is the shock matrix and models the structural shocks to element i in y_t.

A clear advantage with local projections is the flexibility to include identified exogenous shocks. This is what has been used in this study in order to incorporate the exogenous shocks of the global financial crisis, 2007 Q3 to 2010 Q2, and the COVID-19 pandemic, 2020 Q1 to the end of the data. The model is identical to the one by Ramey and Zubairy (2014), with the exception of not using quartic trend. The results of this study are estimated with the following equation:

$$\boldsymbol{y}_{t+h} = \boldsymbol{\alpha}^h + \boldsymbol{B_h}\, shock_t + \boldsymbol{\phi x}_t + trend + \boldsymbol{u}_{t+h}^h \quad h = 0, 1, 2, \dots, H-1 \qquad (3)$$

where $\boldsymbol{y}_{t+h}$ is the variable of interest, $\boldsymbol{\alpha^h}$ is the vector of constants, $\boldsymbol{B_h}$ are matrices of coefficients that corresponds to the response in $\mathbf{y}$ at time $t+h$ to the shock at time t. h is the number of forecast periods and will be limited to twelve. The vector $\boldsymbol{x_t}$ is the control variables, $\boldsymbol{\phi}$ is a polynomial in the lag operator, and the $shock$ is the identified shock variable. There exist two periods with identified exogenous shocks that was used in the models: the global financial crisis and the COVID-19 pandemic. The shocks was represented by a single dummy-variable. Trend is included in the models, as several variables exhibits trends. From a sequence of all estimated $\boldsymbol{B_h}$, the impulse response are constructed.

As Jordà (2005) showed, impulse response estimates from local projections are consistent. Therefore heteroskedastic and autocorrelation robust standard errors, as Newley-West standard errors, can be used with insignificant efficacy loss. Thus, Newley-West standard errors are used for all impulse responses. The local projections were used on mostly natural logarithmic data, with the exception of the unemployment rate and the short-term policy rate for the central banks, both which was expressed as percentage points.

Consideration for the lag length is important for the IRFs. The information criteria can be used to choose the maximum lag *p*, as done by Jordà (2005). Ivanov and Kilian (2005) posit that for quarterly data with sample sizes smaller than 120, the Bayesian information criterion (BIC) is the most accurate. As the data for this model contains between 77 to 95 observations, BIC is the information criteria used for choosing the lag length in the models. The lag length in the models is two for Sweden, four for the euro area, and eight for the United States.

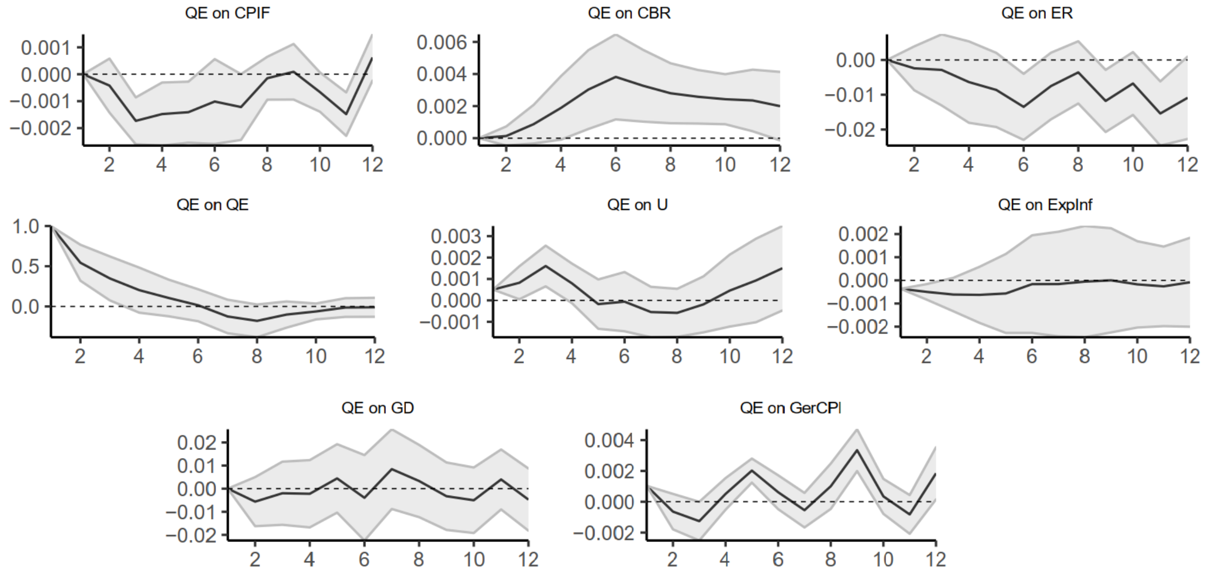
6 Results

6.1 Impulse response functions

The following section will present the local projections impulse response functions (IRFs) for a positive QE shock on the variables in the three different models. The estimation are computed and visualized by the R package **lpirfs** by Adämmer (2019). The shock type is a unit shock, and the width of the confidence bands are 95%. All IRFs are calculated with a trend, and the lag for the exogenous shock was determined by Akaike information criterion (AIC) and is one. The full IRFs for all variables shocks can be found in the Appendices.

6.1.1 Sweden

Figure 1. The IRFs for the Swedish model, with the lag length of two, for a positive QE shock on the eight variables. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



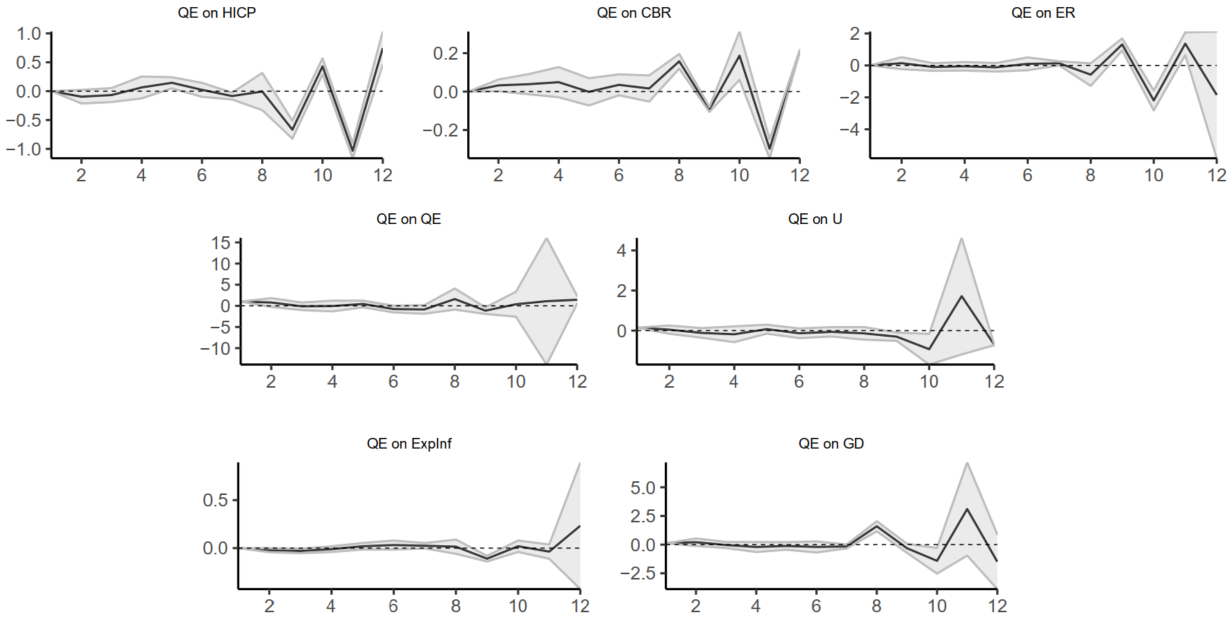
The shock produces both a negative and a positive effect on CPIF during the duration of the impulse. The result implies that a positive QE shock does not have a persistent positive effect on CPIF. On the contrary, the result implies that QE causes deflation for most of the period. Still, the result is not statistically significant for most of the period. Therefore, the result is that QE policies in Sweden by the Riksbank is not in support of a decisive positive impact on consumer inflation. The central bank rate is related to QE shocks. QE shocks shows a positive and persistent effect on the central bank rate, after a delay of two quarters. The QE shock on QE shows an interestingly ‘puzzle’. Initially, a positive and statistically significant effect is observed. After six quarters the effect is about zero, then a negative effect. But after quarter eleven the effect is reversed. The result is not statistically significant after quarter three.

Positive QE shocks on the exchange rate shows a persistent negative effect. Still, most of the impulse is not statistically significant. There seems to be some pattern between quarter six and quarter twelve that could be a seasonally effect. For the unemployment rate, at first the QE shock causes a positive effect on the unemployment rate that is statistically significant. Between quarter five and nine the effect is slightly negative. After quarter nine the effect is once again positive. For the expected inflation and government debt, no clear effect can be observed. The effect on Germany’s CPI shows a seasonally effect. Although, this is not of interest of this study. As a result of Sweden being a small open economy, the effect of domestic QE in Sweden on Germany's CPI is neglectable. It is instead Germany, or rather the euro area, that affects Sweden's economy (Andersson & Jonung, 2020).

6.1.2 The United States

The results are not robust enough to infer any conclusions from.[2] The model does not fit the data well, as clearly seen in the figures below.

Figure 4. The IRFs for the United States model, with the lag of eight, for a positive QE shock on the seven variables. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages

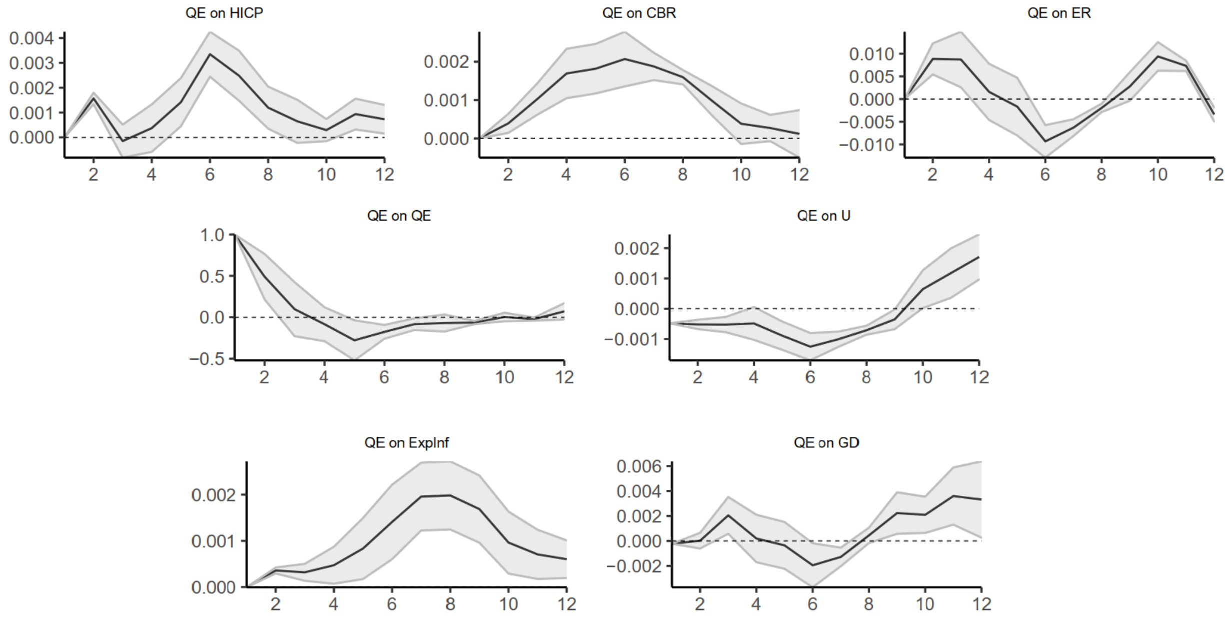


The result that derives from this model is not robust enough to infer results and conclusions that are adequate. The impulses falls apart, by swinging wildly up and down, at the latter part of the horizons. This is highly unlikely, therefore the results from these IRFs is not deemed to be robust enough to infer any result and conclusions from. Still, the result suggest that QE has an indecisive effect on consumer inflation. QE seems to have an indecisive effect on all macroeconomic variables. Most of the result is also not statistically significant.

[2] The author has tried to improve the model unsuccessfully. Several different measurements and data for the independent variables have been used as well as several different combinations of the control variables. Further discussion of the robustness of the model is conducted under the robustness section.

6.1.3 The euro area

Figure 3. The IRF for the euro area model, with the lag length of four, for a positive QE shock on the seven variables. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentage



Firstly, the effect of QE on HICP is almost persistently positive, except for a small dip to below zero at quarter three. This positive effect is mostly statistically significant. Two tops are observed, the first one at quarter two, and the second at quarter six which is also the maximum effect. After quarter six the effect lessens but stays positive. This effect is in line with previous research, which indicates a maximum increase of CPI inflation with 0.6% as a result of QE policies by the ECB (Hohberger, et al., 2019). The effect on the central bank rate is persistent and positive for the full impulse. The maximum effect is at quarter seven for the central bank rate, and at the end of the impulse the effect is minimal. The QE shock on QE shows similar pattern as for Sweden. Initially, a positive and statistically significant effect is observed. The effect is negative for quarter four to until quarter ten, where the effect becomes positive.

For the exchange rate the effect is shaped like the letter M. Firstly a positive effect until quarter five, where the effect stays negative until quarter eight. Here the effect is positive until quarter twelve where the effect is reversed. The effect on expected inflation is persistent and positive for the full impulse and statistically significant. The maximum value is at quarter eight for the expected inflation. The impulse is similar in shape as for the central bank rate.

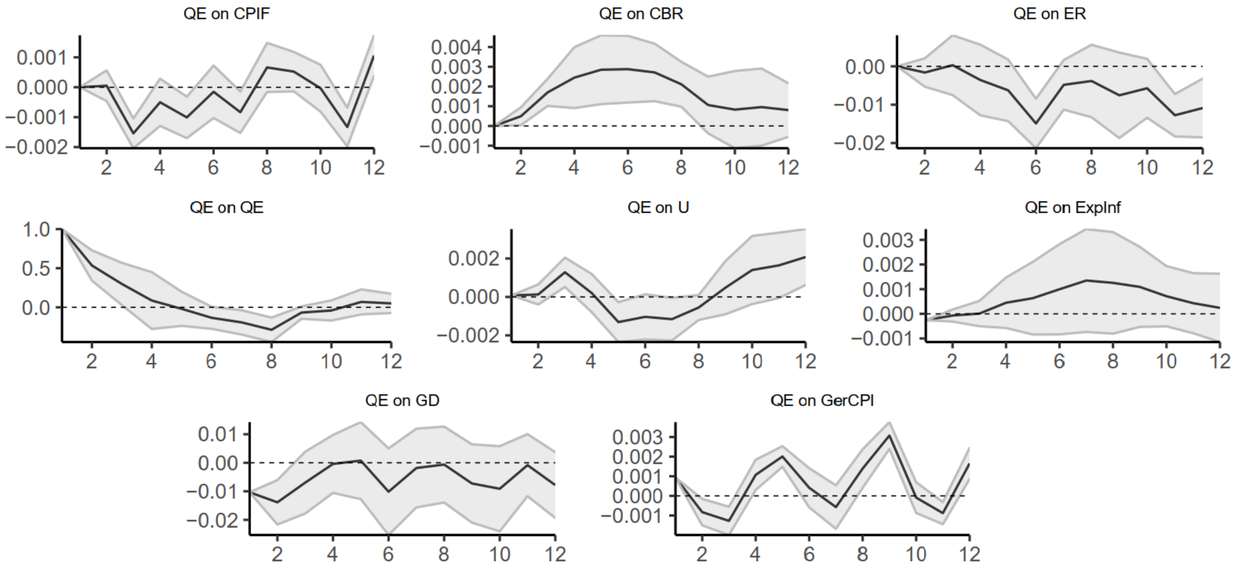
For the effect on the unemployment level, it is negative for the first nine quarters. But then the effect is reversed for the last three quarters. Both the positive and negative effects are statistically significant. The effect for the government debt is positive after a delay of two quarters. The effect is positive until quarter five where the effects becomes negative. At quarter eight the effect is reversed and becomes positive. The maximum positive value is at quarter eleven, and the maximum negative value is at quarter six.

6.2 Sensitivity analysis

Additional IRFs have been calculated to test the sensitivity of the results. As stated by Brugnolini (2018), there is a risk that the information criteria will choose the incorrect lag length, more so when using low sample sizes. Therefore, IRFs with different lag lengths are presented below.

6.2.1 Sweden

Figure 4. The IRFs for the Swedish model, with the lag length of four, for a positive QE shock on the eight variables. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



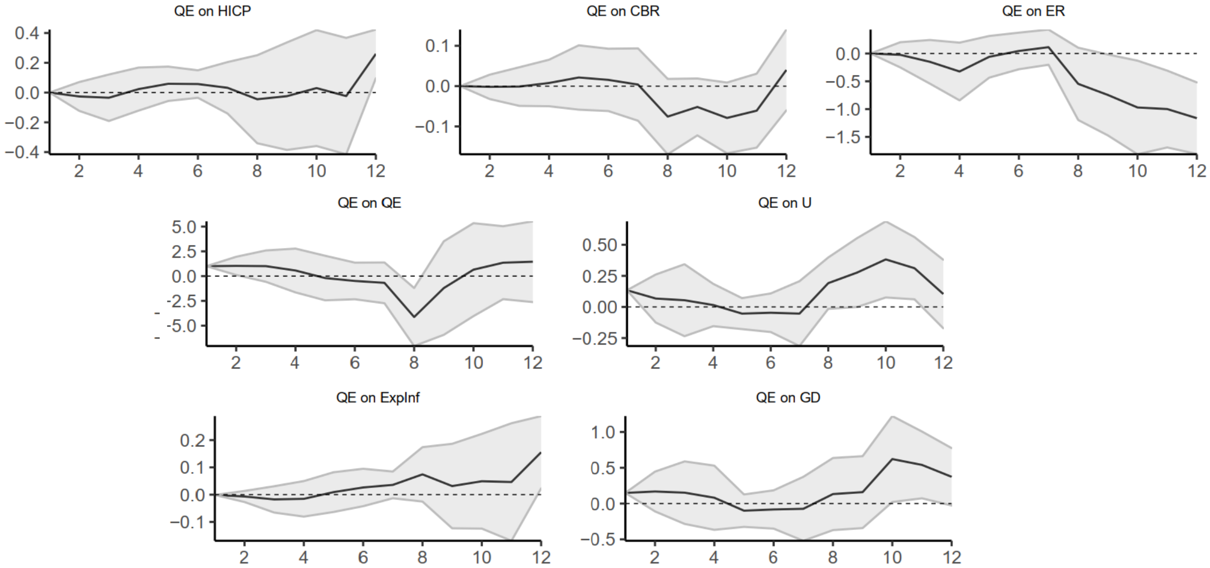
The results is from IRFs with lag length of four, and the result is similar as the IRFs with lag length of two. Here, the effect of QE on CPIF is delayed by two quarters, and the effect between quarter eight to ten are positive. Most of the period is negative, as previously. The change of lag length does not change the result of the impact of QE on CPIF. Altogether, the conclusion is the same as for the IRF with lag length of two: QE by the Riksbank does not elicit a decisive positive and persistent effect on consumer inflation. For the short-term policy rate, a positive QE shock increases the Riksbank’s policy rate, and the effect is positive and persistent. After a delay of two quarters, the effect is statically significant till quarter eight. The maximum effect is at quarter six. The QE shocks on QE is almost identical as with lag length of two. The effect is also here initially positive and statistically significant. After four quarters the effect dips below zero, and after about eleven quarters the effect is reversed.

A positive QE shock indicates a depreciation of the currency, and after three quarters the effect is persistent. The effect is largest at six quarters. The shape of the effect on the unemployment rate is almost identical to the previous IRF. The main difference is an initial delay of two quarters before any measurable effect occurs. For the effect on expected inflation, the change is larger than for the other variables. Now the effect is mostly positive, but the result is not statically significant. The maximum effect is at quarter seven. Previously the effect of QE on government debt was likewise positive and negative, but now the effect is mostly negative. Still, the result is not statistically significant. The effect of QE shocks on Germany’s inflation is also here neglectable by the same reasoning as the IRF with lag length two.

6.2.2 The United States

Even with a different lag length of four, the model still not match the data. More discussion on possible reasons why this is the case follows under the robustness section.

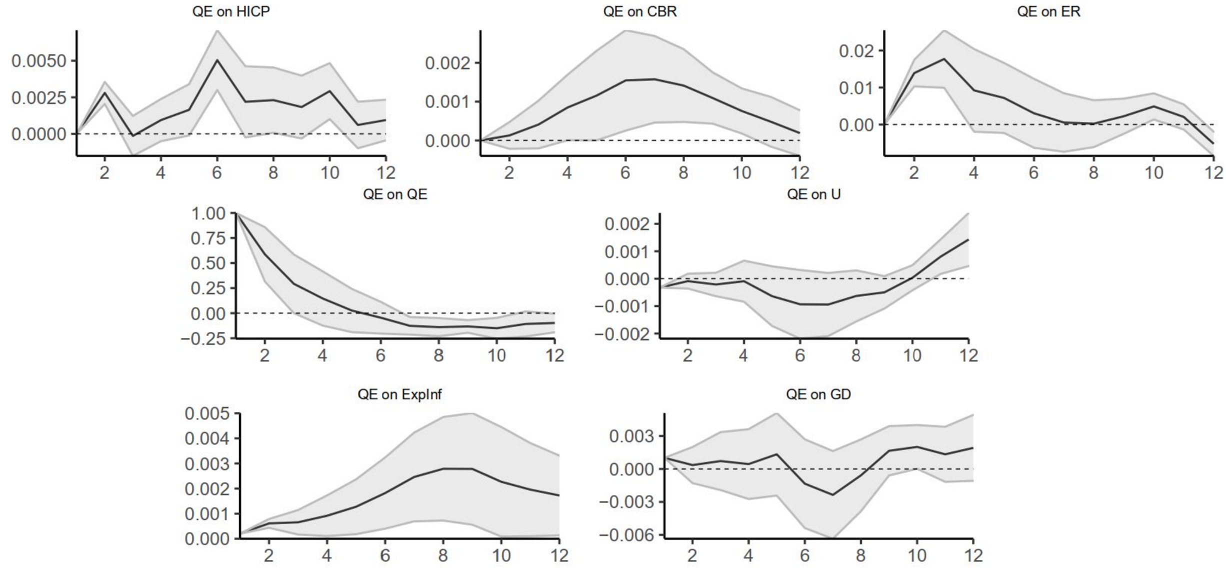
Figure 5. The IRFs for the United States model, with the lag length of four, for a positive QE shock on the seven variables. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



The confidence bands for the IRFs is large and makes any inference from the impulses difficult. The effect of a positive QE shock in HICP does not clearly show a result, and at quarter twelve the impulse increases relatively extremely. The effect on the central bank rate does not have any statistically significant result. The effect on the exchange rate is first negative after a delay of two quarters, then the effect becomes positive for quarter six and seven, and lastly the effect becomes negative. The effect on QE is first positive, then becomes negative between quarter five to nine, lastly at quarter ten the effect becomes positive again. The effect of QE on the unemployment rate is at first positive. At quarter five the effect becomes negative and is lastly reversed to a positive effect at quarter eight. The effect on the expected inflation is first negative until quarter five where the effect is reversed to a positive effect. The effect on government debt is first positive but is reversed at quarter five. The effect stays negative until quarter eight where the effect is once again positive. The results from both IRFs does not hold up to a reasonableness assessment, and therefore it would be unwise to infer any conclusion from the results.

6.2.3 The euro area

Figure 6. The IRFs for the euro area model, with the lag length of two, for a positive QE shock on the seven variables. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



For the IRFs with lag length of two, the result is similar to the IRFs with lag length of four. The overall effect of QE on HICP is the same, even if the shape is somewhat different. QE seems to indicate a higher HICP inflation. For the short-term policy interest rate, the confidence band is higher than before, but the effect still has the same shape. The effect on QE is now initial positive, as before, but then persistent negative. Further, the result implies that QE causes an appreciation of the currency, the euro. This result is not in line with previous research which shows that QE policies by the ECB causes a persistent deprecation of the exchange rate (Dedola, et al., 2021). The confidence bands are higher for the impulse on the unemployment rate and for the expected inflation. Still, the overall shape is still the same for both effects. For the government debt, the effect is mostly positive, with a negative effect for quarter six and seven.

6.3 Robustness

The biggest limitation lies with how short the sample periods available were. The macroeconomic variables used only have a limited sample period available, and there is not possible to extend the time period before 1998. Since the period before inflation targeting will make the relationship between several variables unstable. Further, QE policies are still in their relatively early stages, and therefore limiting the available data even more. The model includes several macroeconomic variables, but there still exist a possibility of omitted variables. Specially for the euro area and the United States. Incorrect lag length can also make the result less clear, but it should not make the result obsolete. But both the lag length that the information criterium indicates and an additional IRFs with a different lag length has been used, and the results have been compared to each other. Herbst and Johannsen (2021) showed that for local projections with small samples, the standard errors that are estimated by Newey-West estimator, as done in this thesis, often understate the uncertainty surrounding the estimated IRFs. This could lead to a misleading conclusion and make the results weaker. As discussed in the data section, this study used level data. This could also affect the results, and therefore cautious needs to be displayed for any drawn conclusions. The models with different lag length did not dramatically change the result for Sweden and the euro area. The effect on inflation is therefore the same even in the models in the sensitivity analysis. For the United States, the change in lag length did not drastically improve the robustness of the model. The data still do not match the model, and no workable result was achieved for the United States.

6.3.1 United States model

For the model for the United States, the data did not fit the model and reason for this is not clear. The result was mostly not statistically significant, and the result was highly unlikely. This can be clearly seen in the figures. Therefore, the result was unusable. The full IRFs for the United States are available in Appendix F and Appendix G. Possible explanations could be any of the points listed in the section above: low sample period, omitted variables, and incorrect lag length. First, low sample size reduces the power of the study and increases the margin of error, and the United States model had the fewest observations for all three models. Further, local projections with very small samples can be very biased (Herbst & Johannsen, 2021). Second, there might be omitted variables, and the variables chosen might not be suitable to model the economy for the United States. Third, incorrect lag length will impact the IRFs, and make the result obtained not as it actually is. Furthermore, for the United States there was lack of data that reported the true sizes of the QE purchases, therefore proxies was used. This should also lead to a result that is farther away from the true values. Still, this problem will persist until better data are available. The author considers the problem of a low sample to be the main culprit, and further modelling with local projections should be used with a larger sample size. It is also possible that other problems with the model that are not listed in this section explains the problem with the results.

6.4 Discussion

The main purpose of this study was to analyse the impact of QE on consumer price inflation. The impact on other macroeconomic variables have also been investigated. Some readers might find it surprising that the result does not report a strong positive effect of QE on consumer inflation in Sweden. A possible explanation for the reason of this result might be the economic climate when QE was implemented. The Riksbank implemented QE during a boom and making them the only central bank to do so. This might be the reason to why the effect is not what the expectation might be: QE should increase consumer inflation. The result from this thesis indicates that QE in Sweden might even cause deflation, even if it is very unlikely to be the case. The result is not conclusive, and the result is not strong enough to use as evidence that the Riksbank expansionary monetary policy causes deflation. Still, the result can be compared to other studies. Andersson and Jonung (2020) also investigated the effect of QE on consumer inflation in Sweden. They argues that the CPIF inflation is mainly a result of the inflation in the euro area, and not the monetary policy by the Swedish Riksbank. Furthermore, the result from Di Casola and Stockhammar (2021) BVAR model found that domestic QE implemented by the Riksbank have an unclear effect on inflation. Instead, Di Casola and Stockhammar asserts that QE implemented by the ECB did have a large positive effect on inflation in Sweden. This is consistent with the result of this study: QE by the Riksbank, domestic QE policies, does not clearly increase consumer inflation in Sweden. For the QE policies implemented by the ECB, the result indicates that consumer inflation increases. It could be two reasons why the result is different for the euro area than for Sweden. As discussed previously, it was a different between the economic environment when QE was implemented by the Riksbank and the ECB. The ECB used QE policies as a crisis tool, while the Riksbank implemented QE during a boom. The other difference is that Sweden is a small open economy, while the euro area is a large open economy. It is reasonable to assume that the effects would not be identical for this reason. Previous research indicate that QE policies by the ECB does increase inflation within the euro area (Hohberger, et al., 2019). Hohberger, Priftis and Voge showed that QE by the ECB during 2015-2018 increased CPI inflation by a maximum of 0.6%. Therefore, this study provides further evidence that QE policies by the ECB increases the consumer inflation in the euro area.

The result derived for the United States does not exhibits the robustness necessary to draw a conclusion of the effectiveness of QE policies. Also, the sensitive analysis did not correct for the lack of robustness. The reason for the lack of workable result is not clear, but several hypothesis has been presented under the robustness section. A limitation that was unique for the model for the United States, was that there was no direct data for the sizes of QE purchases. Proxies was instead used to approximate the QE purchases. The result for the United States highlights the possible weakness when using local projections. As small samples that may lead to sampling uncertainty for the standard errors (Herbst & Johannsen, 2021). Local projections might also suffer from small-sample bias (Brugnolini, 2018). As proposed by Herbst and Johannsen (2021), it might be better to use VARs instead of local projections in typical empirical macroeconomic research, as VARs have effective methods for bias corrections. Therefore, for further research that uses local projections IRFs, the author recommends to also include a VAR model for comparison, as done by Haugh and Smith (2012) and many others.

When it comes to the effect of QE on other macroeconomic variables, the results indicates that the Riksbank's expansionary monetary policy caused deprecation of the exchange rate for the time period examined. The effect is persistently negative, even if much of the result is not statically significant. This effect was also found for the study by Andersson and Jonung (2020). They further also argues that even if the Swedish Riksbank's monetary policy has not impacted the consumer inflation historically, their monetary policy can impact the exchange rate. The same result can be inferred from Di Casola and Stockhammar (2021). The effect might be a because QE increases the monetary supply and injects it into the broader economy. When the Riksbank creates more Swedish krona, the relative amount has increased in relationship to other currencies. This should lead to a lower purchasing power of the currency. Exchange rates can also be affected through the signalling channel. Present QE policies indicates future monetary policy rates. QE in the present might indicate that the policy rates will be kept low for the foreseeable future, or for the whole horizons in models. If the central banks are credible, their QE policies can signal that they will keep their interest rates low and compress the interest rate differentials. Lower interest rate differentials expectations will depreciate the currency in the present. This is what Dedola, Georgiadis, Gräb and Mehl (2021) argues, QE mainly affects the exchange rate through interest rate differentials and through expectations. This study has not examined the effects in the transmission channels, but QE should definitely work through a combination of them. The same result of depreciation is not found for the euro area. Instead, the result of QE policies on the effective exchange rate is unclear. This is in stark contrast to previous empirical research that shows that QE announcements in the euro area by the ECB should have a sizeable and persistent effect on the exchange rate (Dedola, et al., 2021).

Another effect that was observed, was for the euro area there was indications that inflation expectations increased as a consequence of the QE policies. This would be in line with the theory of the expectation channel, which states that if market participates believe that the central bank will be willing to anything, like QE, to reach the inflation target, inflation expectations might be anchored around the inflation target. Another channel that might impact the expected inflation is the signalling channel, which states that direct asset purchases by the central bank will signal consistency of commitment by the central bank to hold the announced policy rate. As expected inflation will impact real inflation, the expectations of QE to be effective in increasing the inflation, the expectations itself might spur inflation. No link between QE shocks and inflation expectation was found for Sweden. This might also be an explanation why QE did not increase consumer inflation in Sweden. Further, this might indicate a weak link between the Riksbank's intentions and the markets expectations of the Riksbank. The market might believe that the ECB can impact inflation in the euro area through QE but might not believe that the Riksbank can impact inflation in Sweden. Further investigation of the expectation channel is required to give a clear conclusion why QE does not increase inflation expectations in Sweden.

The biggest limitation of this study was sample period. It was not possible to extend the sample period earlier, as the introduction of inflation targeting changed the monetary policy framework. Furthermore, some of the data collected was not available to the for the full period from after the implementation of inflation targeting to present time. Still, the finding of the study might be valuable. The research on the impact of QE on the economy is limited for the case of Sweden. It might be possible to infer what the influence of QE would be to economies that are similar to Sweden. The use of QE in a boom makes Sweden a unique case to study. Additionally, the lack of link between QE and inflation expectations for Sweden is intriguingly. While the result for the euro area further proves that the ECB's QE policies can increase consumer inflation.

7 Conclusion

The global financial crisis led to the implementation of QE policies by several central banks in order to spur inflation. The effects of these policies have not been enterally clear, and much discussion still occur. The main aim of this thesis has therefore been of estimate the effect on consumer inflation of QE policies by the Riksbank, the ECB, and the Federal Reserve. The effect of QE policies on other macroeconomic variables have also been investigated. The econometric study was done with a local projections impulse response function (IRF).

The result indicates that QE policies implemented by the Riksbank did not increase CPIF inflation. This is in line with the earlier studies. Possible explanations to why the result does not indicate increased inflation in the case for Sweden has been presented. First, the implementation of QE policies in Sweden occurred during an economic boom. Second, Sweden's economy is not identical to the United States and other large open economies, and therefore previous empirical evidence is not directly translatable for Sweden. Third, the result implied no link between QE and inflation expectations. The expectation channel is one of the ways QE can impact inflation. The effectiveness of the ECB's QE policies are in line with the assumption by the ECB: consumer inflation increased. The result is similar to the result of Hohberger, Priftis and Voge (2019), who shows an increase in CPI inflation of 0.6% as a result of QE policies by the ECB. The result also indicates a link between QE and inflation expectations. This link was not found for Sweden. If that result is valid, it might give an indication that the market's inflation expectation has not been moved by the actions of the Riksbank. Further investigation is required to give any valid conclusion. Another finding of the study is that the result suggest that QE policies will cause deprecation of the exchange rate for Sweden. Depreciation as an effect of QE in Sweden policies is also what previous studies such as Andersson and Jonung (2020) and Di Casola and Stockhammar (2021) shows. Evidence of deprecation was not found for the euro area. The result was contrary to previous empirical research that shows that QE announcements in the euro area has a deprecating effect on the exchange rate (Dedola, et al., 2021).

The model for the United States gave a result that was not robust enough to infer any conclusion. The model does not match the data. This might be because of the relatively low sample period, as the model for the United States had the lowest sample size of the three models. Herbst and Johannsen (2021) proposes that for empirical research with low sample sizes, VARs with already effective methods for bias corrections might be better for estimating impulse responses than using local projections. This thesis might give more evidence that local projections will not give a better result than VARs in all cases. Therefore, the author recommends further research using local projections to include an estimate from VAR for comparison, as done by Haugh and Smith (2012). The robustness of the result was also investigated by changing the lag length of the three models. The change of lag length does not change the core conclusions. Still, in the case of Sweden the expected inflation was changed to a positive effect. But the result was not robust.

Finally, in contrast to most previous studies, the use of a local projections IRFs was used in this study. Therefore, this thesis might serve as a first step to do more thoroughly estimates of QE policies with the use of local projections IRFs. However, as QE policies is a new tool, especially for Sweden, decisive conclusions is difficult to infer due to the lack of data. More data is needed to give a clearer estimate of the effects of QE policies. Even when acknowledging the shortcomings with the methods and data in this study, this thesis can still serve as a point of reference for further research, especially in the case of Sweden and other small open economies.

8 References

Aastveit, K. A., Natvik, G. J. & Sola, S., (2017). Economic uncertainty and the influence of monetary policy. *Journal of International Money and Finance,* Volume 76, pp. 50-67.

Adämmer, P., (2019). lpirfs: An R Package to Estimate Impulse Response Functions by Local Projections. *The R Journal*, 11(2), pp. 421-438.

Andersson, F. N. G. & Jonung, L., (2020). Den svenska Phillipskurvan är internationell – vad betyder detta för Riksbanken?, trans. M Hagenbäck. *Ekonomisk Debatt,* 48(4), pp. 74-81.

Baumeister, C. & Benati, L., (2013). Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound. *International Journal of Central Banking,* 9(2), pp. 165-212.

Benford, J. et al., (2009). Quantitative easing. *Bank of England. Quarterly Bulletin,* Volume 49, pp. 90-100.

BIS, (2022). *BIS effective exchange rate.* [Online]
Available at: https://www.bis.org/statistics/eer.htm
[Accessed 22 Mars 2022].

Board of Governors of the Federal Reserve System (US) via FRED, (2022). *Assets: Securities Held Outright: Mortgage-Backed Securities: Wednesday Level [WSHOMCB].* [Online]
Available at: https://fred.stlouisfed.org/series/WSHOMCB
[Accessed 25 Mars 2022].

Board of Governors of the Federal Reserve System (US) via FRED, (2022). *Assets: Securities Held Outright: U.S. Treasury Securities: All: Wednesday Level [TREAST].* [Online]
Available at: https://fred.stlouisfed.org/series/TREAST
[Accessed 25 Mars 2022].

Board of Governors of the Federal Reserve System (US) via FRED, (2022). *Federal Funds Effective Rate [DFF].* [Online]
Available at: https://fred.stlouisfed.org/series/DFF
[Accessed 30 Mars 2022].

Board of Governors of the Federal Reserve System (US) via FRED, (2022). *General Government (Consolidated); Debt Securities and Loans; Liability, Level*

[BOGZ1FL374104005Q]. [Online]
Available at: https://fred.stlouisfed.org/series/BOGZ1FL374104005Q
[Accessed 30 Mars 2022].

Borio, C. & Zabai, A., (2016). Unconventional monetary policies: a re-appraisal. *BIS Working Papers No 570*, Bank for International Settlements.

Bowman, D., Cai, F., Davies, S. & Kamin, S., (2015). Quantitative easing and bank lending: Evidence from Japan. *Journal of International Money and Finance,* Volume 57, pp. 15-30.

Brugnolini, L., (2018). About Local Projection Impulse Response Function Reliability. *CEIS Research Paper 440,* Tor Vergata University, CEIS.

Canofari, P., Di Bartolomeo, G. & Messori, M., (2019). Sovereign Debt Crisis, Fiscal Consolidation and Quantitative Easing in a Monetary Union. *Working Paper 14*, Luiss School of European Political Economy.

Carcel, H., Gil-Alana, L. A. & Wanke, P., (2018). Application of local projections in the monetary policy in Brazil. *Applied Economics Letters*, 25(13), pp. 941-944.

Chung, H., Laforte, J.-P., Reifschneider, D. & Williams, J. C., (2012). Have We Underestimated the Likelihood and Severity of Zero Lower Bound Events?. *Journal of Money, Credit and Banking,* February, Volume 44, pp. 47-82.

Cúrdia, V. & Woodford, M., (2011). The central-bank balance sheet as an instrument of monetary policy. *Journal of Monetary Economics,* Volume 58, pp. 54-79.

De Rezende, R. B., (2017). The interest rate effects of government bond purchases away from the lower bound. *Journal of International Money and Finance,* Volume 74, pp. 165-186.

Dedola, L., Georgiadis, G., Gräb, J. & Mehl, A., (2021). Does a big bazooka matter? Quantitative easing policies and exchange rates. *Journal of Monetary Economics,* Volume 117, pp. 489-506.

Di Casola, P. & Stockhammar, P., (2021). When domestic and foreign QE overlap: evidence from Sweden. *Sveriges Riksbank Working Paper Series 404*, Sveriges Riksbank.

Draghi, M., (2017). Accompanying the economic recovery. *Introductory speech by Mario Draghi, President of the ECB, at the ECB Forum on Central Banking*. Sintra, 27 June 2017.

ECB Statistical Data Warehouse, (2022). *ECB Main refinancing operations - fixed rate tenders (fixed rate) (date of changes).* [Online]
Available at: https://sdw.ecb.europa.eu/browse.do?node=9691107
[Accessed 12 April 2022].

ECB Statistical Data Warehouse, (2022). *Gross government debt (consolidated).* [Online]
Available at:
https://sdw.ecb.europa.eu/browseTable.do?org.apache.struts.taglib.html.TOKEN=69c7bad17883c304a098d8d0707e92c0&df=true&ec=&dc=&oc=&pb=&rc=&DATASET=0&removeItem=&removedItemList=&mergeFilter=&activeTab=GFS&showHide=&MAX_DOWNLOAD_SERIES=500&SERIES_MAX_NUM=50
[Accessed 12 April 2022].

ECB Statistical Data Warehouse, (2022). *HICP - Overall index.* [Online]
Available at:
https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=122.ICP.M.U2.N.000000.4.INX&periodSortOrder=ASC
[Accessed 12 April 2022].

ECB, (2022). *Asset purchase programmes.* [Online]
Available at: https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html
[Accessed 21 Mars 2022].

ECB, (2022). *Pandemic emergency purchase programme (PEPP).* [Online]
Available at: https://www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html
[Accessed 21 Mars 2022].

Eggertsson, G. B. & Woodford, M., (2003). The Zero Bound on Interest Rates and Optimal Monetary Policy. *Brookings Papers on Economic Activity*, pp. 139-211.

European Central Bank, (2014). *ECB announces operational details of asset-backed securities and covered bond purchase programmes.* [Online]
Available at: https://www.ecb.europa.eu/press/pr/date/2014/html/pr141002_1.en.html
[Accessed 5 April 2022].

Eurostat via FRED, (2022). *Gross Domestic Product (Euro/ECU series) for Euro Area (19 Countries) [EUNNGDP].* [Online]

Available at: https://fred.stlouisfed.org/series/EUNNGDP
[Accessed 30 Mars 2022].

Eurostat via FRED, (2022). *Gross Domestic Product for Sweden [CPMNACSCAB1GQSE].* [Online]
Available at: https://fred.stlouisfed.org/series/CPMNACSCAB1GQSE
[Accessed 30 Mars 2022].

Eurostat via FRED, (2022). *Harmonized Index of Consumer Prices: All Items for United States [CP0000USM086NEST].* [Online]
Available at: https://fred.stlouisfed.org/series/CP0000USM086NEST
[Accessed 12 April 2022].

Fawley, B. W. & Neely, C. J., (2013). Four Stories of Quantitative Easing. *Federal Reserve Bank of St. Louis Review,* 95(1), pp. 51-88.

Forbes, K., (2015). Much ado about something important: How do exchange rate movements affect inflation?. *The Manchester School,* Volume 84, pp. 15-41.

Friedman, M., (1977). Nobel Lecture: Inflation and Unemployment. *Journal of Political Economy,* 85(3), pp. 451-472.

Gertlera, M. & Karadi, P., (2013). QE 1 vs. 2 vs. 3. . . : A Framework for Analyzing Large-Scale Asset Purchases as a Monetary Policy Tool. *International Journal of Central Banking,* January, Volume 9, pp. 5-53.

Haldane, A. G., Roberts-Sklar, M., Wieladek, T. & Young, C., (2016). QE: the story so far. *Working Paper 624*, Bank of England.

Haug, A. A. & Smith, C., (2012). Local linear impulse responses for a small open economy. *Oxford Bulletin of Economics and Statistics*, 74(3), pp. 470-492.

Herbst, E. P. & Johannsen, B. K., (2021). Bias in Local Projections. *Finance and Economics Discussion Series 2020-010r1*, Washington: Board of Governors of the Federal Reserve System.

Hohberger, S., Priftis, R. & Voge, L., (2019). The macroeconomic effects of quantitative easing in the euro area: Evidence from an estimated DSGE model. *Journal of Economic Dynamics and Control*, Volume 108.

Ivanov, V. & Kilian, L., (2005). A Practitioner's Guide to Lag Order Selection For VAR Impulse Response Analysis. *Studies in Nonlinear Dynamics and Econometrics,* 9(1), pp. 1-34.

Jordà, Ò., (2005). Estimation and inference of impulse responses by local projections. *American Economic Review,* 95(1), pp. 161-182.

Joyce, M., Miles, D., Scott, A. & Vayanos, D., (2012). Quantitative Easing and Unconventional Monetary Policy – an Introduction. *The Economic Journal,* 122(564), pp. 271-288.

Kapetanios, G., Mumtaz, H., Stevens, I. & Theodoridis, K., (2012). Assessing the Economy-wide Effects of Quantitative Easing. *The Economic Journal,* 122(564), pp. 316-347.

Klau, M. & Fung, S. S., (2006). The new BIS effective exchange rate indices. *BIS Quarterly Review, March,* pp. 51-65.

Krishnamurthy, A. & Vissing-Jorgensen, A., (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. *Brookings Papers on Economic Activity,* Volume 2, pp. 215-287.

Lin, J.-L. & Tsay, R. S., (1996). Co-Integration Constraint and Forecasting: An Empirical Examination. *Journal of Applied Econometrics,* 11(5), pp. 519-538.

Michl, T. R., (2009). Tinbergen Rules the Taylor Rule. *Eastern Economic Journal*, 34(3), pp. 293-309.

OECD, (2020). *Harmonised unemployment rate (HUR) (indicator).* [Online]
Available at: https://data.oecd.org/unemp/harmonised-unemployment-rate-hur.htm
[Accessed 19 April 2022].

OECD, (2022). *Consumer price indices (CPIs) – Complete database.* [Online]
Available at: https://stats.oecd.org/
[Accessed 21 Mars 2022].

OECD, (2022). *Inflation forecast (indicator).* [Online]
Available at: https://data.oecd.org/price/inflation-forecast.htm
[Accessed 19 April 2022].

Ramey, V. A., (2016). Macroeconomic Shocks and Their Propagation. *Working Paper 21978,* National Bureau of Economic Research

Ramey, V. A. & Zubairy, S., (2014). Government Spending Multipliers in Good Times and in Bad: Evidence from U.S. Historical Data. *NBER Working Paper No. 20719*, National Bureau of Economic Research.

Riksbank, (2015). *Riksbank cuts repo rate to −0.10 per cent, buys government bonds for SEK 10 billion and is prepared to do more at short notice.* [Online]
Available at: http://archive.riksbank.se/en/Web-archive/Published/Press-Releases/2015/Riksbank-cuts-repo-rate-to-010-per-cent-buys-government-bonds-for-SEK-10-billion/index.html
[Accessed 5 April 2022].

SCB, (2021). *Offentlig förvaltnings konsoliderade bruttoskuld enligt EU:s konvergenskriterier. Kvartal 1996K1 - 2021K4.* [Online]
Available at:
https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__NR__NR0108/FirBruttoKonvKv/
[Accessed 22 Mars 2022].

SCB, (2022). *KPIF exklusive energi, index (1987=100).* [Online]
Available at: https://www.scb.se/hitta-statistik/statistik-efter-amne/priser-och-konsumtion/konsumentprisindex/konsumentprisindex-kpi/pong/tabell-och-diagram/konsumentprisindex-med-fast-ranta-kpif-och-kpif-xe/kpif-exklusive-energi-index-1987100/
[Accessed 12 April 2022].

Sveriges Riksbank, (2022). *Purchases of government bonds.* [Online]
Available at: https://www.riksbank.se/en-gb/monetary-policy/monetary-policy-instruments/purchases-of-government-bonds/
[Accessed 21 Mars 2022].

Sveriges Riksbank, (2022). *Reporänta (1994-06-01 -).* [Online]
Available at: https://www.riksbank.se/sv/statistik/sok-rantor--valutakurser/?g2-SECBREPOEFF=on&from=1998-01-01&to=2022-06-01&f=Quarter&c=cAverage&s=Comma
[Accessed 30 Mars 2022].

Sveriges Riksbank, (2022). *The Riksbank's purchases of securities.* [Online]
Available at: https://www.riksbank.se/en-gb/monetary-policy/monetary-policy-instruments/the-riksbanks-extended-purchases-of-securities/
[Accessed 21 Mars 2022].

Taylor, J. B., (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy,* Volume 39, pp. 195-214.

The Federal Reserve, (2008). *Federal Reserve announces it will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises and mortgage-backed securities backed by Fannie Mae, Freddie Mac, and Ginnie Mae.* [Online]
Available at:
https://www.federalreserve.gov/newsevents/pressreleases/monetary20081125b.htm
[Accessed 5 April 2022].

U.S. Bureau of Economic Analysis via FRED, (2022). *Gross Domestic Product [GDP].* [Online]
Available at: https://fred.stlouisfed.org/series/GDP
[Accessed 30 Mars 2022].

Urbschat, F. & Watzka, S., (2020). Quantitative Easing in the Euro Area -An Event Study Approach. *The Quarterly Review of Economics and Finance,* Volume 77, pp. 14-36.

Williamson, S. D., (2017). Quantitative Easing: How Well Does This Tool Work?. *The Regional Economist,* 25(3), pp. 8-14.

9 Appendices

Appendix A

Table 3. Descriptive statistics for Sweden

Statistic	N	Mean	St. Dev.	Min	Max
CPI	95	96.461	6.060	86.430	107.652
CBR	95	0.017	0.017	-0.005	0.045
ER	95	100.675	5.060	90.093	111.443
GDP	95	890,346.700	229,961.400	529,262	1,352,517
QE	95	99,801.050	193,162.700	0	884,500
U	95	0.073	0.010	0.051	0.092
ExpInf	95	115.363	9.738	99.727	132.248
GD	95	1,488,212.000	247,043.500	1,176,126	1,982,014
GerCPI	95	93.446	8.117	81.218	109.903
CPIF	95	180.989	16.774	153.647	211.390

Appendix B

Table 4. Descriptive statistics for the United States

Statistic	N	Mean	St. Dev.	Min	Max
CPI	77	95.334	10.212	79.121	116.724
CBR	77	0.013	0.016	0.001	0.053
ER	77	109.934	9.897	93.593	129.257
GDP	77	16,648,458.000	3,287,004.000	11,061,433	24,002,815
QE	77	2,793,323.000	2,008,271.000	475,921	8,267,764
U	77	0.061	0.020	0.036	0.130
ExpInf	77	140.220	15.300	112.170	169.603
GD	77	14,353,973.000	5,992,855.000	5,502,071	27,111,738
HICP	77	95.084	9.951	75.873	115.637

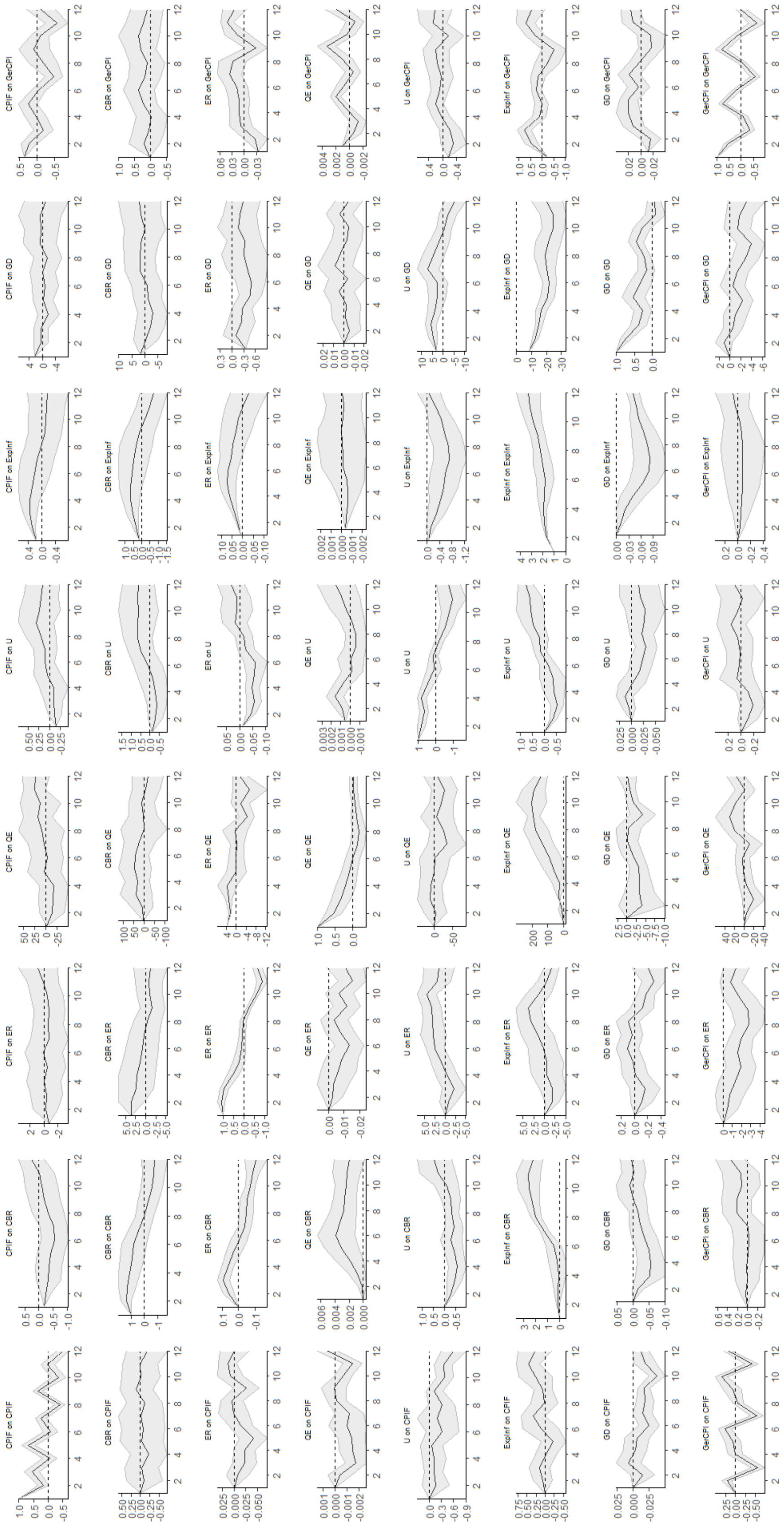
Appendix C

Table 5. Descriptive statistics for the euro area

Statistic	N	Mean	St. Dev.	Min	Max
CPI	87	94.056	7.802	79.540	106.437
CBR	87	0.015	0.015	0.000	0.048
ER	87	98.468	7.527	77.603	109.437
GDP	87	2,407,741.000	368,281.600	1,725,454.000	3,122,369.000
QE	87	690,790.800	1,218,727.000	0	4,480,575
U	87	0.093	0.014	0.073	0.122
ExpInf	87	127.626	13.319	102.912	147.274
GD	87	7,840,317.000	2,069,725.000	4,839,997	11,731,494
HICP	87	92.984	9.451	75.367	108.023

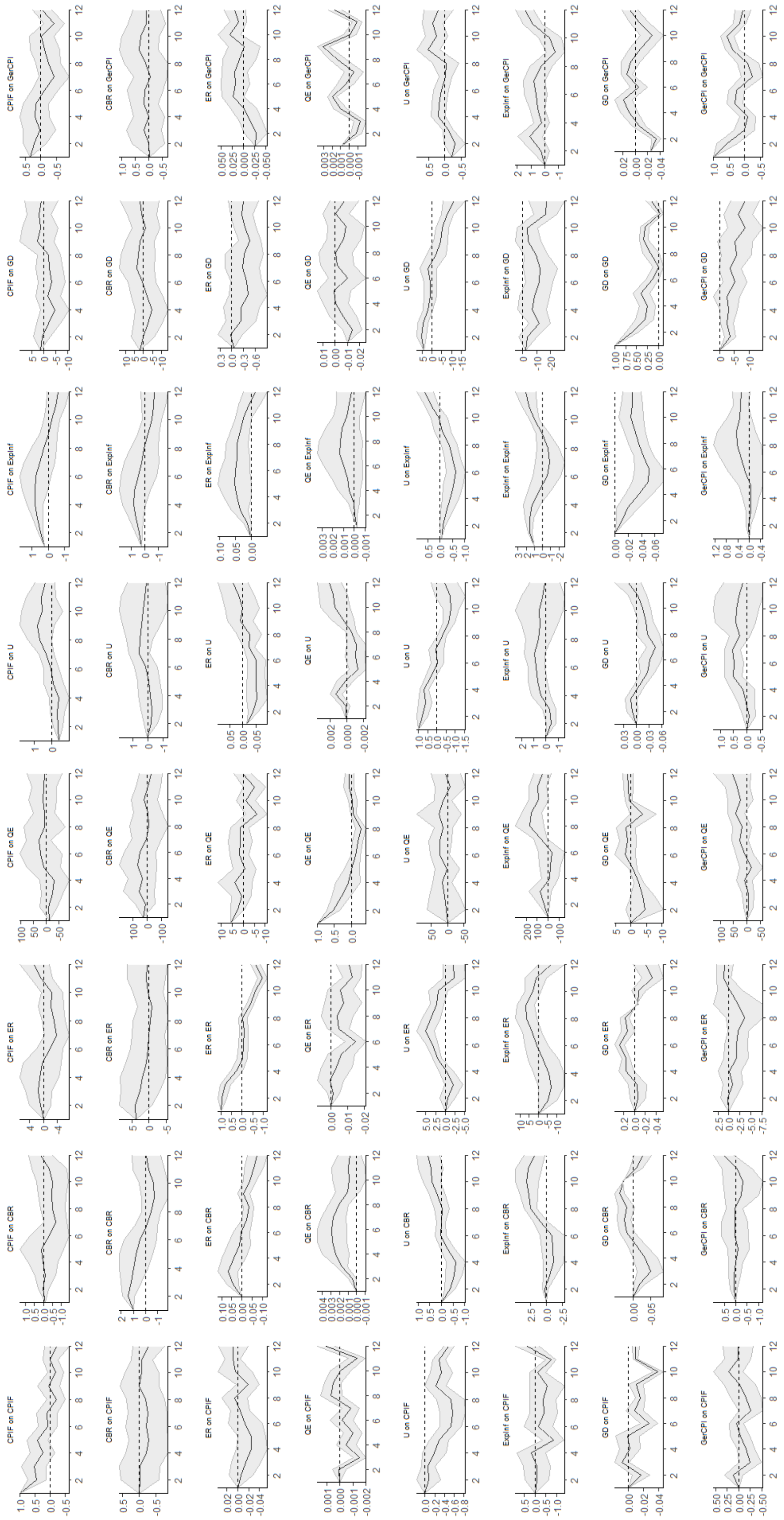
Appendix D

Figure 6. Full IRFs for the Swedish model, with the lag length of two. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



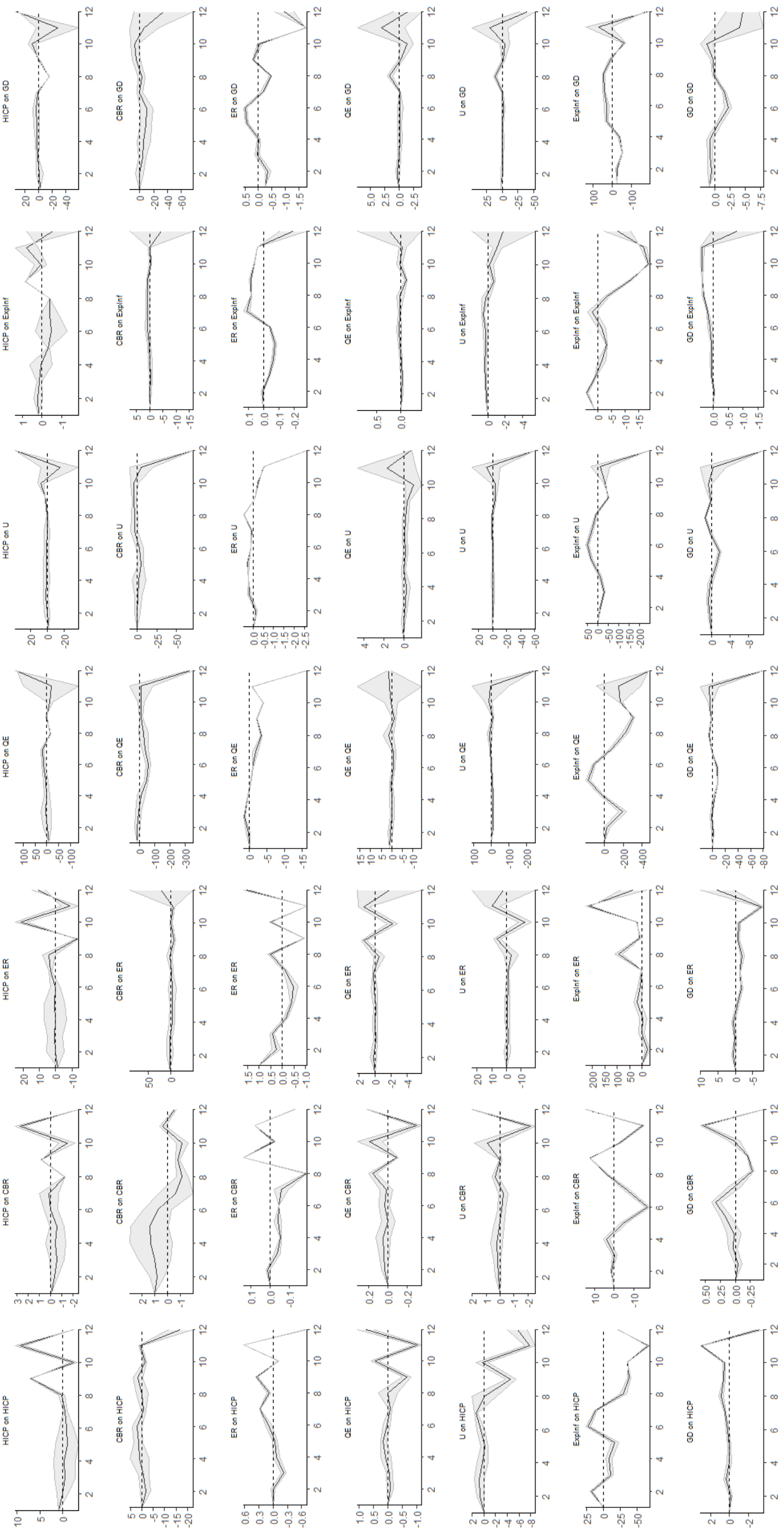
Appendix E

Figure 7. Full IRFs for the Swedish model, with the lag length of four. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



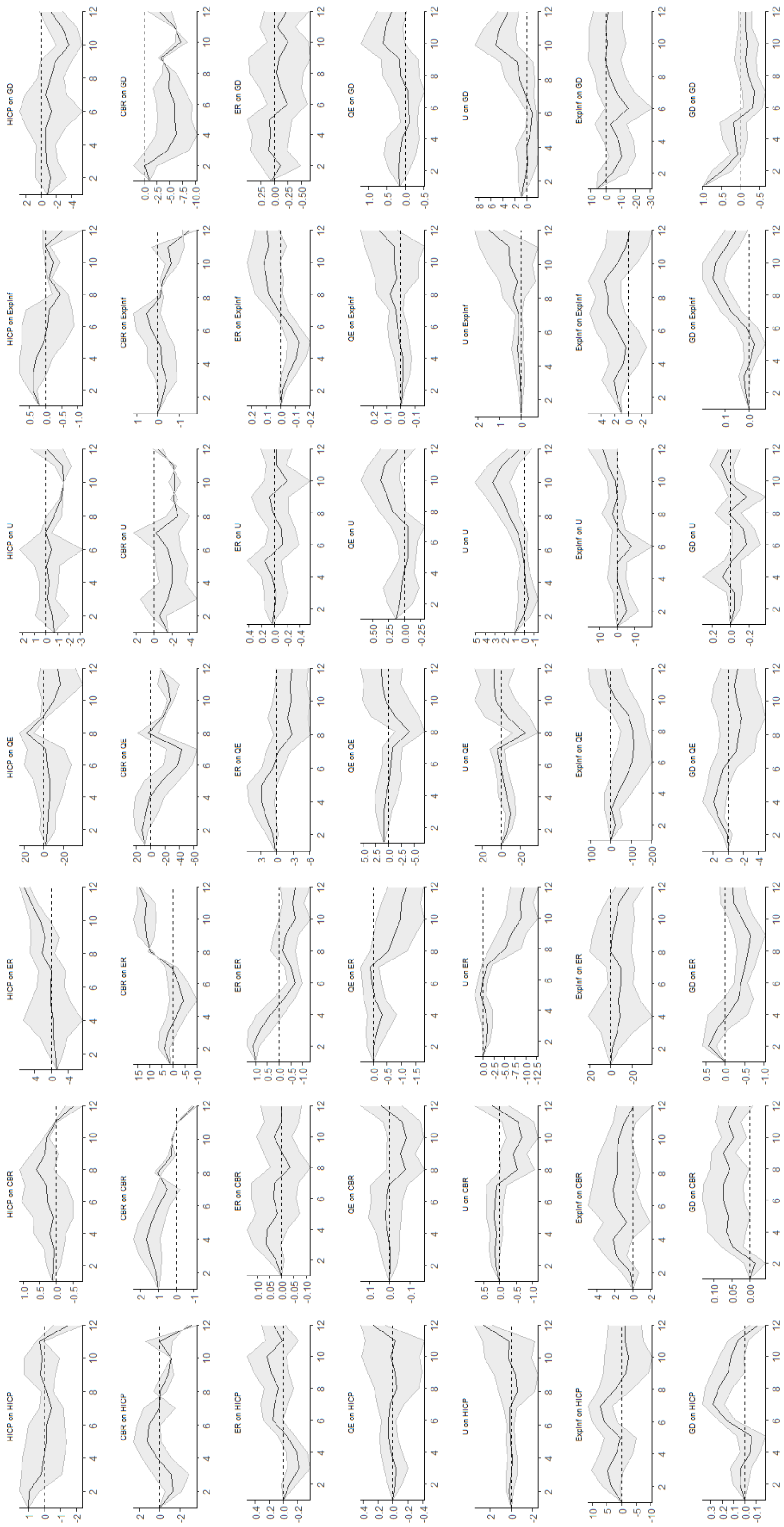
Appendix F

Figure 8. Full IRFs for the United States model, with the lag length of eight. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



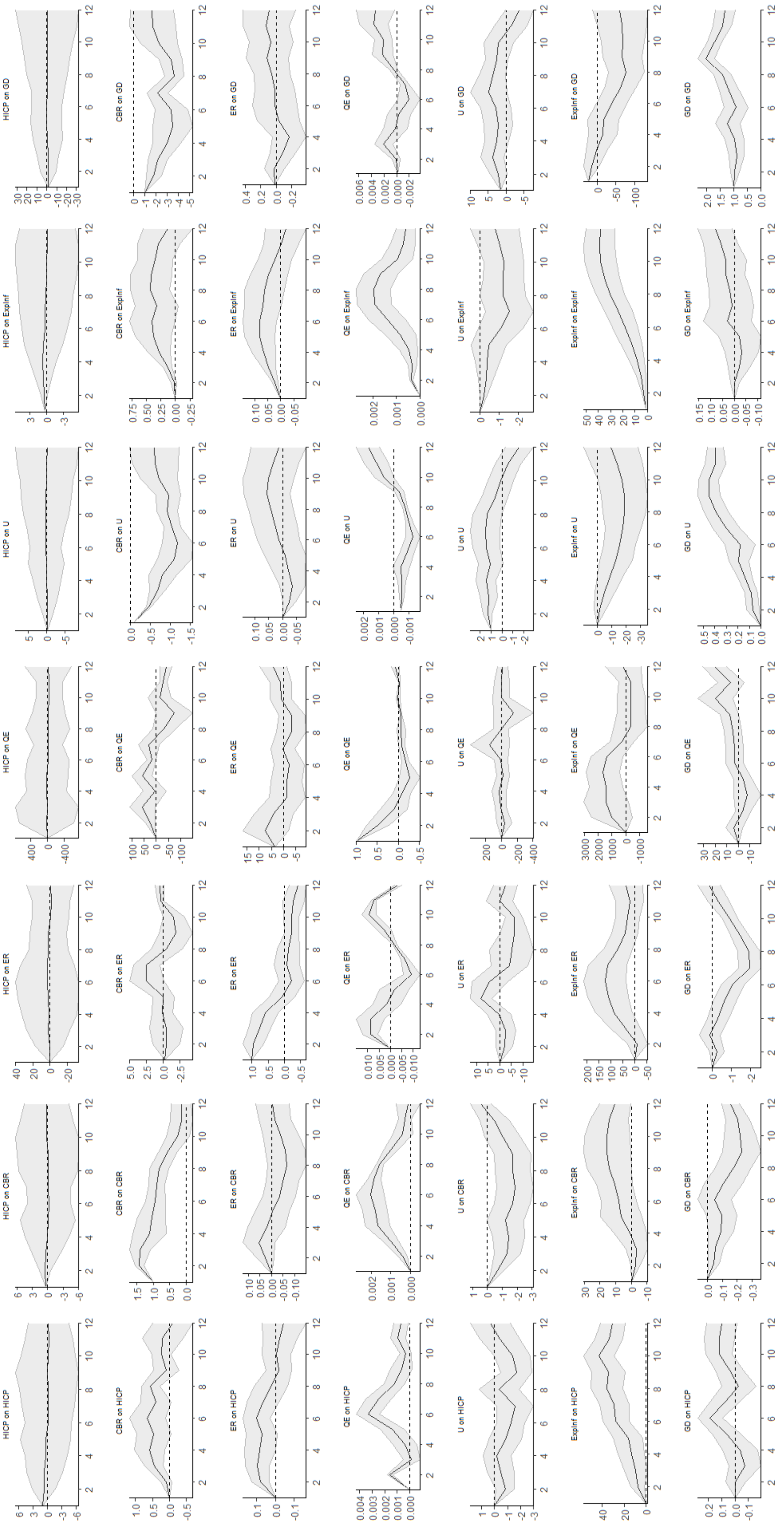
Appendix G

Figure 9. Full IRFs for the United States model, with the lag length of four. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



Appendix H

Figure 10. Full IRFs for the euro area model, with the lag length of four. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages



Appendix I

Figure 11. Full IRFs for the euro area model, with the lag length of two. The shaded area is the 95% confidence band, the x-axel is the horizons in quarters, and the y-axel is hundredths of percentages