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An Empty Suit:

An Analysis of the Swedish Riksbank in an Integrated Economy

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Abstract

The 2010s have raised questions about the influence of small central banks in an integrated economy. This thesis investigates the efficacy of the Swedish Riksbank and the effect of economic integration since the adoption of a floating exchange rate in 1993. Theoretically, I examine how financial integration and trade may impact the Mundell-Fleming trilemma. To investigate the impact of integration, and the efficacy of the Riksbank, two VARs are modelled. The first includes control variables for the Eurozone and US economies, the second does not. The difference between the models is the effect of economic integration as a confounding variable. The first model shows the efficacy of the Riksbank's monetary policy. I find that the Riksbank has only weak efficacy, not able to significantly affect other variables when control variables are introduced. The effect of integration is shown to be large, with most variables being statistically insignificant. Both results concur with the general literature.

Keywords: Monetary Policy, The Riksbank, Vector Auto-Regression, Trilemma, Economic Integration.

Words: 8061

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1 Introduction

To what extent does the Swedish central bank steer the Swedish economy? Does economic integration decrease central bank efficacy (i.e., ability to produce the intended result)? In this thesis, I investigate these two questions through an empirical study of the Swedish Riksbank.

The study of monetary policy, although time-honoured, has increased in relevance as an upshot of the 2010s. The inability of central banks to raise inflation during these years has raised questions concerning their strength (Sauga & Seith, 2014). I investigate the question of central bank efficacy in the Swedish case. The research question is stated as follows:

How efficacious is the Riksbank under economic integration?

I then also consider the sub-question:

To what extent does economic integration impact Riksbank efficacy?

Note that the first question concerns the Riksbank's efficacy, and the second concerns to what extent integration impacts this efficacy.

To answer the research questions, I estimate and compare two vector auto-regression (VAR) models of Swedish monetary policy. I look at the effect of Riksbank monetary policy shocks (interest rate and quantitative easing (QE)) on the key variables inflation, unemployment, housing prices, and the exchange rate, and examine what changes when European and U.S. control variables are introduced. The observed difference is the impact of integration. This two-pronged, parsimonious methodology – both analysing the "regular" VAR regression and the change that occurs when control variables are introduced – allows me to answer both research questions. I use a SVAR with a Cholesky decomposition, causally ordering my variables, building on a large VAR literature.

The Mundell-Fleming trilemma has traditionally been the theoretical underpinning of the effects of integration on monetary policy. It states that a floating exchange rate insulates monetary policy and allows both an open capital account and an independent, efficacious central bank (Klein & Shambaugh, 2015). The trilemma may be questioned through looking at the effects of financial integration and trade. The financial critique is most prominently expressed by Rey (2013; 2016), who instead argued that international financial transmission mechanisms diminish monetary policy efficacy in small open economies. The trade critique argues that the real economy of Sweden has become synchronised with other economies and thus depends to a larger extent on international developments. Therefore, the efficacy of the Riksbank decreases.

The efficacy of monetary policy has both intra- and extra-disciplinary relevance. Monetary policy is, after all, one of the main ways that the economy is steered. Yet, there is substantial academic disagreement about its efficacy (Rasche & Williams, 2007). Within the discipline, many studies on monetary policy, especially within the trilemma/dilemma debate, have been conducted with panel studies. These studies lack the ability to closely examine country-specific economic circumstances that might affect efficacy. Many more VARs thus need to be run (Rey, 2016). I attempt to fill this gap in the literature. In 2023, there has been a resurgent debate in Sweden as to whether the country should abandon the Swedish krona in favour of the Euro (Wahlin, 2023), in effect abandoning monetary policy independence. An important aspect of this debate, which my research addresses, is the efficacy of the Riksbank. If domestic monetary policy does not noticeably affect the real economy, there is not much point in having an independent central bank. The results therefore have relevance to the Euro debate.

This thesis constrains itself to testing for the strength of the links between the Swedish economy and the two main tools of monetary policy in recent years: interest rates and QE. A central bank can influence the economy in other ways, such as with macro-prudential policies. The impact of these policies lies outside the demarcations of the thesis. Furthermore, I only consider the period from 1993Q1, the first full quarter with a floating currency. The move to a floating exchange rate drastically changed the role of the central bank. The sample period also roughly coincides with Sweden joining the EU and adopting the inflation targeting regime.

I find that *when European and U.S. control variables in the form of unemployment, interest rate, and QE are introduced, the efficacy of the Riksbank decreases.* The effects of an interest rate or QE shock on key variables either turn from statistically significant to insignificant or, if they were already insignificant, make the confidence bands close in on zero. As such, the control variables are shown to work as confounding variables, impacting the relationship between monetary policy and the economy. The results concur with the literature (Keskin, 2023).

Analysing the model with control variables shows a Riksbank with low efficacy, hardly able to statistically affect the economy – an empty suit. These results concur with the general literature on monetary policy, which has struggled to find strong effects of monetary policy in VARs (Rasche & Williams, 2007).

However, the model is unstable. I conduct a large number of robustness checks. The checks show that results need to be interpreted with some scepticism, as outcomes vary greatly depending on how the variables are measured. The weakness of the model is an interesting result in itself.

In the final discussion chapter, I focus on the issue of the instability of the model. Building on the results from my robustness checks, I discuss potential underlying issues.

The thesis is structured as follows: Chapter 2 examines the background of Swedish monetary policy and integration. Chapter 3 constructs the theoretical framework. Chapter 4 deals with the VAR methodology. Chapter 5 shows the results of the estimated VARs and the robustness checks. Chapter 6 gauges some causes of instability and concludes.

2 Background

Two principal developments within the Swedish economy are noteworthy: the modern role of the Riksbank and the increasing integration of the Swedish economy with the US and Eurozone.

The Riksbank operates under the price stability norm regime. It aims at a 2% inflation target. Without endangering the inflation target, the Riksbank is also tasked with output and employment stabilisation. Much like other central banks, the Riksbank engaged in QE during the 2010's.

During this time period, central banks have had their efficacy questioned (Sauga & Seith, 2014). This perceived weakening of the Riksbank has coincided with a massive increase in economic integration, accelerating since Sweden joined the EU and WTO in 1995. The integration of Sweden into the global economy may be described through three principal developments: trade integration, financial integration, and labour market integration.

Trade integration globally has increased steadily since WWII (Borbo & Helbling, 2010), so too in Sweden. Ever since joining the European Free Trade Area in 1972, Sweden has increasingly become intertwined with the European market. Since then, Swedish exports as a percentage of GDP have grown from 30% in 1990 (Ingves, 2022) to 52% today (Torstensson, 2023a). It also has above average export dependence for countries of comparable size (Nordström, 2019), making Swedish growth closely correlate to that of its trading partners (Ingves, 2022).

Financial integration began in the 1980s, when the financial sector was deregulated (Sveriges Riksbank). Then, Sweden joined the EU in 1995, leading to further financial integration due to the freedom of capital. Concurrently, the globalisation of the financial system has led to increased integration with the United States. Almost all financial institutions in the world have assets and liabilities issued in USD. For example, in 2014, dollar credit borrowed by non-financial non-US actors amounted to $8 trillion (equal to about 13% of non-US GDP) (McCauley, McGuire, Sushko, 2014). The USD serves as the *monetae franca*, the common international currency. The world, EU, and Sweden are thus intimately connected to the US, through the prevalence of dollar-denominated debt issued by European global banks (Rey, 2016).

Finally, even the labour market is indirectly connected to the European market. The Swedish wage-setting process follows to a large degree the benchmark set by the so-called Industry Agreement. This agreement takes the Swedish industry's international competitiveness into direct account (Torstensson, 2023b). Empirically, Swedish wages are shown to strongly correlate with European wages (Ljungqvist & Sargent, 2010; Westermark, 2019).

In summary Sweden is today highly integrated with the rest of the world. The three principal developments of note for this thesis have been trade, finance, and labour. The heightened integration inevitably prompts us to consider: what does this entail for monetary policy?

3 Monetary Policy in an Integrated World

The theoretical framework aims to provide an understanding of what determines the efficacy of a central bank in an integrated economy. The central theoretical understanding of the interaction between monetary policy and integration has traditionally been the Mundell-Fleming trilemma. Within the trilemma, a floating exchange rate insulates the economy from international monetary, financial, and real developments and ensures an independent monetary policy.

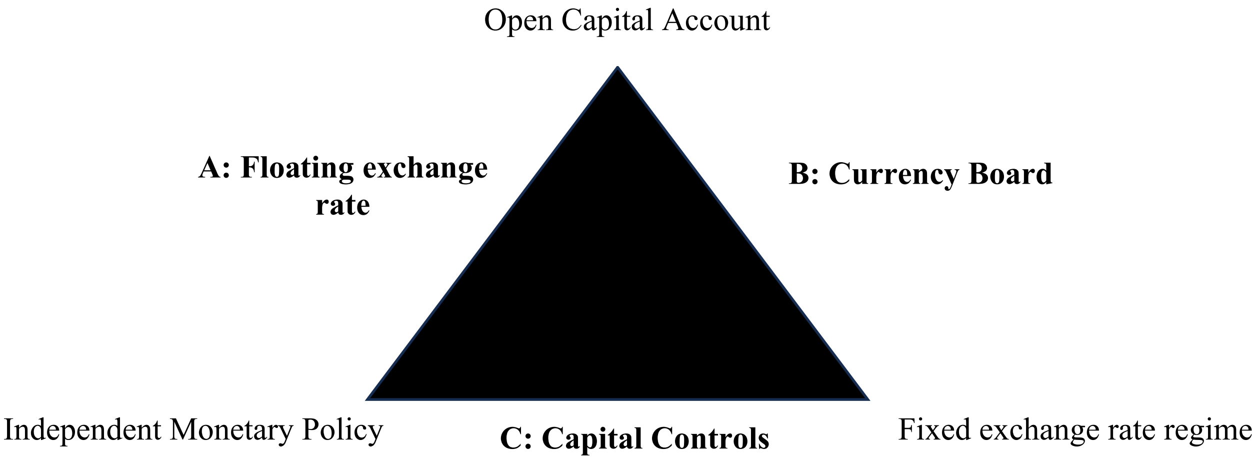
The trilemma has been questioned in recent years. I consider two critical approaches: the financial integration approach and the real economic integration approach. The financial integration approach hinges on the seminal paper "Dilemma not Trilemma" by Rey (2013). It posits that due to a global financial cycle and international financial transmission mechanisms the trilemma transforms into a dilemma: either free flow of capital, or an independent central bank. The real economic integration approach focuses on how unemployment and inflation have become synchronised with other countries due to increased trade. As such, the real economy depends more on international rather than domestic variables, decreasing central bank efficacy.

I first examine the rationale behind the trilemma. Then, I turn to the financial and real economic critiques. I finish with a summary of the key theoretical takeaways.

3.1 The Mundell-Fleming Trilemma

The Mundell-Fleming trilemma (see Klein & Shambaugh, 2015), also called the impossible trinity, is a textbook macroeconomic result. It states that a country choosing between the three traditionally desirable options of an open capital account, a fixed exchange rate, and an independent monetary policy, can choose two, but not all three. The trilemma is best explained as shown in figure 3.1:

Figure 3.1: The Mundell-Fleming trilemma.



Source: Klein & Shambaugh, 2015.

For independent monetary policy to exist, a country needs either a floating exchange rate or controlled capital movements. A floating exchange rate, according to the trilemma, allows the central bank to set an interest rate that differs from the international interest rate. If the domestic interest rate is higher than the international rate, the currency appreciates in response to capital inflows (and vice versa), thus creating interest rate parity. Alternatively, the economy can close the capital account through capital controls. The interest rate could then deviate from the international level, and a fixed exchange rate could be maintained, since capital inflows would be constrained. A floating exchange rate or a closed capital account thus parries international developments, insulating the economy, and allowing for an independent monetary policy with full efficacy (Klein & Shambaugh, 2015).

Since the collapse of the Bretton-Woods system, most countries have elected **A**. A floating exchange rate has many advantages. It allows monetary policy to focus on other goals, like inflation. It reaps the gains of capital flows that have come with financial globalisation. It avoids potential balance-of-payments crises and, in theory, insulates the country from international shocks. It also means that the exchange rate transmission mechanism kicks into force, with stronger central bank efficacy. As the central bank raises the interest rate, capital flows into the country seeking higher returns. The exchange rate appreciates in response and makes exports dear and imports cheap, decreasing net exports and thus output (Beyer et. al., 2017). Some countries have chosen **B** by joining currency unions with common policy (like the Eurozone), thus in effect giving up central bank autonomy. However, the currency unions allow the currency to float, electing **A**.

In more recent research, the trilemma is usually understood in terms of degrees, not absolutes. A capital account can have varying degrees of openness depending on financial integration; an exchange rate can be fixed, fixed within a band, or completely floating; and monetary policy has degrees of autonomy (Klein & Shambaugh, 2015).

3.2 The Impact of Integration

The world is a different place from when the trilemma was first argued. Globalisation has increased financial integration and trade exponentially – as evidenced in chapter 2. I now turn to how integration entails economic mechanisms that function outside the trilemma and diminish monetary policy efficacy and autonomy. I focus on two types of integration – financial integration and trade – that entail linkages which circumvent the insulating effects of the floating exchange rate and diminish monetary policy efficacy, but the total effects of integration go beyond the theory discussed below. Integration is a large, complicated phenomenon, including a plethora of markets, transactions, and other aspects.

3.2.1 *The Rey Dilemma*

In 2013, Hélène Rey wrote a seminal paper critiquing the Mundell-Fleming trilemma. She argued that a global financial cycle (GFC) makes independent monetary policy impossible, given an open capital account. US monetary policy "spills over" through the financial transmission mechanisms that make up the GFC, impacting macroeconomic variables in peripheral (small and open) economies (Dedola, Rivolta, & Stracca, 2017). The more open the capital account is – i.e., the more financially integrated the economy is – the less monetary policy is independent and efficacious.

The GFC is a stylised fact that describes the broad commonalities in the global flows of credit and asset prices. The cycle correlates strongly with a measure of risk called the VIX. When the market believes that risk is low, asset prices and gross credit flows *across the globe* increase, creating the GFC. (Miranda-Agrippino & Rey, 2022; Rey, 2013; see Cerutti, Claessens & Rose, 2017 for evidence against the GFC). US monetary policy drives the GFC. The ECB also drives the GFC, although to a lesser extent (see Miranda-Agrippino & Rey, 2022 for a literature review).

The US transmits its monetary policy in the form of the GFC through the credit channel and risk-taking channel. These "spillover" channels are strengthened by financial integration. The credit channel concerns the financial frictions that decrease with the net worth of the borrower, as adverse selection and moral hazard problems are alleviated (Rey, 2016). When the Fed funds rate decreases, the interest payments of liabilities (such as borrowed debt in USD) decreases and the present value of assets increases, increasing the net worth of borrowers, *no matter where in the world they are.* Fed monetary policy thereby spills over. Empirically, US monetary policy is found to drive both the UKs finance premium (the price of financial frictions) (Passari & Rey, 2015), as well as the finance premium in other small, floating exchange rate economies. However, no real statistically significant effects are found in the Swedish case (Rey, 2016).

The risk-taking channel describes the changes in actors' risk appetite. With expansionary monetary policy, the risk premia in financial markets decrease due to an increase in the demand for assets, which in turn relax the value-at-risk constraints of financial actors, allowing for increased leverage. Greater integration means that domestic banks and financial actors are more sensitive to the GFC. Thus, their leverage will to a larger extent be determined by global conditions, as opposed to domestic conditions, entailing less efficacy (Rey, 2016). Bruno & Shin (2014) find that US monetary policy affects cross-border banking flows and international bank leverage.

Even the interest rate channel is weakened by integration, as actors can more easily borrow from foreign lenders at other interest rates (Meier, 2013) Given the ubiquitousness of the dollar, the borrower might not even need to exchange to SEK, nullifying the exchange rate mechanism.

As such, financial integration causes the efficacy of a central bank to decrease. The greater the integration, the more sensitive the economy is to the GFC and thus

US and Eurozone monetary policy, decreasing the extent to which the domestic central bank can control the economy.

The rest of the literature, however, struggles to find strong empirical evidence for a strict dilemma view (Keskin, 2023). The results have been varied, with most papers finding that although monetary policy might be constrained by financial integration, the trilemma view is, in general, still fruitful (see e.g. Aizenman, Chin, & Ito, 2016; Georgiadis & Mehl, 2015; Klein & Shambaugh, 2015; Ligonnière, 2017; Obstfeld, 2015). Important empirical studies include Aizenman et. al. (2016), who find that the sensitivity of financial conditions in 100 peripheral (developing and emerging) countries to macroeconomic conditions in centre countries (US, Eurozone, China, Japan) depending on the exchange rate regime. Similarly, Klein and Shambaugh (2015) find that countries with a floating exchange rate deviate their interest rate comparatively more from the centre country to stabilise output and inflation, corroborating the trilemma.

Theoretical arguments have also been raised. Prominently, Georgiadis and Mehl (2015) argues that one effect of global financial integration has been that countries are increasingly net long in foreign currency reserves. As the central bank tightens monetary policy, the exchange rate appreciates, and the net value (in domestic currency) of asset and liabilities (denominated in foreign and domestic currency, respectively) decreases. This creates a negative wealth effect, given that the foreign currency exposure (net denomination of assets and liabilities) is positive, thus strengthening the exchange rate mechanism. Law, Tee, & Lau (2017) concur.

3.2.2 *The Impact of Trade*

Monetary policy efficacy may also be diminished through integration of the real economy. As observed in the chapter 2, Sweden has in most regards become completely integrated into the real economy of the EU through the free movement of goods and of people. In essence, integration of the real economy (i.e., increased trade of goods and services) means that core macroeconomic variables like unemployment and inflation become more dependent on international developments. As such, the central bank has less control over domestic variables. I examine the effects of increased trade through the synchronisation of inflation by global value chains and synchronisation of unemployment by business cycle synchronisation.

Global value chains refer to the fact that different parts of goods and services in an integrated world are produced in different countries. Shocks to production costs in one country spills over to other countries in the supply chain, creating inflation linkages (Auer, Borio, & Filardo, 2017; Auer & Mehrota, 2014; de Soyres & Franco, 2020). Auer, Levchenko, & Sauré (2017) show that trade accounts for about 50% of all producer price inflation globally. The Riksbank does not have any control over foreign production cost shocks, and as such its ability to steer domestic inflation decreases – diminishing efficacy.

Unemployment has also become synchronised. The overarching theoretical explanation concerns business cycle synchronisation, which in turn drives cyclical unemployment. These business cycle synchronisations have increased over the last hundred years in 16 western (including Japan) countries (Bordo & Helbing, 2010). Business cycle synchronisation has been thoroughly documented in the literature (Pham & Sala, 2020). Trade is the primary driver, as it means that the GDPs of the integrating partners become interlinked through export dependence (Asteriou & Moudatsou, 2015; Beck, 2019; Böwer & Guillemineau, 2006; Pyun & An, 2016). Researchers also point to FDI (Antonakakis, & Tondl, 2014; Lee, Park, & Pyun, 2022) and animal spirits (De Grauwe & Ji, 2017) as causes of business cycle synchronisation. Contrary evidence does, however, also exist. In the above-mentioned historical study by Bordo and Helbing (2010), they note that integration has over the last hundred years had an U-shaped pattern (with the interwar period exhibiting much lower integration than the 1880s), while business synchronisation has steadily increased. Krugman (1993) argues that integration decreases synchronisation, since regional specialisation decreases the global impact of industry-specific shocks.

Such synchronisation is apparent in Sweden as well. Swedish unemployment is dependent on European unemployment (Andersson & Jonung, 2020). The synchronisation of Swedish unemployment with the eurozone is driven superficially by the labour market model and the competitiveness-clause of the Industry Agreement. The reason the competitiveness-clause exists, however, is due to the heavy export-dependence of the Swedish economy. As Swedish unemployment is so dependent on foreign GDP, the two become interwoven and synchronised (Nordström, 2019). As such, the structure of the Swedish labour market means that the interest rate channel of the Riksbank is weakened, as the relative importance of the change in marginal costs that occur due to interest rate change decreases (Westermark, 2019).

3.3 Key Theoretical Takeaways

The effects of financial integration on monetary policy have its theoretical underpinnings in the trilemma/dilemma debate. Financial integration makes a domestic economy more sensitive to centre countries' monetary policy (in Sweden's case, the US and to a lesser extent the Eurozone), weakening the domestic central bank's control of the economy. But, as the literature suggests, the floating exchange rate still insulates the economy to some extent. The diminishing effects on monetary policy efficacy through the integration of the real economy are caused by synchronisation of inflation and unemployment. As the dependence of unemployment and inflation on foreign variables increases, the ability of the central bank to affect these variables decreases. The degree to which the exchange rate insulates the economy from the effects of integration differs from country to country – the very subject of this thesis.

4 Methodology

Policy both reacts to the economy and changes it. Vector auto-regression models (VARs), the workhorse methodology of the study of monetary policy (Rasche & Williams, 2007), are used when the causality of variables flows both ways.

I estimate two VAR models centred on the short-term interest rate (STIR) and QE – the tools of modern monetary policy. I analyse the period during which Sweden had a floating exchange rate (1993Q1-2023Q2). One model includes US and Eurozone control variables in the form of unemployment, STIR, and QE, the other does not. A difference between the two shows the impact of integration as a confounding variable on monetary policy efficacy. The control model can then be analysed as a measure of monetary policy efficacy. Thus, both research questions are answered. The strength of the methodology lies in its simple, parsimonious character.

Measuring monetary policy independence from other economies and its associated aspects robustly remains a problem in econometrics (Aizenman, 2010), therefore necessitating simpler models to gain insights. The interpretation of the change is more understandable than a convoluted econometric model.

The chapter is structured as follows: I begin laying out my model and the reasoning behind it. I then examine the mathematics and the underlying assumptions. I finish with a description of the data.

4.1 A Two-Pronged Methodology

The control/no-control methodology is two-pronged, in accordance with the two research questions. The first prong gauges the importance of integration as a confounding variable. A confounding variable is a third variable which influences both independent and dependent variables (in VARs, all variables are both independent and dependent). Another way to think about it is that changes between the models imply that some aspects of the system are better ascribed to control variables than to endogenous ones. As noted above, integration is a complicated thing. Focusing on one aspect is bound to miss others. This methodology aims at capturing the full effects. However, this does also mean that the methodology cannot distinguish between different types of integration, such as the relative importance of financial integration versus trade.

The second prong estimates the efficacy of the Riksbank – the degree to which monetary policy affects the economy. It should be noted that if confounding variables are found, the no-control model is not valid. Therefore, only the control model can be utilised. Analysis of the control model tells us much the same things that a regular regression might.

The analysis, in practical terms, centres on the use of impulse response functions (IRFs). The regular coefficients in a VAR are difficult to interpret. Instead, an IRF traces how an unanticipated one-unit change in one variable flows through the system, looking at the impact of every other variable over the next several periods. The efficacy of the Riksbank can thus be seen in how much an impulse in the STIR changes, say, inflation or unemployment.

4.1.1 *Structural Restrictions*

Due to the contemporaneous effects and the subsequent correlation between the error terms in a VAR, the model cannot be estimated directly. To solve this so-called identification problem (which corresponds to distinguishing endogenous shocks from exogenous), structural restrictions of the VAR must be made (Enders, 2015).

I restrict the VAR through a causal ordering of the variables, called the SVAR model approach. This approach uses theoretical arguments to causally order the variables in time, such that the last variable cannot contemporaneously affect any variables, the second-to-last can only contemporaneously affect the last, and so on (Clower, 2022). Other methods of restrictions have been used in the literature, such as the narrative approach (see Romer & Romer, 1989) and the high frequency approach (see Rey, 2016). No method is perfect, and the choice often comes down to the researcher's preference for theory or empirics. Nonetheless, the high-frequency approach suffers from some strong assumptions: it assumes that the relationship between the shock and the instrument is stable over time (Amir-Ahmadi, Matthes & Wang, 2023) and that the whole shock is transmitted to the rest of the economy (Andersson, 2023). It has also already been extensively explored in the literature (e.g. Rey 2016). The narrative approach requires a large amount of manual labour in examining documents from central bank meetings (Romer & Romer, 1989). It thus lies outside the practical limitations of this thesis.

4.1.2 *Mathematics and Assumptions*

The models can be represented mathematically as:

Equation 4.1:

$$B_0 y_t = c + \sum_{i=1}^{L} B_i y_{t-i} + C x_{t-j} + \varepsilon_t$$

The right-hand side includes a constant *c,* matrices of parameters B_i; i=1, …, L lags of the vector of endogenous variables y_{t-i}; a matrix of parameters C; a vector of exogenous variables x_{t-j} lagged by j periods; and a vector of errors ε_t which are assumed to be independently and normally distributed with zero mean and constant variance. The left-hand side includes a vector of the endogenous variables at time *t,* as well as a matrix B_0 which models the contemporaneous effects of the endogenous variables. The no-control model excludes C and x_{t-j}.

The vector y_t includes the following endogenous Swedish variables: unemployment (u_t), the SEK/USD exchange rate ($e_t^{SEK/\$}$), CPIF quarterly inflation rate (π_t^F), real housing prices (h_t), QE (qe_t), and the short-term interest rate (i_t). The inclusion of unemployment, inflation, QE, and STIR are self-explanatory. The exchange rate is included to account for Sweden's heavy export dependence as well as the financial transmission channels. Housing is included for two reasons. First, it's been shown to be very important for financial stability and boom-bust cycles (Rey 2016). Second, the housing market and monetary policy are closely linked (Di Casola, 2023). Therefore, not including the housing market would be running the risk of omitted variable bias.

Equation 4.2:

$$y_t = \begin{pmatrix} u_t \\ e_t^{SEK/\$} \\ \pi_t^F \\ h_t \\ qe_t \\ i_t \end{pmatrix}$$

Similarly, the vector x_t includes the following control variables: the VIX (*VIX_t)* as well as US and Eurozone unemployment, QE, and short-term interest rate respectively. The US and Eurozone variables control for their economies and monetary policy. The VIX controls for the global financial cycle.

Equation 4.3:

$$x_t = \begin{pmatrix} VIX_t \\ u_t^{US} \\ qe_t^{US} \\ i_t^{US} \\ u_t^{Euro} \\ qe_t^{Euro} \\ i_t^{Euro} \end{pmatrix}$$

The above mathematics make some important assumptions. First and foremost, I assume that the economy can be accurately represented through the limited selection of variables above. The number of variables must be constrained as to not overparameterise the model (Andersson, 2023). Lag length is also assumed to be 4, i.e. $L = 4$ and $j = 4$. Normally, the lag length is determined by lag length criteria like AIC and BIC, but the lag length criteria widely differed for the model (1, 3, and 8, for Schwarz criterion, BIC, and AIC respectively)

The causal ordering of endogenous variables constitutes the pivotal assumption of the methodology. I assume that unemployment contemporaneously affects all other variables, the exchange rate everything but unemployment, etc. Ordering unemployment first, and monetary policy last, follows the literature (see e.g. Andersson, 2023). The intuition for unemployment being ordered first is that it represents the real economy, which all other variables “take into account”. As for monetary policy, it has long and variable lags, sometimes estimated at one to three years (Andersson, 2023). Exchange rates come second as they move quickly and may thus contemporaneously affect all other variables except for the real economy. Then comes quarterly inflation rate and the housing prices. For housing prices developments to affect inflation, the wealth effect must come into effect. This wealth effect has been shown to be "sluggish" (Caroll, Otzuka, & Slacalek, 2010). Housing prices may thus be contemporaneously affected by inflation.

The causal ordering is achieved through restricting the B_0 term in Equation (1), which captures contemporaneous effects, so that it becomes lower triangular. The identification problem can then be solved through a Cholesky decomposition (a mathematical operation) of the error-covariance matrix, allowing for estimation (Clower, 2022). The restriction of the B_0 matrix is shown in Table 4.1:

Table 4.1: Restrictions of Contemporaneous Effects.

Cholesky Decomposition Scheme

	u_t	$e_t^{SEK/\$}$	π_t^F	h_t	qe_t	i_t
u_t	1	0	0	0	0	0
$e_t^{SEK/\$}$		1	0	0	0	0
π_t^F			1	0	0	0
h_t				1	0	0
qe_t					1	0
i_t						1

4.2 Descriptive Statistics

Here, I briefly describe some of the notable trends in the data. Sources and the undertaken transformations can be found in Appendix 1. First, figure 4.1 shows the development of the STIRs over the sample period. Note the period of negative interest rates during the 2010s.

Diagram 4.1: Interest Rate Developments

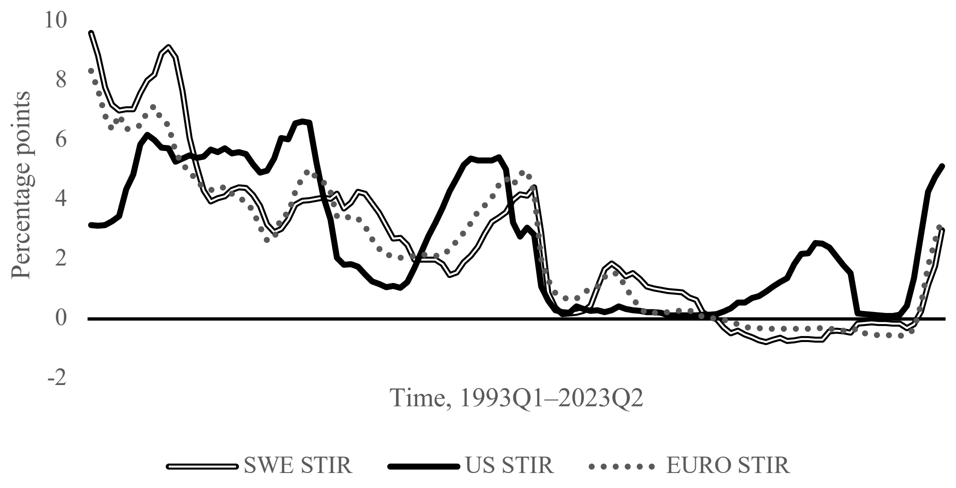
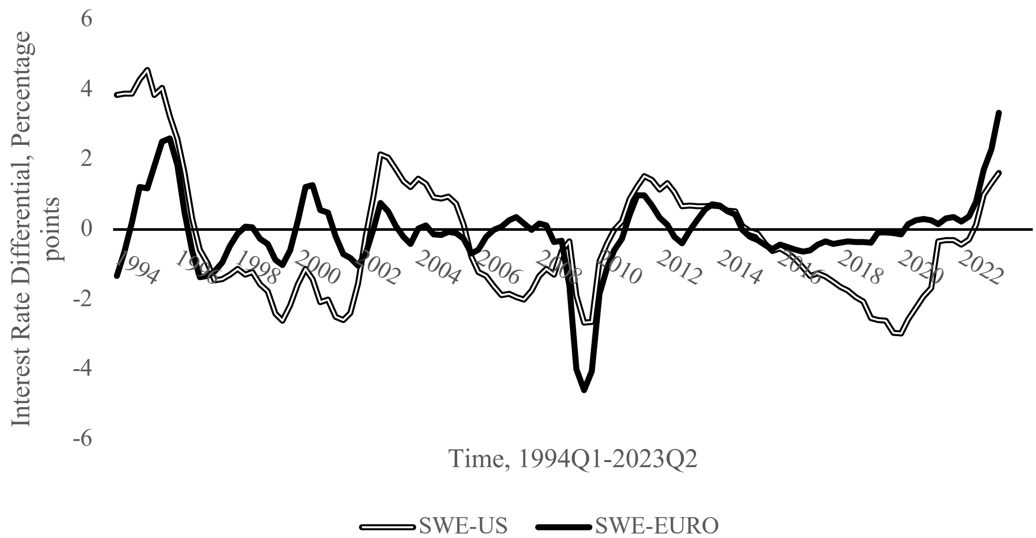


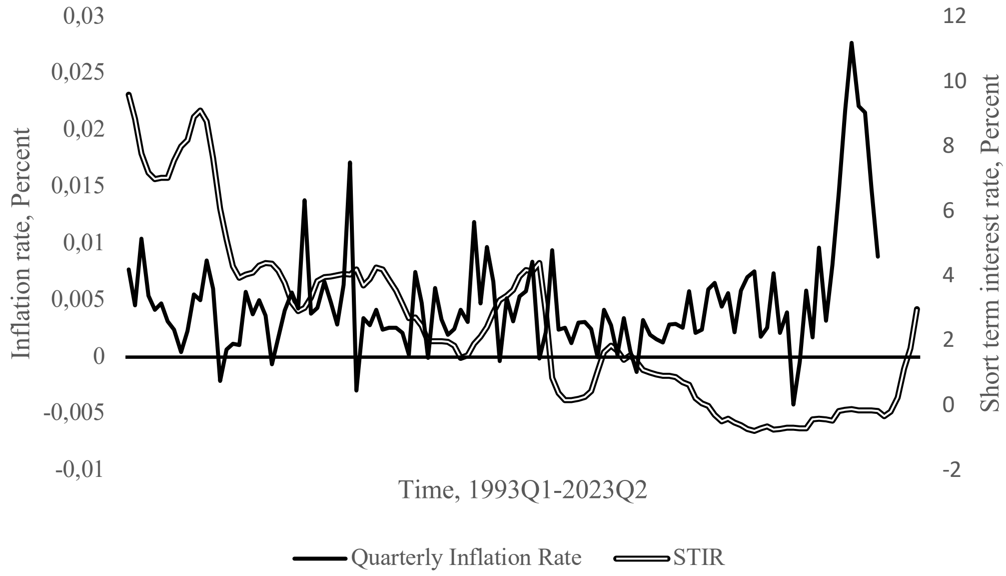
Figure 4.2 shows the 4-quarter lagged interest rate differential between the Sweden and the US one year before and Sweden and the Eurozone one year before respectively (a positive value means that the Swedish STIR is larger). Sweden's interest rate stays within ±2 percentage point to the Eurozone STIR (except for the drastic change in 2008), deviating comparatively more from the US STIR.

Figure 4.2: Interest rate differential, lagged



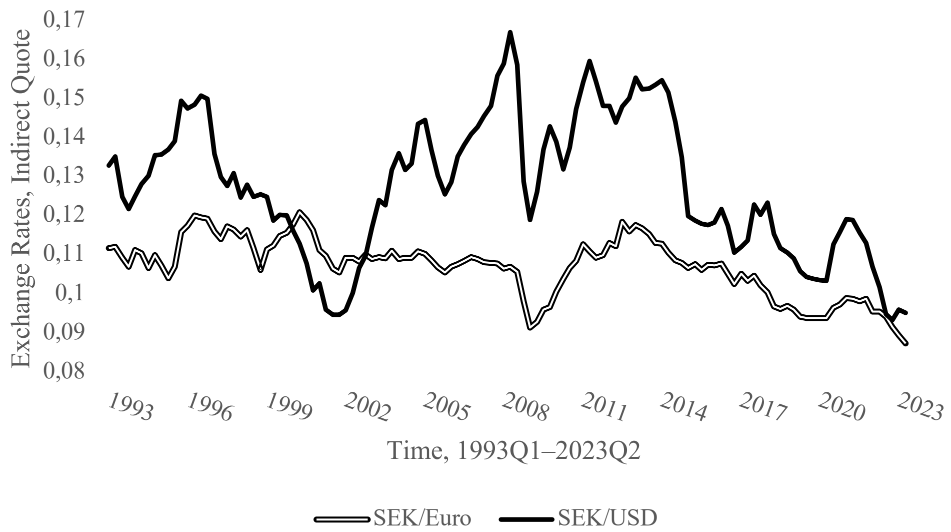
Having noted the negative interest rates of the 2010s, now consider seasonally adjusted quarterly inflation compared to the STIR in figure 4.3. Inflation does not seem to be strongly negatively correlated with the STIR. No effects of the negative interest rates on quarterly inflation are noticeable.

Figure 4.3: Quarterly inflation compared to the Swedish STIR.



Also consider the exchange rate fluctuations in figure 4.4, in indirect quotation. As the Swedish krona is a small currency, it fluctuates heavily. Since the peak in 2008Q2, the krona has depreciated by 40% against the dollar. It has depreciated by 25% against the euro since the peak in 1999.

Figure 4.4: Exchange rate fluctuations



Below, I also summarise some descriptive statistics of all variables. Note that although I use the detrended housing price index in the model, I report the annual real housing price inflation, as that makes for an easier understanding of the data.

Table 4.2: Descriptive Statistics of Endogenous Variables

	Housing price inflation	*STIR*	*Unemployment*	*QE, share of GDP*	*SEK/Euro*	*CPIF, Seasonally adjusted*
Mean	0,044	2,482	7,668	0,281	0,107	0,005
Median	0,053	1,987	7,65	0,292	0,108	0,004
Std. Dev	0,056	2,672	1,182	0,218	0,008	0,005
Min	-0,146	-0,777	5,1	0	0,087	-0,006
Max	0,138	9,597	10,3	0,692	0,121	0,026

Table 4.3: Descriptive Statistics of Exogenous Variables

	VIX	*Euro STIR*	*Euro Unemployment*	*Euro QE/GDP*	*US STIR*	*US Unemployment*	*US QE/GDP*
Mean	19,718	2,348	9,509	0,309	2,639	5,71	0,182
Median	18,102	2,135	9,483	0,296	2,143	5,333	0,182
Std. Dev	7,295	2,366	1,394	0,21	2,196	1,78	0,094
Min.	10,308	-0,566	6,667	0,002	0,1	3,5	0,06
Max.	58,588	8,323	12,2	0,596	6,627	12,967	0,355

5 Results

The results are presented in the form of IRFs. The granger causality, forecast error variance decomposition, and model estimation output of each model can be found in Appendix 2.

The results show that the Riksbank is weak in the control model, only producing notable results in the effect of QE on inflation and on housing prices. The difference between the models points toward a large impact of integration as a confounding variable in the no control model. Including control variables makes the statistically significant effects of the STIR on unemployment disappear. The confidence bands shift downwards for the STIR effect on inflation and housing. The response of inflation to QE gets halved.

However, the results need to be interpreted with some scepticism. The robustness checks of 768 variations of the models show that the relevant statistical indicators vary greatly when only small changes in input are made – changing the measurement of inflation, for example. Neither can the model handle different sample lengths. In general, this result is not uncommon. But the robustness checks nonetheless indicate the results should be interpreted with a grain of salt.

5.1 Key Results

Compare the IRFs, with 90% confidence bands, for the STIR and QE with and without control variables for the Eurozone and US economies, show in figures 5.1, 5.2, 5.3, and 5.4:

Diagram 5.1: No Control Variables, STIR impulse.

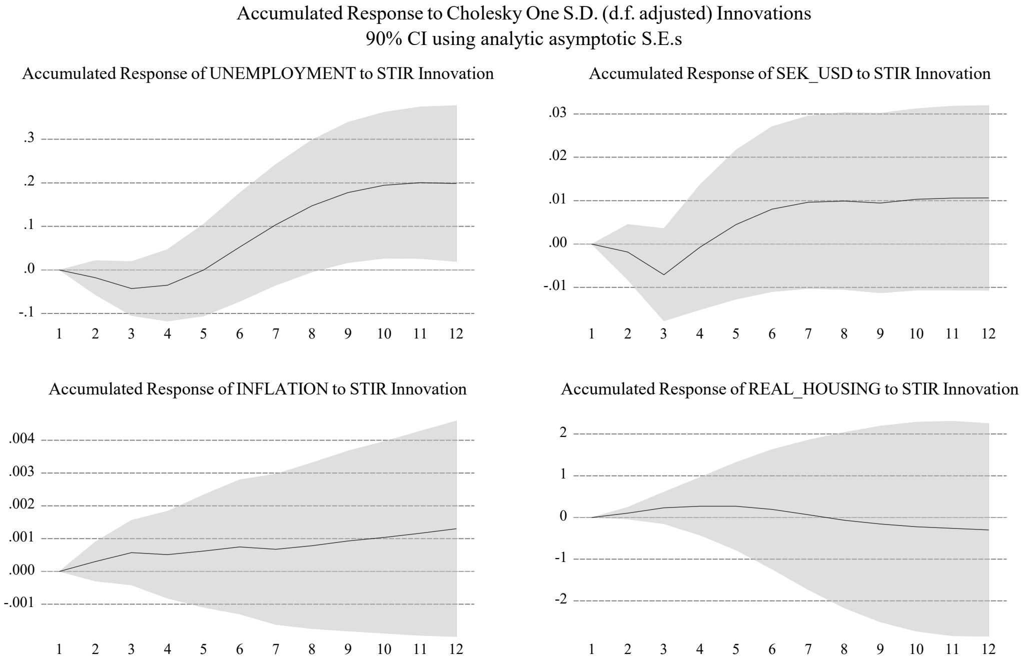
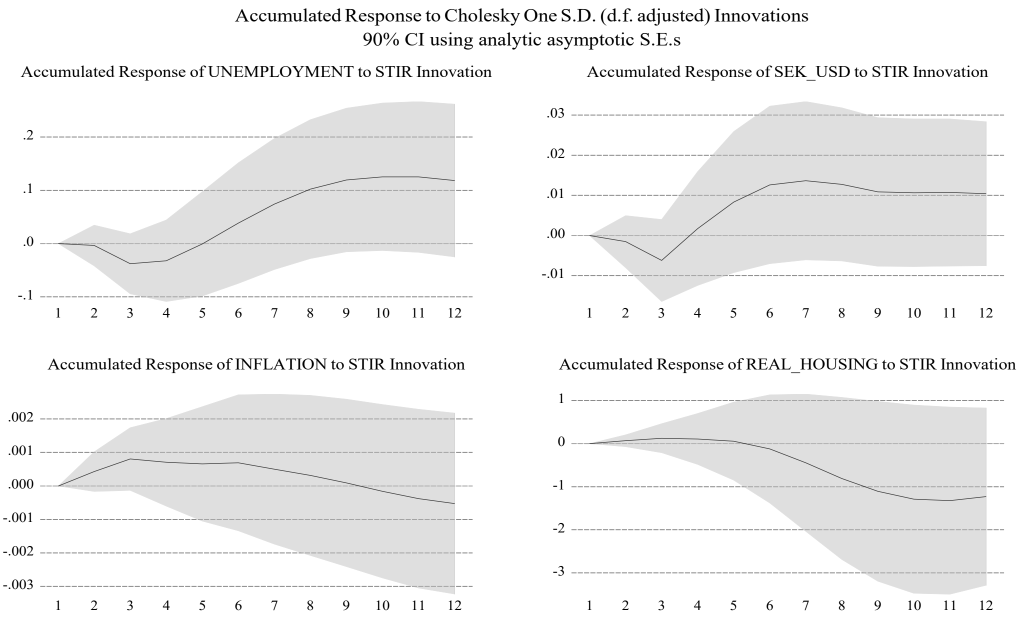


Diagram 5.2: Including Control Variables, STIR impulse.



Looking at the IRFs for the STIR, two things are clear: first, that the difference between the no-control and control model is large, second, that a change in the STIR barely produces any statistically significant results in the control model. In the model with no control variables, a shock to the STIR increases unemployment by between 0.02% and 0.35%. Including control variables makes the effect no longer statistically significant. As such, the model shows that changes in Swedish unemployment are better attributed to European and U.S. variables than Swedish ones, capturing the effect of integration. The confidence bands for the effect of STIR on inflation and housing shift downwards but are not significant in either of the models. The effect on the exchange rate barely changes.

Now, compare the effects of QE:

Diagram 5.3: No Control Variables, QE Impulse.

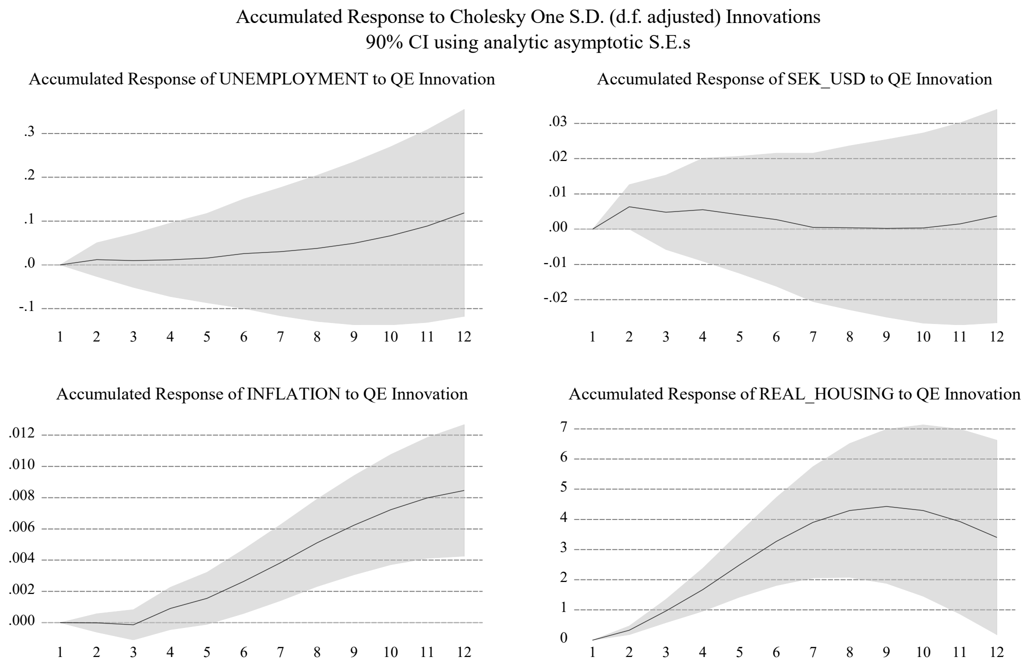
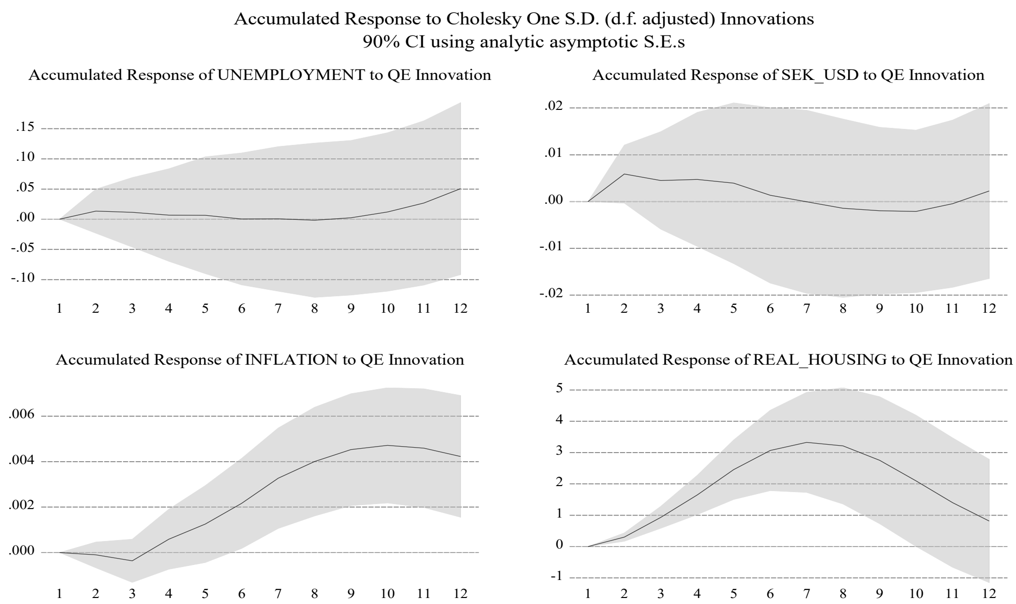


Diagram 5.4: Including Control Variables, QE impulse.



Looking at the effects of QE and the difference between the models, similar results appear. However, QE does not become as insignificant as the STIR does. The effect of QE on the CPIF inflation rate is halved but remains significant. The effect of QE on housing has its upper bound decrease and becomes insignificant after 10 periods. The exchange rate increases as a result of a QE shock in the first two periods, but then becomes statistically insignificant.

The results show that the efficacy of the Riksbank is weak and that there is a large effect of the confounding variable integration. Monetary policy, in the control model, do not produce statistically significant results on unemployment. The effect of STIR on inflation is insignificant, while the effect of QE is between 0.002 and 0.006 increase in quarterly inflation (corresponding to ≈0.8% and ≈1.2% year-on-year inflation). QE produces, at its maximum, between 2 and 5 index points increase in the real housing prices around its long-term trend. The comparatively strong results of Swedish QE on housing accord with previous studies (Andersson, Beechey Österholm, & Gustafsson, 2022).

Looking at the forecast error variance decomposition (FVED, which shows the relative importance of each variable, available in Appendix 2) of the control model, we see that STIR only has a slightly noticeable effect on housing and unemployment and is hardly relevant in any of the others. The significance of a shock to the STIR when explaining variations in inflation is miniscule. QE is the most important variable when explaining variations in inflation, but 60% of the variation is still explained by its own past values. As for unemployment, the most important variable (except its own past values) is the exchange rate, reflecting the export-dependent and economically integrated nature of the Swedish economy. Housing is, of all variables, the least explained by its own past values. QE, STIR, and inflation do most of the heavy lifting. The effects of STIR and QE, in general, take about 8 periods, i.e. 2 years, to kick into effect, reflecting the 'long and varied' lags of monetary policy. QE positively impacts inflation, while producing very large effects on the housing market. The exchange rate, interestingly, is only explained by its own past values. This, together with the granger causality results, indicate that the variable should potentially be modelled as exogenous.

5.2 Robustness

I conduct several robustness checks. First, I look at how the model changes when the sample period of data is split in half. The first model below uses data from 1993-2008 (no longer includes QE as it was not in use), and the second from 2008-2023. Second, I look at descriptive statistics of 768 different models that differ in small ways from the ones estimated above. As the model cannot handle different sample lengths, and the different models produce widely different results (apparent in the large standard deviations), I conclude that the results are not robust.

5.2.1 *Sample Period Robustness*

Figures 4.8 to 4.11 show how the model cannot handle different sample periods.

Figure 5.8: Sample Period 1993q1-2008q1, Control Model

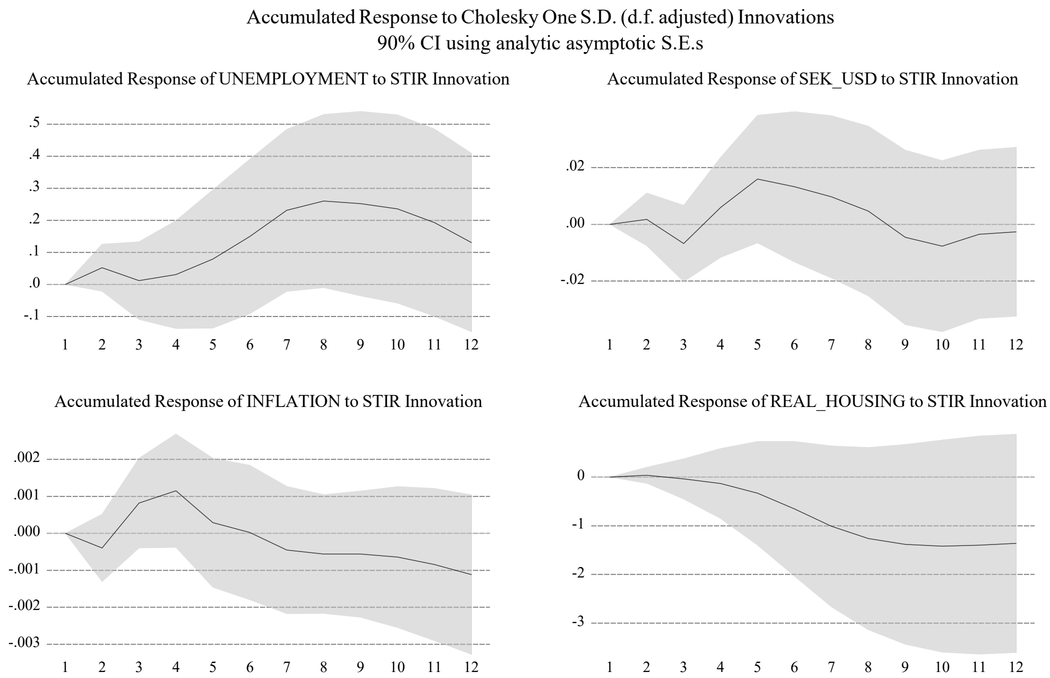


Figure 5.10: Sample period 2008 Q1-2023 Q2, STIR Impulse, Control Model.

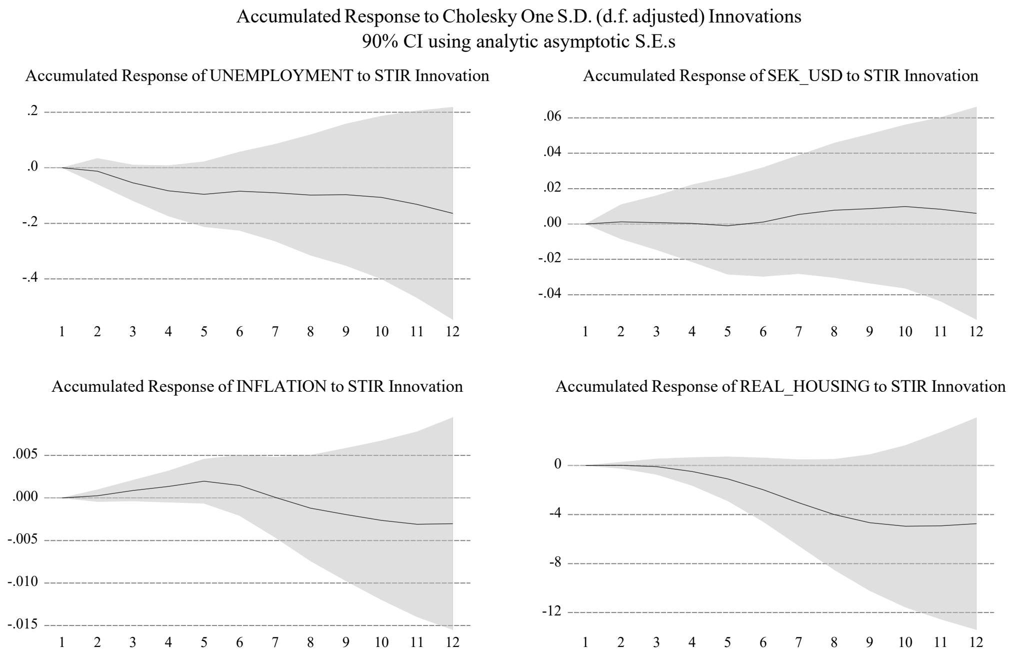
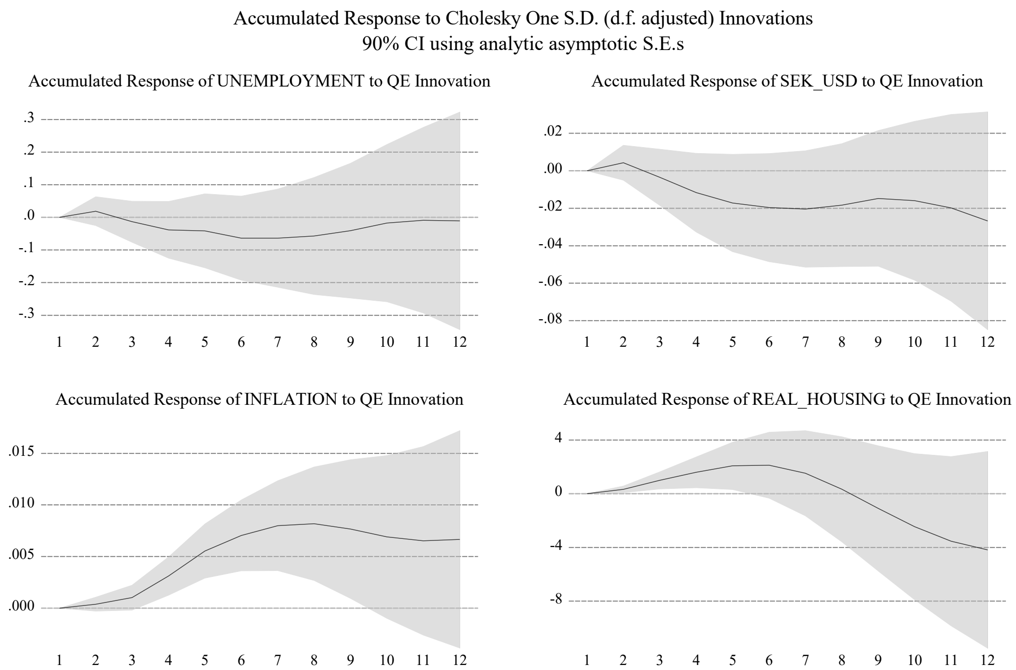


Figure 5.11: Sample period 2008 Q1-2023 Q2, QE Impulse, Control Model



The IRFs drastically change depending on sample period. In the early period, the responses to STIR become "spikey" while in the late period, the responses fan out. Fanning out means that the model is unstable, and the "spikey" functions are theoretically implausible. A reasonable function would develop smoothly, much like the estimated models with full sample length. This is partly a degrees of freedom problem: the number of estimated parameters close in on the number of observations. Nonetheless, it does showcase the model's instability.

5.2.2 *768 Variations*

To further check robustness, I estimate 768 different models using a python script, available in Appendix 1. I check all possible combinations of the following possibilities, where all models include unemployment, Swedish QE, and housing prices:

1. Measurement error in variables: True or False.
2. Including control variables: True or False.
3. Inflation measurement: Quarterly CPIF seasonally adjusted using the STL filter, quarterly CPIF seasonally adjusted using the US. Census bureau's X-13-ARIMA tool, or quarterly CPIFXE with STL adjustment with an exogenous energy variable.
4. Energy variables, exogenous in combination with CPIFXE: Oil or Global Energy Price Index.
5. Interest rate measurement: Policy rate or STIR.
6. Lag lengths: 1 to 6 lags.
7. Exchange variables: either SEK/Euro or SEK/USD, and being either endogenous or exogenous (i.e., 4 possible cases)

All possible combinations add up to 768. I then save the t-scores of each estimated coefficient, the f-statistic, AIC value, and BIC value for each model, as well as the percentage of p-values that are less than 0.1. Some descriptive statistics of the results are collected below, rounded to three significant figures:

Table 5.1:

	AIC	*BIC*	*Absolute value of T-statistic*	*P-value of t-statistic*	*F-statistic*
Total no.	768	768	110 831	110 831	768
Mean	797	603	245	N/A	1.22e+10
Std. dev.	555	416	3690	N/A	1.57e+11
Min	2.79	2.13	0.000000144	N/A	2.32
25%	231	235	0.0781	N/A	43.6
50%	741	548	0.246	N/A	93.5
75%	1233	1930	1.01	N/A	21700
Max	1790	1610	254 000	N/A	3.14e+12
% < 0.1	N/A	N/A	N/A	20.2%	N/A

The results show three important things: first, that the coefficients are, in general, jointly significant. Second, although the mean of the t-statistics is quite high, the median coefficient is not significant. Third, the standard deviations are huge – a clear sign of instability.

The F-statistic tests the joint significance of all lags of the endogenous variables in the VAR. The median model has a 93.5 F-stat, and at the 25th percentile it is 43.6. Although the critical F-value depends on the degrees of freedom in numerator and denominator, anything over 10 will reject the null in most cases. So the coefficients are in general jointly significant.

The t-statistics appeared to be skewed by a very large max t-statistic, such that the mean is much larger than the median. However, the median coefficient is not significant. About 20.2% of all the t-statistics have a p-value less than 0.1.

Most important, however, are the huge standard deviations. For example, the standard deviation of the AIC and BIC are 555 and 416 respectively, with means of 797 and 603, and the standard deviation of the t-statistic at 3690 (with a mean of 245!).

At this point, it is important to remember that these models are *very* similar. The differences lie in using different ways of seasonally adjusting quarterly inflation or using SEK/Euro or SEK/USD as the exchange rate variable. These models should have similar results. The instability of the two main models is therefore not a one-off mistake. Rather, their instability is due to them being part of an unstable "family" of models. I discuss the cause of this instability in the next chapter.

5.3 Theoretical Implications

Two conclusions are inferred. First, monetary policy shocks induced by the Riksbank in the control model have very small effects. Second, the large differences between the no-control and control model implies a large effect of integration with the Eurozone and US.

The models show that changes in the STIR do not have any statistically significant effects on inflation or unemployment. QE does affect inflation. The result are on the smaller side of the literature, but does still concur with the general findings. In 1999, an extensive literature review found that “there is agreement that monetary policy shocks account for only a very modest percentage of the volatility of aggregate output; they account for even less of the movements in the aggregate price level” (Rasche & Williams, 2007, taken from Christiano, Eichenbaum, & Evans, 1999, p.71). In addition, VARs have struggled to identify precise effects of monetary policy (Cagan, 1989; Rasche & Williams 2007).

The statistically insignificant effect of STIR on the SEK/USD exchange rate, in conjunction with the exchange rate only being explained by its own values in the forecast error variance decomposition, is interesting. One of the key features of the floating exchange rate option within the trilemma is that the exchange rate appreciates with a positive monetary policy shock and as such enables interest rate parity. It is the key mechanism, in the framework, which enables monetary policy autonomy. The mechanism should also exist in the dilemma framework, only that it does not ensure monetary policy autonomy. However, the FVED and granger causality suggest that the exchange rate is determined exogenously. The non-existence of such a mechanism might be interpreted in two ways: either there is no interest rate differential (thus no exchange rate effects would occur), or the model suffers from some bias or omission. The first option is not true. Therefore, the non-existence of exchange rate mechanisms can be interpreted as a sign of model weakness.

The results affirm the theory of the negative impact of integration on monetary policy efficacy, in accordance with the literature on both financial (Keskin, 2023) and trade integration (Auer, Levchenko, & Sauré, 2017). Inflation moves towards zero, affirming the fact that inflation in Sweden may be better attributed to US and

Eurozone monetary policy and unemployment. The result shows the importance of financial integration and global value chains (although the methodology cannot distinguish the relative importance of the causes). Equivalently, the insignificant effects on unemployment by the STIR and the importance of the exchange rate in the FVED affirms the export-dependence of the Swedish economy and the linkages with European variables (Andersson & Jonung, 2020).

But, as the robustness tests show, the model is unstable. These results should therefore be taken with a grain of salt.

6 Discussion

The objective of this thesis has been to answer whether the efficacy of the Swedish Riksbank has weakened due to integration, which it has. However, the results should be interpreted with some care. In this chapter, I focus my attention on what might have caused the instability of the model. Why are only 20.2% of all t-statistic p-values less than 0.1, when all members of the "family" of models seem somewhat reasonable? I then finish with a summary of the conclusions and recommend future research.

6.1 Potential Causes of Instability

The statistical significance and measures of fit (AIC and BIC) change drastically with only small changes in the measurement of the variables, such as using different methods for seasonally adjusting CPIF. In addition, in some of the models that I have estimated (models that are not that different from the ones above) the causality goes completely opposite to theory. The robustness checks mean that the results are not, in the language of Lakatos, able to penetrate the protective belt around the hard core of established theory (Leamer, 1983). This is, however, a common problem in VAR models of monetary policy (Cagan, 1989). It has turned out to be suspiciously difficult to identify the effects of monetary policy in a precise manner.

Why might this be? First, Li et. al. (2016) show that VARs have trouble detecting weak transmission mechanisms, and even have low power to detect strong mechanisms when the sample size is small (which is true of my 122 observations).

Second, the relatively small sample size also means that there is a risk of overfitting. Overfitting occurs when degrees of freedom are few, and makes the model correspond too closely to the set of data, losing the ability to estimate the true trend. There are thus two statistical problems conditional on lack of data.

Third, due to the mathematics behind the model, identification schemes are required. These schemes impose assumptions that are, in many cases, disputable, and in addition lead to different estimates (Christiano, Eichenbaum, & Evans, 1999, p.71). My model assumes that (as is standard in the literature) unemployment has contemporaneous effects on all other variables. But we know about information lags – it takes time for people and policymakers to realise what is going on. In addition, the lags between monetary policy and the effect on the economy are "long and varied" (Rasche & Willams, 2007). Thus, these assumptions are precisely what Leamer (1983) calls "whimsical", that is, should be questioned.

The underlying problem of all three issues is that the economy is *very* complicated. Central bankers look at everything, and econometric models like VARs only use a few variables. But simply including more variables causes overfitting problems. So the model simultaneously potentially suffers from an omitted variable bias (a common bias in VARs (Rasche & Williams, 2007) and a risk of overfitting.

The solution appears simple: include more data. But the economy also changes drastically over time. The very reason I am only able to include 122 observations, is, of course, that Sweden switched to a floating exchange rate in November of 1992. Sweden has had 4 or 5 policy regimes since 1873 (Andersson, 2023). Each of these regimes have different underlying true processes.

The issue of the mismatch between the theoretical expectations of financial markets, central banks, and economists on the real effects of money in the short run and the conclusions of VAR analyses was raised as early as 1989 by Cagan and later by Rudebusch (1998). Perhaps economists should return to the careful historical analyses of Anna Schwartz and Milton Friedman, instead of pushing time series data through the "regression meat grinder" (Cagan, 1989). After all, few economists would say that their views have been formed by VAR analyses (Rasche & Williams, 2007).

6.2 Conclusion and Future Research

This thesis has investigated the efficacy of Swedish Riksbank monetary policy. I have used a VAR analysis to investigate the effect of Riksbank monetary policy on key variables – inflation, unemployment, housing, and the exchange rate – and how these effects change when controlling for the US and Euro economies. When controlling for external economies the statistically significant effects disappear. Thus, the results show the negative impact of integration on monetary policy efficacy. In the control model, the efficacy of the Riksbank is very limited, with the only notable effect being the increase in housing prices as a response to QE. The Riksbank is shown to be an empty suit.

I then conducted an extensive set of robustness checks, looking at how the model performs under different sample periods and the average statistical significance of 768 different variations of the model. The robustness checks show that the model is unstable and that the results should therefore be taken with a grain of salt. I finish the thesis with a discussion about the potential causes of the model's instability.

Future research should continue to investigate the autonomy of individual countries, and especially on highly integrated economies. This study can, for example, be easily extended to look at the other Nordic countries, which have varying degrees of integration with the EU economy. Such studies would enlarge our understanding of how integration affects monetary policy efficacy. In line with my discussion, I end with a recommendation for a combination of broad historical studies and regression-based time series analysis.

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8 Appendix 1: Data, Transformations, and Robustness Check

8.1 Data and Transformations

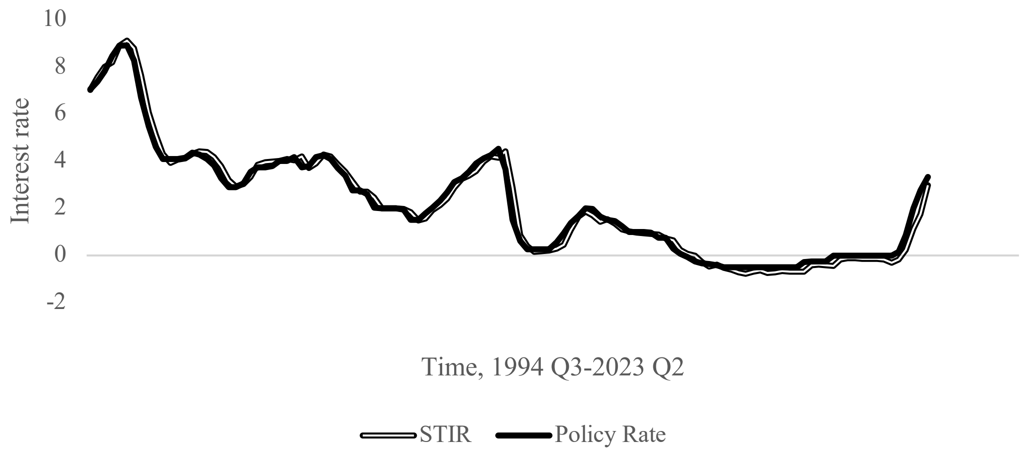
VAR models assume stationarity and linearity. The data must therefore be transformed to fit these assumptions. Here, I describe these transformations. When making data stationary, it is inappropriate to detrend a difference-stationary variable, and first-differencing a trend-stationary variable (Enders, 2015, p.191) Care has been taken to ensure appropriate transformations.

Variable	*Data transformation*	*Source*
Endogenous Variables		
Unemployment	I assume that unemployment follows the pre-pandemic trend and fit the data accordingly. I take the first difference to make it stationary.	OECD: https://data.oecd.org/unemp/unemployment-rate.htm
SEK/USD	The exchanges rates are inversed to indirect quotation. They are then logged and first differenced. I put a dummy on the US exchange rate to adjust for the sudden spike in the beginning of the financial crisis.	Sveriges Riksbank: https://www.riksbank.se/sv/statistik/rantor-och-valutakurser/sok-rantor-och-valutakurser/?fs=1&s=g130-SEKAUDPMI#riksbank-seriesform
CPIF Inflation	I model inflation using the CPIF index, instead of the standard CPI index. CPIF has a fixed interest rate and is the target index of the Riksbank. The real housing prices take mortgage costs into account, and interest rates are included separately. Using the CPIF thus both accords with the Riksbank and lessens	SCB database: https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__PR__PR0101__PR0101G/KPIF/

	potential multicollinearity issues. CPIF inflation is calculated as quarterly inflation change in the CPIF index, where 2015q1 = 100. I take the average of the CPIF index over a quarter and calculate the quarterly change. The inflation rate is then seasonally adjusted through the US Census Bureau X-13 ARIMA tool which makes it stationary.	
Real Housing Prices	Index, 2015=100. I detrend the real housing prices using the Hodrick-Prescott filter, ensuring stationarity. I include a dummy in 2017 to adjust for amortization rules.	OECD database, "Real Housing Prices": https://data.oecd.org/price/housing-prices.htm
Swe QE	Taken from the Riksbanks balance sheet, available through its Weekly Report. The post in question is "Värde-papper i svenska kronor utgivna av hemma-hörande i Sverige". I average the quarterly holdings. I then divide by GDP and take first difference.	Sveriges Riksbank: https://www.riksbank.se/sv/statistik/riksbankens-balansrakning/riksbankens-tillgangar-och-skulder-veckorapport/
STIR SWE	I use the STIR instead of the Policy rate. The STIR moves more "naturally" with more variation. Their similarity can be seen in diagram 7.1. The short-term interest rate is calculated as the mean over a three-month period. I take the first difference to make it stationary.	OECD database: https://data.oecd.org/interest/short-term-interest-rates.htm
Control Variables		
US/Eurozone unemployment	Same as unemployment SWE above.	OECD: https://data.oecd.org/unemp/unemployment-rate.htm
US/Eurozone STIR	Same as STIR above. For the year 1993, I use the German STIR as data on the EMU began in 1994.	OECD: https://data.oecd.org/interest/short-term-interest-rates.htm
US/Eurozone QE	EU QE is total assets purchased under APP. QE comes from total assets of the FED. Both are divided by GDP and with first difference taken.	FRED: https://fred.stlouisfed.org/series/WALCL EURO APP: https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html

Robustness Variables		
Oil prices	I use the Brent crude oil prices. No transformations were necessary.	FRED: https://fred.stlouisfed.org/series/DCOILBRENTEU
Energy prices	I use the global price of energy index. No transformations were necessary.	FRED: https://fred.stlouisfed.org/series/PNRGINDEXM
Policy Rate	Same as STIR.	Sveriges Riksbank: https://www.riksbank.se/sv/statistik/rantor-och-valutakurser/sok-rantor-och-valutakurser/
CPIF-XE	Same as CPIF above	SCB: https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__PR__PR0101__PR0101G/KPIF/
CPIF (STL)	Same as CPIF above, except that the STL decomposition tool is used for seasonal adjustment	SCB: https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__PR__PR0101__PR0101J/KPIFexEN/
SEK/EURO	Same as SEK/USD.	Sverige Riksbank: https://www.riksbank.se/sv/statistik/rantor-och-valutakurser/sok-rantor-och-valutakurser/

Diagram 3.1: STIR and Policy Rate



8.2 Robustness Check

The code used to conduct the robustness checks is available on my github at: https://github.com/theodorselimovic/VAR-model.git. I thank Axel Beke for help with the coding.

9 Appendix 2: Granger Causality, Forecast Error Variance Decomposition, and Model Estimation Outputs

9.1 Table 8.1: Granger Causality for No Control VAR.

VAR Granger Causality/Block Exogeneity Wald Tests			
Dependent variable: UNEMPLOYMENT			
Excluded	Chi-sq	df	Prob.
SEK_USD	16.53290	4	0.0024
INFLATION	1.751868	4	0.7813
REAL_HOUSING	6.896159	4	0.1415
QE	1.189236	4	0.8799
STIR	15.72300	4	0.0034
All	44.04161	20	0.0015
Dependent variable: SEK_USD			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	2.362992	4	0.6693
INFLATION	2.953426	4	0.5656
REAL_HOUSING	2.375464	4	0.6671
QE	5.077533	4	0.2794
STIR	9.453161	4	0.0507
All	19.62158	20	0.4818
Dependent variable: INFLATION			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	6.174582	4	0.1865
SEK_USD	4.129045	4	0.3888
REAL_HOUSING	10.44682	4	0.0335
QE	7.568473	4	0.1087
STIR	1.263876	4	0.8675
All	42.33206	20	0.0025

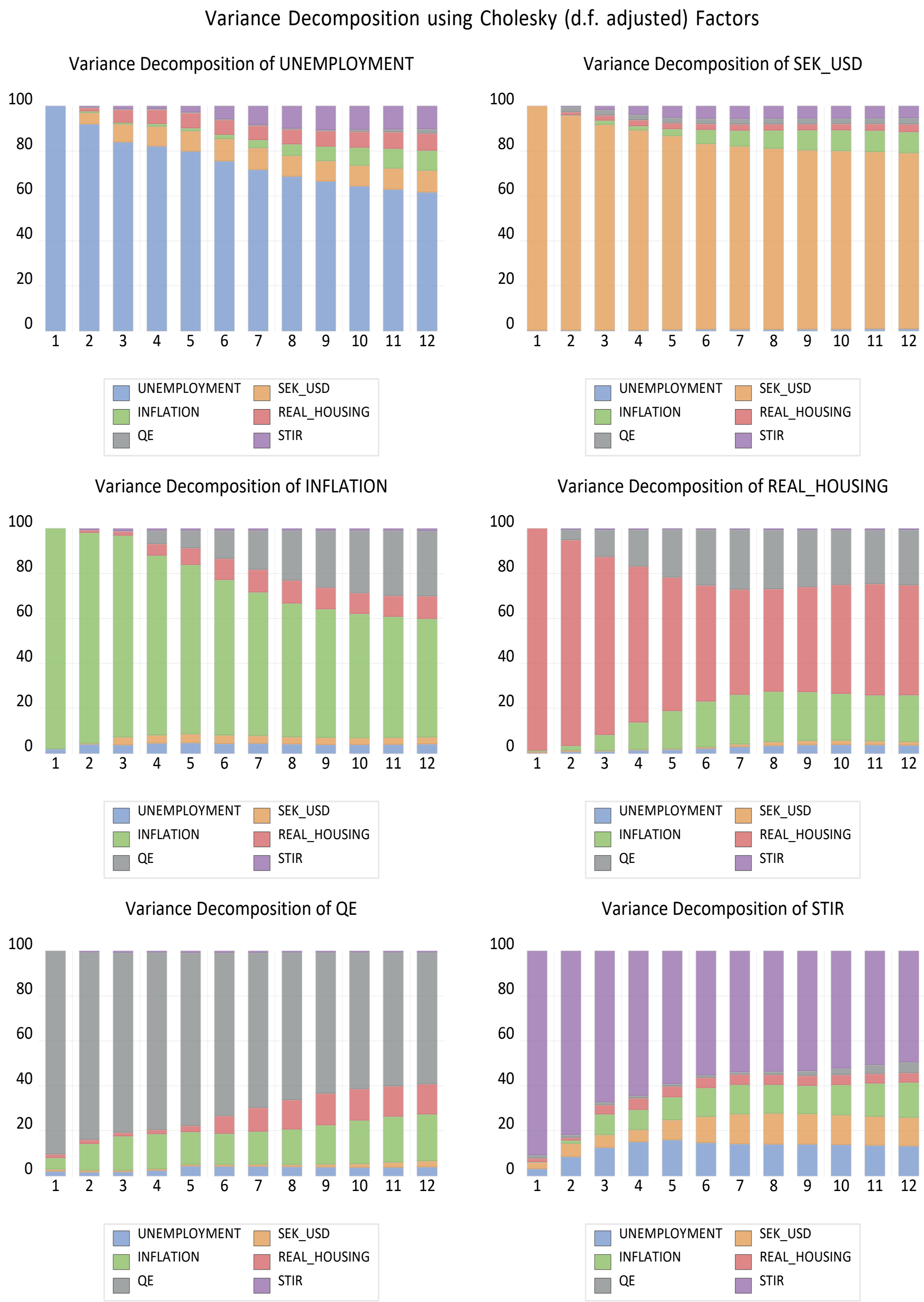
Dependent variable: REAL_HOUSING			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	6.367940	4	0.1733
SEK_USD	8.155574	4	0.0860
INFLATION	3.489833	4	0.4794
QE	22.46908	4	0.0002
STIR	4.112555	4	0.3910
All	48.45018	20	0.0004
Dependent variable: QE			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	8.920427	4	0.0631
SEK_USD	0.777369	4	0.9415
INFLATION	8.605383	4	0.0718
REAL_HOUSING	6.664055	4	0.1547
STIR	1.979189	4	0.7396
All	30.43865	20	0.0631
Dependent variable: STIR			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	7.720872	4	0.1024
SEK_USD	3.606309	4	0.4619
INFLATION	23.95724	4	0.0001
REAL_HOUSING	8.130797	4	0.0869
QE	0.726454	4	0.9480
All	51.97891	20	0.0001

9.2 Table 8.2: Granger causality for Control VAR.

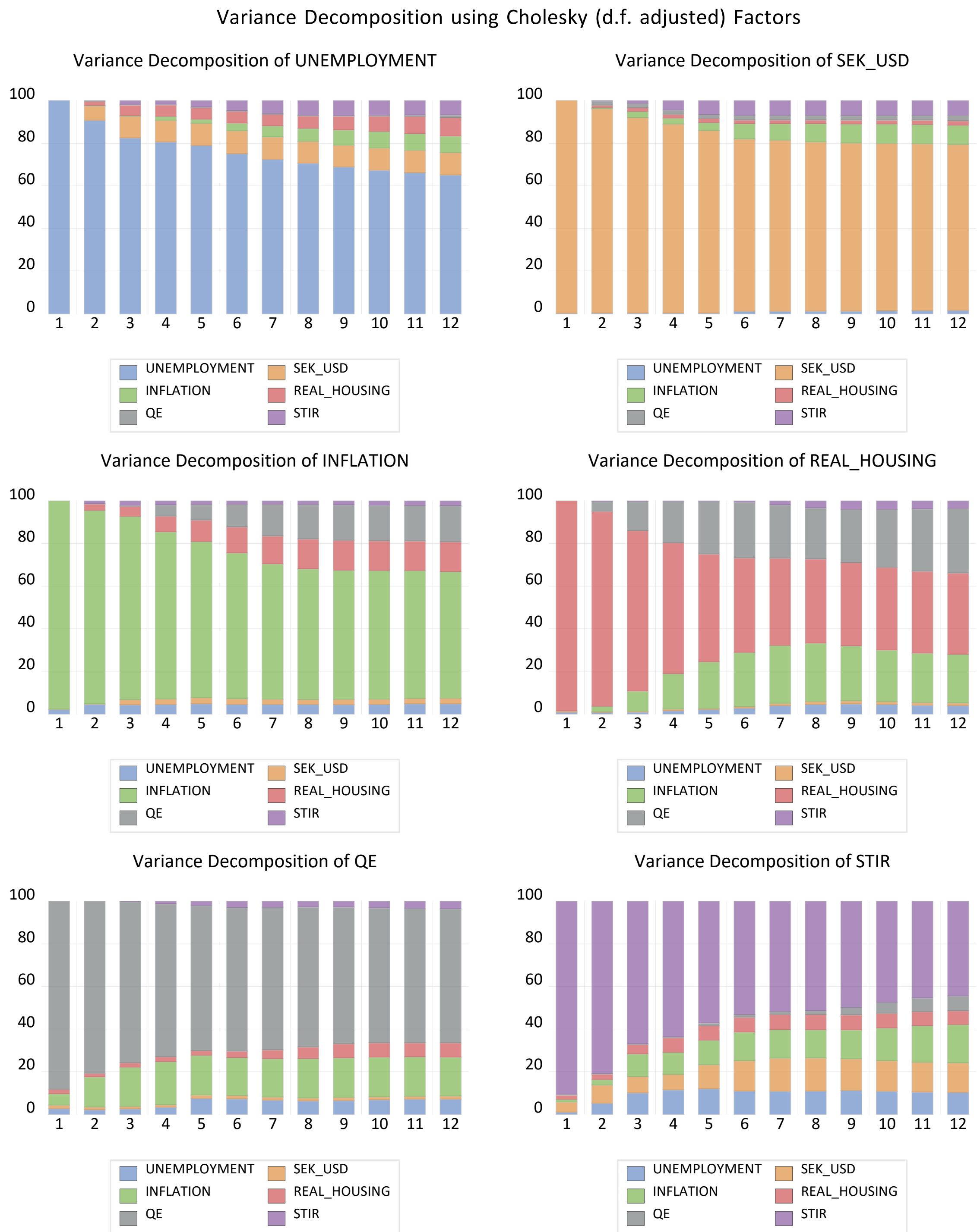
VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1993Q1 2023Q2			
Included observations: 117			
Dependent variable: UNEMPLOYMENT			
Excluded	Chi-sq	df	Prob.
SEK_USD	16.60666	4	0.0023
INFLATION	1.896268	4	0.7548
REAL_HOUSING	6.806788	4	0.1465
QE	1.271873	4	0.8661
STIR	12.69462	4	0.0129
All	41.53188	20	0.0032
Dependent variable: SEK_USD			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	1.403581	4	0.8436
INFLATION	2.205216	4	0.6981
REAL_HOUSING	1.424464	4	0.8399
QE	3.980494	4	0.4087
STIR	8.055323	4	0.0896
All	17.50220	20	0.6202
Dependent variable: INFLATION			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	5.809394	4	0.2138
SEK_USD	1.480935	4	0.8300
REAL_HOUSING	10.35102	4	0.0349
QE	6.941813	4	0.1390
STIR	2.102937	4	0.7168
All	41.26978	20	0.0034
Dependent variable: REAL_HOUSING			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	7.173557	4	0.1270
SEK_USD	10.57322	4	0.0318
INFLATION	4.066948	4	0.3970
QE	22.68878	4	0.0001
STIR	1.749179	4	0.7818
All	50.91055	20	0.0002

Dependent variable: QE			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	9.148710	4	0.0575
SEK_USD	1.207409	4	0.8769
INFLATION	9.643974	4	0.0469
REAL_HOUSING	4.424953	4	0.3515
STIR	1.631354	4	0.8031
All	28.58311	20	0.0963
Dependent variable: STIR			
Excluded	Chi-sq	df	Prob.
UNEMPLOYMENT	7.004596	4	0.1356
SEK_USD	3.814017	4	0.4318
INFLATION	22.49336	4	0.0002
REAL_HOUSING	5.360736	4	0.2522
QE	2.377157	4	0.6668
All	53.63032	20	0.0001

9.3 Diagram 8.1: Forecast Error Variance Decomposition of Model with No Control Variables



9.4 Diagram 8.2: Forecast Error Variance Decomposition of Model with Control Variables



9.5 Table 8.3: No Control VAR Model Output

Vector Autoregression Estimates						
Sample (adjusted): 1994Q2 2023Q2 Included observations: 117 after adjustments Standard errors in ( ) & t-statistics in [ ]						
	UNEMPLOY-MENT	SEK_USD	INFLATION	REAL HOUSING	QE	STIR
UNEMPLOYMENT(-1)	0.129614	-0.012112	0.003270	-0.856356	-0.007001	-0.232996
	(0.09744)	(0.01585)	(0.00148)	(0.35376)	(0.00587)	(0.11414)
	[1.33020]	[-0.76441]	[2.20709]	[-2.42072]	[-1.19336]	[-2.04135]
UNEMPLOYMENT(-2)	0.204065	0.003699	-0.000232	0.342587	-0.003559	-0.133287
	(0.10256)	(0.01668)	(0.00156)	(0.37237)	(0.00618)	(0.12014)
	[1.98963]	[0.22176]	[-0.14861]	[0.92002]	[-0.57626]	[-1.10942]
UNEMPLOYMENT(-3)	0.162033	0.015831	0.001066	0.026780	0.015160	-0.068740
	(0.10244)	(0.01666)	(0.00156)	(0.37193)	(0.00617)	(0.12000)
	[1.58170]	[0.95028]	[0.68426]	[0.07200]	[2.45781]	[-0.57284]
UNEMPLOYMENT(-4)	0.017620	0.011359	0.000265	-0.149132	-0.011163	-0.006957
	(0.09702)	(0.01578)	(0.00148)	(0.35225)	(0.00584)	(0.11365)
	[0.18161]	[0.71994]	[0.17945]	[-0.42337]	[-1.91096]	[-0.06122]
SEK_USD(-1)	-1.470538	0.271757	-0.009155	-1.199505	-0.025707	1.002418
	(0.65984)	(0.10730)	(0.01003)	(2.39562)	(0.03973)	(0.77293)
	[-2.22862]	[2.53266]	[-0.91244]	[-0.50071]	[-0.64707]	[1.29691]
SEK_USD(-2)	2.231711	0.141558	-0.010454	-4.638320	-0.013996	-0.630795
	(0.65679)	(0.10680)	(0.00999)	(2.38453)	(0.03954)	(0.76935)
	[3.39791]	[1.32539]	[-1.04667]	[-1.94517]	[-0.35392]	[-0.81991]
SEK_USD(-3)	0.845271	-0.132386	-0.006254	4.441619	0.003873	0.228425
	(0.70621)	(0.11484)	(0.01074)	(2.56396)	(0.04252)	(0.82724)
	[1.19691]	[-1.15277]	[-0.58238]	[1.73233]	[0.09109]	[0.27613]
SEK_USD(-4)	-0.881726	-0.013523	0.001945	2.658407	0.003842	-0.832969

	(0.67166)	(0.10922)	(0.01021)	(2.43853)	(0.04044)	(0.78677)
	[-1.31275]	[-0.12381]	[0.19045]	[1.09017]	[0.09500]	[-1.05872]
INFLATION(-1)	-4.271602	-0.073442	0.290798	-18.19304	-0.945637	8.968646
	(7.08893)	(1.15278)	(0.10780)	(25.7370)	(0.42682)	(8.30384)
	[-0.60257]	[-0.06371]	[2.69761]	[-0.70688]	[-2.21555]	[1.08006]
INFLATION(-2)	5.973806	-0.821568	0.097134	-39.20382	-0.218899	23.33762
	(7.09419)	(1.15363)	(0.10788)	(25.7561)	(0.42714)	(8.31001)
	[0.84207]	[-0.71216]	[0.90040]	[-1.52212]	[-0.51248]	[2.80838]
INFLATION(-3)	6.289128	1.091079	0.192176	8.827987	0.178677	-17.81538
	(7.91920)	(1.28779)	(0.12042)	(28.7514)	(0.47681)	(9.27640)
	[0.79416]	[0.84725]	[1.59583]	[0.30705]	[0.37473]	[-1.92050]
INFLATION(-4)	-0.004312	1.687660	0.025724	6.013412	0.967608	23.35667
	(7.70703)	(1.25329)	(0.11720)	(27.9811)	(0.46403)	(9.02788)
	[-0.00056]	[1.34658]	[0.21949]	[0.21491]	[2.08521]	[2.58717]
REAL_HOUSING(-1)	0.031102	0.004335	0.000538	1.346085	-0.002378	0.008307
	(0.02914)	(0.00474)	(0.00044)	(0.10580)	(0.00175)	(0.03414)
	[1.06727]	[0.91487]	[1.21358]	[12.7229]	[-1.35507]	[0.24336]
REAL_HOUSING(-2)	-0.104351	-0.000867	-0.000478	-0.456360	0.004589	0.071676
	(0.04984)	(0.00810)	(0.00076)	(0.18094)	(0.00300)	(0.05838)
	[-2.09389]	[-0.10699]	[-0.63118]	[-2.52223]	[1.52940]	[1.22781]
REAL_HOUSING(-3)	0.071152	-0.002506	0.000718	-0.105427	-0.004367	-0.139498
	(0.04807)	(0.00782)	(0.00073)	(0.17454)	(0.00289)	(0.05631)
	[1.48005]	[-0.32056]	[0.98235]	[-0.60404]	[-1.50882]	[-2.47718]
REAL_HOUSING(-4)	-0.004334	0.000197	-0.000187	0.042593	0.000487	0.057414
	(0.02790)	(0.00454)	(0.00042)	(0.10131)	(0.00168)	(0.03269)
	[-0.15532]	[0.04344]	[-0.43991]	[0.42044]	[0.28964]	[1.75657]
QE(-1)	1.053942	0.484069	-0.004120	22.93877	0.457151	-0.011035
	(1.75132)	(0.28479)	(0.02663)	(6.35833)	(0.10545)	(2.05146)
	[0.60180]	[1.69972]	[-0.15472]	[3.60767]	[4.33542]	[-0.00538]
QE(-2)	-0.572294	-0.505125	-0.019484	5.964392	0.316271	0.381200
	(1.92764)	(0.31347)	(0.02931)	(6.99848)	(0.11606)	(2.25800)
	[-0.29689]	[-1.61142]	[-0.66469]	[0.85224]	[2.72503]	[0.16882]

QE(-3)	-0.570118	-0.224821	0.081710	-11.52052	-0.025329	-1.926940
	(1.99970)	(0.32518)	(0.03041)	(7.26009)	(0.12040)	(2.34241)
	[-0.28510]	[-0.69137]	[2.68706]	[-1.58683]	[-0.21037]	[-0.82263]
QE(-4)	1.707301	-0.035922	-0.022032	8.161295	0.051567	0.720763
	(2.12660)	(0.34582)	(0.03234)	(7.72082)	(0.12804)	(2.49106)
	[0.80283]	[-0.10388]	[-0.68128]	[1.05705]	[0.40274]	[0.28934]
STIR(-1)	-0.066345	-0.007032	0.001132	0.395132	0.004474	0.692911
	(0.09047)	(0.01471)	(0.00138)	(0.32846)	(0.00545)	(0.10598)
	[-0.73333]	[-0.47797]	[0.82292]	[1.20298]	[0.82133]	[6.53841]
STIR(-2)	-0.062896	-0.017575	-0.000138	-0.475792	-0.000384	-0.288737
	(0.10787)	(0.01754)	(0.00164)	(0.39162)	(0.00649)	(0.12635)
	[-0.58309]	[-1.00195]	[-0.08438]	[-1.21493]	[-0.05906]	[-2.28516]
STIR(-3)	0.121950	0.042995	-0.000704	-0.220478	-0.004698	0.102432
	(0.10437)	(0.01697)	(0.00159)	(0.37891)	(0.00628)	(0.12225)
	[1.16849]	[2.53337]	[-0.44386]	[-0.58187]	[-0.74761]	[0.83787]
STIR(-4)	0.189507	-0.005078	1.24E-05	0.327599	0.005424	-0.141380
	(0.08425)	(0.01370)	(0.00128)	(0.30588)	(0.00507)	(0.09869)
	[2.24930]	[-0.37062]	[0.00971]	[1.07099]	[1.06934]	[-1.43256]
C	-0.032787	-0.005491	0.001817	0.032882	0.001572	-0.199190
	(0.05949)	(0.00967)	(0.00090)	(0.21597)	(0.00358)	(0.06968)
	[-0.55118]	[-0.56769]	[2.00878]	[0.15225]	[0.43904]	[-2.85865]
F-statistic	3.358144	1.473307	5.256861	61.22415	5.185124	7.681280
Log likelihood		974.5029				
Akaike information criterion		-14.09407				
Schwarz criterion		-10.55282				

9.6 Table 8.4: Control VAR Model Estimation Output

Vector Autoregression Estimates						
Sample (adjusted): 1994Q2 2023Q2 Included observations: 117 after adjustments Standard errors in ( ) & t-statistics in [ ]						
	UNEMPLOY-MENT	SEK_USD	INFLATION	REAL HOUSING	QE	STIR
UNEMPLOYMENT(-1)	0.095283	-0.012424	0.003355	-0.969086	-0.004879	-0.212137
	(0.10364)	(0.01757)	(0.00160)	(0.36943)	(0.00577)	(0.11459)
	[0.91937]	[-0.70721]	[2.10348]	[-2.62319]	[-0.84543]	[-1.85131]
UNEMPLOYMENT(-2)	0.160611	0.004603	0.000951	0.123631	-0.006877	-0.197219
	(0.11272)	(0.01911)	(0.00173)	(0.40182)	(0.00628)	(0.12463)
	[1.42481]	[0.24088]	[0.54837]	[0.30768]	[-1.09563]	[-1.58239]
UNEMPLOYMENT(-3)	0.158418	0.012391	0.000897	-0.049947	0.013311	-0.047795
	(0.10317)	(0.01749)	(0.00159)	(0.36775)	(0.00574)	(0.11407)
	[1.53555]	[0.70855]	[0.56505]	[-0.13582]	[2.31716]	[-0.41901]
UNEMPLOYMENT(-4)	-0.037291	0.009082	0.000246	0.110260	-0.011937	-0.013881
	(0.10393)	(0.01762)	(0.00160)	(0.37045)	(0.00579)	(0.11491)
	[-0.35882]	[0.51556]	[0.15402]	[0.29764]	[-2.06284]	[-0.12080]
SEK_USD(-1)	-1.719243	0.250320	-0.007914	-1.403583	-0.019331	1.064711
	(0.68796)	(0.11661)	(0.01059)	(2.45229)	(0.03831)	(0.76064)
	[-2.49904]	[2.14659]	[-0.74745]	[-0.57236]	[-0.50465]	[1.39976]
SEK_USD(-2)	2.306012	0.109632	-0.007717	-6.085473	-0.014829	-0.737744
	(0.69567)	(0.11792)	(0.01071)	(2.47979)	(0.03874)	(0.76917)
	[3.31479]	[0.92971]	[-0.72071]	[-2.45403]	[-0.38281]	[-0.95915]
SEK_USD(-3)	0.832082	-0.152147	-0.002321	3.537695	0.007494	0.400792
	(0.74646)	(0.12653)	(0.01149)	(2.66081)	(0.04156)	(0.82532)

	[1.11471]	[-1.20247]	[-0.20205]	[1.32955]	[0.18031]	[0.48562]
SEK_USD(-4)	-0.918266	-0.032292	-0.002244	3.213161	0.027607	-0.605464
	(0.68174)	(0.11556)	(0.01049)	(2.43013)	(0.03796)	(0.75376)
	[-1.34694]	[-0.27944]	[-0.21384]	[1.32222]	[0.72725]	[-0.80325]
INFLATION(-1)	-0.936180	-0.383619	0.267628	-33.56291	-0.969155	7.134128
	(7.26308)	(1.23113)	(0.11179)	(25.8899)	(0.40442)	(8.03039)
	[-0.12890]	[-0.31160]	[2.39409]	[-1.29637]	[-2.39643]	[0.88839]
INFLATION(-2)	6.482430	-0.932313	0.060612	-31.67209	-0.205530	22.06911
	(7.09748)	(1.20306)	(0.10924)	(25.2995)	(0.39520)	(7.84729)
	[0.91334]	[-0.77495]	[0.55486]	[-1.25188]	[-0.52007]	[2.81232]
INFLATION(-3)	6.646178	0.897094	0.171654	2.688989	0.076863	-13.73726
	(8.01265)	(1.35818)	(0.12332)	(28.5617)	(0.44615)	(8.85914)
	[0.82946]	[0.66051]	[1.39190]	[0.09415]	[0.17228]	[-1.55063]
INFLATION(-4)	0.440289	1.542850	0.005099	18.09052	0.951266	23.44601
	(7.88349)	(1.33629)	(0.12134)	(28.1013)	(0.43896)	(8.71634)
	[0.05585]	[1.15458]	[0.04202]	[0.64376]	[2.16708]	[2.68989]
REAL_HOUSING(-1)	0.038382	0.003879	0.000934	1.233520	-0.001313	-0.016138
	(0.03295)	(0.00559)	(0.00051)	(0.11746)	(0.00183)	(0.03643)
	[1.16482]	[0.69445]	[1.84240]	[10.5020]	[-0.71545]	[-0.44297]
REAL_HOUSING(-2)	-0.105971	-0.000508	-0.000719	-0.399401	0.004200	0.094537
	(0.05063)	(0.00858)	(0.00078)	(0.18048)	(0.00282)	(0.05598)
	[-2.09303]	[-0.05922]	[-0.92321]	[-2.21305]	[1.48977]	[1.68879]
REAL_HOUSING(-3)	0.054021	-0.002007	0.000477	-0.046522	-0.002613	-0.101900
	(0.04986)	(0.00845)	(0.00077)	(0.17772)	(0.00278)	(0.05512)
	[1.08353]	[-0.23749]	[0.62146]	[-0.26177]	[-0.94116]	[-1.84856]
REAL_HOUSING(-4)	0.003928	0.000446	0.000101	-0.007441	-0.000616	0.024699
	(0.02951)	(0.00500)	(0.00045)	(0.10521)	(0.00164)	(0.03263)
	[0.13310]	[0.08921]	[0.22318]	[-0.07072]	[-0.37507]	[0.75688]
QE(-1)	1.118486	0.487274	-0.010654	24.44383	0.419606	-0.046333
	(1.82421)	(0.30921)	(0.02808)	(6.50253)	(0.10157)	(2.01692)
	[0.61314]	[1.57586]	[-0.37947]	[3.75913]	[4.13104]	[-0.02297]
QE(-2)	-0.680072	-0.500606	-0.038501	12.07543	0.194388	0.538780

	(2.08407)	(0.35326)	(0.03208)	(7.42885)	(0.11604)	(2.30425)
	[-0.32632]	[-1.41710]	[-1.20029]	[1.62548]	[1.67513]	[0.23382]
QE(-3)	-1.277189	-0.211729	0.076218	-6.272912	-0.085266	-1.987012
	(2.06507)	(0.35004)	(0.03178)	(7.36111)	(0.11499)	(2.28323)
	[-0.61847]	[-0.60487]	[2.39802]	[-0.85217]	[-0.74153]	[-0.87026]
QE(-4)	2.175986	0.003064	-0.007339	9.075224	-0.345242	-3.110974
	(2.71961)	(0.46099)	(0.04186)	(9.69427)	(0.15143)	(3.00692)
	[0.80011]	[0.00665]	[-0.17532]	[0.93614]	[-2.27987]	[-1.03460]
STIR(-1)	-0.014677	-0.006252	0.001739	0.269068	-0.000121	0.581160
	(0.09477)	(0.01606)	(0.00146)	(0.33783)	(0.00528)	(0.10479)
	[-0.15486]	[-0.38921]	[1.19219]	[0.79647]	[-0.02289]	[5.54618]
STIR(-2)	-0.148650	-0.014315	-0.000203	-0.216356	-1.44E-05	-0.249356
	(0.11428)	(0.01937)	(0.00176)	(0.40736)	(0.00636)	(0.12635)
	[-1.30074]	[-0.73900]	[-0.11541]	[-0.53111]	[-0.00227]	[-1.97346]
STIR(-3)	0.120193	0.047341	-0.000728	-0.191853	-0.006188	0.015726
	(0.11506)	(0.01950)	(0.00177)	(0.41016)	(0.00641)	(0.12722)
	[1.04457]	[2.42726]	[-0.41101]	[-0.46775]	[-0.96578]	[0.12361]
STIR(-4)	0.196625	-0.002177	7.96E-05	0.324172	-0.000937	-0.153537
	(0.08877)	(0.01505)	(0.00137)	(0.31642)	(0.00494)	(0.09814)
	[2.21507]	[-0.14472]	[0.05827]	[1.02451]	[-0.18950]	[-1.56440]
C	-0.014512	-0.010517	-0.000806	0.027928	0.001764	-0.053357
	(0.10752)	(0.01823)	(0.00165)	(0.38328)	(0.00599)	(0.11888)
	[-0.13496]	[-0.57705]	[-0.48693]	[0.07287]	[0.29457]	[-0.44882]
L_VIX	-0.001265	0.000422	0.000151	0.001668	-7.82E-05	-0.008681
	(0.00462)	(0.00078)	(7.1E-05)	(0.01648)	(0.00026)	(0.00511)
	[-0.27366]	[0.53836]	[2.11756]	[0.10119]	[-0.30373]	[-1.69787]
L_EURO_STIR	0.181209	-0.011025	-0.000848	-0.288839	0.007661	0.093339
	(0.13320)	(0.02258)	(0.00205)	(0.47479)	(0.00742)	(0.14727)
	[1.36045]	[-0.48830]	[-0.41374]	[-0.60834]	[1.03301]	[0.63380]
L_US_STIR	-0.211399	0.008501	0.001346	0.436954	-0.007757	0.140923
	(0.08686)	(0.01472)	(0.00134)	(0.30964)	(0.00484)	(0.09604)
	[-2.43365]	[0.57733]	[1.00706]	[1.41118]	[-1.60387]	[1.46732]

L_QE_EURO	0.965066	0.027317	0.027335	-22.87059	0.726559	7.630020
	(3.99703)	(0.67752)	(0.06152)	(14.2477)	(0.22256)	(4.41930)
	[0.24145]	[0.04032]	[0.44434]	[-1.60521]	[3.26456]	[1.72652]
L_QE_US	-2.964996	0.090160	-0.001792	12.37489	0.342489	2.853750
	(2.13026)	(0.36109)	(0.03279)	(7.59350)	(0.11862)	(2.35531)
	[-1.39184]	[0.24969]	[-0.05466]	[1.62967]	[2.88739]	[1.21162]
L_UNEMP_US	-0.012799	0.008007	-0.003025	1.225509	-0.004750	0.113761
	(0.14654)	(0.02484)	(0.00226)	(0.52236)	(0.00816)	(0.16202)
	[-0.08734]	[0.32236]	[-1.34136]	[2.34608]	[-0.58214]	[0.70212]
L_UNEMP_EURO	0.186027	0.019718	0.003269	-1.118726	-0.002683	-0.018278
	(0.18738)	(0.03176)	(0.00288)	(0.66794)	(0.01043)	(0.20718)
	[0.99276]	[0.62080]	[1.13345]	[-1.67488]	[-0.25712]	[-0.08822]
Adj. R-squared	0.344924	0.035448	0.469099	0.930197	0.553247	0.635502
Log likelihood		1024.636				
Akaike information criterion		-14.23310				
Schwarz criterion		-9.700300				
Number of coefficients		192				