The Effects of Quantitative Easing on Swedish Inflation:

An Empirical Study of the Swedish Riksbank's Quantitative Easing Programme between 2015-2019

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Abstract

This paper investigates the effects on inflation of the Quantitative Easing programme employed by the Swedish Riksbank during the years 2015-2019. As previous studies have presented contradicting results on the topic, this paper aims to evaluate the potential effect of asset purchases on inflation through some of the main transmission channels identified by prevailing literature, namely the exchange rate, portfolio balancing and signalling channel. The effects are estimated with a Structural Vector Autoregressive (SVAR) model and includes monthly data of the Swedish consumer price index (CPI), growth domestic product (GDP) estimator, real exchange rate of the Swedish krona and term spread, along with data of the announcements and real asset purchases during the time period. To examine the existence of a signalling channel, the model is extended to include interest rate expectations. The results of the study indicate that inflation increases with large-scale asset purchases, mainly through the signalling channel.

Keywords

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1. Introduction

In the wake of the Global Financial Crisis (GFC), the global economy was defined by low economic activity, rising unemployment and sharp declines in output. During this time, the outlook was gloomy leading major central banks, including the European Central Bank, Federal Reserve and Bank of England to cut policy rates toward the zero-lower bound. Despite aggressive cuts of policy rates, the global economy remained distressed, and many large economies continued to struggle with low inflation expectations and economic growth. As the monetary policy tools were considered to be insufficient to combat the economic crisis, many central banks sought alternative policy tools. Among them was quantitative easing, a novel form of unconventional monetary policy strategy which consists of large-scale asset purchases.

By December 2008, the Federal Reserve had cut their policy rate from 5.25 % in September 2007 to 0 %. Nevertheless, unemployment continued to be widespread, and the economy kept contracting. With the policy rate in the zero-lower bound, conventional monetary policies became ineffective and the Federal Reserve started to seek for other policy tools. On the 28th of November 2008, the Federal Reserve publicly announced that a quantitative easing programme would be implemented to combat the crisis and would include large-scale purchases of government bonds and other financial assets. Between March 2009 and March 2010, the Federal Reserve purchased $1.25 trillion in mortgage-backed securities, $300 billion in long-term Treasury debt and $200 billion in agency debts (The American Deposit Management Co).

While several central banks launched large-scale asset purchase programmes as early as in 2008 as a direct effect of the financial crisis, the Swedish Riksbank did not hold government bonds until August 2012. During the period between 2012 and 2015, the Riksbank started to purchase government bonds to a small scale, with the purpose to prepare to use quantitative easing later on. It was not until 2015, when the Swedish Riksbank first embarked on an asset-purchase programme. The main objective with the programme was to stimulate inflation and spur economic growth by scaling up the purchases of government bonds. As the Riksbank wanted to hold the interest rates on a low level but at the same time facilitate a credit supply, the unconventional monetary policy strategy served as a more adequate tool than changing the policy rate (Riksbanken, 2022).

As of February 2015, the Swedish Riksbank decided to simultaneously lower the policy interest to negative for the first time in history. During this time, the economic uncertainty was rising globally, and the largest countries were in different states of the economic cycle. In June 2015, the European Central Bank announced an expansion of their existing Quantitative Easing programme, where they would start purchasing securities for 60 billion euros every month for at least the upcoming 1,5 years. Meanwhile, the Federal Reserve planned to restrain their monetary policy and did later on, in 2017, perform quantitative tightening.

In Sweden, the inflation rate had been below the target of 2 % for a long period with a downwards trend and low expectations. During this time, the Swedish Riksbank assessed from their inflation forecasts that it would not reach its target in the near future if no further actions would be taken. According to the Riksbank, a QE programme was therefore implemented with the main objective to stimulate the inflation rate and steer the inflation towards the target level. The QE consisted of a purchase of government bonds of 10 billion and was funded by reserves from the monetary policy counterparties. Between the years 2015 and 2017, the purchases of nominal- and real government bonds amounted to a total of 290 billion Swedish kronor (Swedish Riksbank, 2022).

Figure 1: Announced Purchases and Holdings
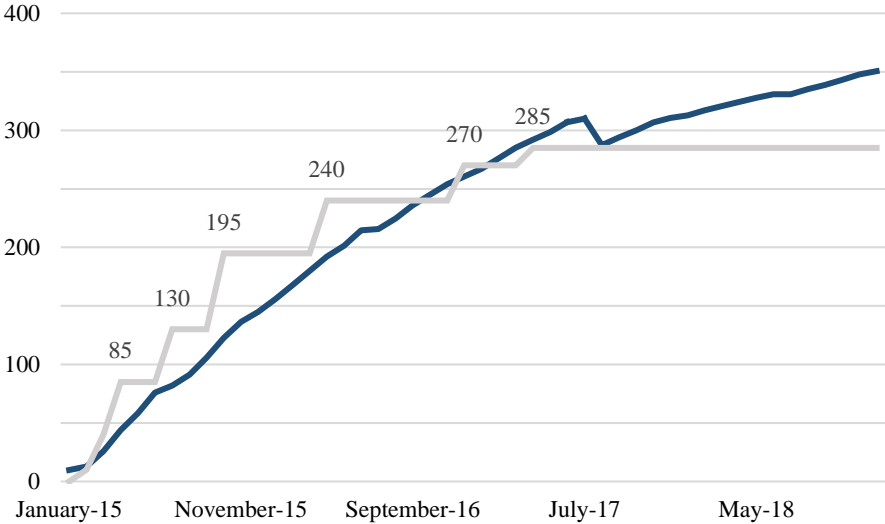
Cumulative sum of asset purchases (billion SEK) announced by the Swedish Riksbank (light grey line) and asset holding in the balance sheet (dark grey line)

While many central banks shifted to quantitative easing in response to the Global Financial Crisis, the research within the field and the side-effects with quantitative easing was not much

explored during the time. In hindsight, academic research has taken several issues to surface which have caused an extensive debate of the credibility of the policy tool and its impact on the economy (International Monetary Fund, 2022). Even though the main objective of quantitative easing is to provide monetary policy stimulus, some economists argue that large-scale asset purchases cause side-effects which render its usefulness. Some of the potential dangers include the fear of asset bubbles and long-run inflation, depreciating exchange rates, and adverse effects on the financial market when the government sells the securities (International Monetary Fund, 2022). However, the key concern which shapes the debate regards the macroeconomic effect of large-scale asset purchases, and in particular its effect on inflation. Even though the objective with the Swedish quantitative easing programme was particularly to stimulate inflation, there is an identified risk of the asset purchases causing rampant inflation. This is of great importance to highlight, in particular given the high inflation we experience today.

This paper examines the controversies of quantitative easing and the seeming disconnect between and among theory and practise concerning its impact on the economy. Mainly three transmission channels are discussed and further explored, namely the *signalling*, *portfolio balancing*, and *exchange rate channel*. In short, the signalling channel relies on the assumption that announcements of quantitative easing convey an indication that the central bank is committed to keep the policy rate low in the near time. This forms market expectation of low short-term interest rates and low cost of borrowing, which increase investments and consumption. The portfolio balance channel assumes that the lower long-term yields induced by QE announcements makes investors shift from assets with longer duration to assets with higher risks after QE announcements. Lastly, the exchange rate channel postulates that the increased money supply arising from asset purchases lowers the price of domestic assets relative to overseas assets, hence stimulates the exports. Several studies find empirical evidence of the signalling channel, for instance Eggertson and Woodford (2003) and Bernanke et al. (2004), as well as the portfolio balancing channel, see Eggertson and Woodford (2003), Haldane et al. (2016) and Weale and Wieladek (2016).

Further, there is a disagreement of the impact of quantitative easing on inflation. One strand of literature argues that large-scale asset purchases have deflationary effects (Boehl et al., 2022), and some that it should not have any macroeconomic effects at all as rational individuals with no credit restrictions do not differentiate between assets held by a central bank and assets held by themselves, hence central banks asset purchases do not have any

effect on the macroeconomy. Others find evidence of a large impact on inflation, even to the extent that it can explain the high inflation the following years after the quantitative easing programmes (International Monetary Fund, 2022).

Most analyses of the quantitative easing programmes are done by central banks; however, their results tend to show greater effects on the economy than studies performed by academia (Kempf and Pástor, 2020). Further, most empirical work on quantitative easing has mainly focused on the effects on long-term interest rates within the context of larger economies, such as the United States and United Kingdom. However, studies of the macroeconomic impact of quantitative easing effects are scarce, particularly in small open economies. To fill this important gap, this paper evaluates the asset purchase programme by the Swedish Riksbank during 2015-2019, with a focus on exploring the objective with the programme to stimulate inflation.

The aim of the study is to examine the effect of the quantitative easing programme on inflation and its potential transmission channels. As the main objective with the QE programme was to stimulate the Swedish inflation rate, the idea with this paper is to study the transmission channels in order to evaluate the strategy to use quantitative easing as an unconventional monetary policy tool to combat low inflation. Further, the programme was introduced in a time where most central banks were prepared to conduct quantitative tightening, which makes the Swedish QE programme of particular interest to evaluate.

The following research questions are formulated and addressed in this paper:

● How does quantitative easing affect the Swedish inflation rate?
● Through which transmission channels do quantitative easing affect the Swedish inflation rate?

To answer the research questions, the empirical strategy consists of a structural vector autoregressive model (SVAR), with a Cholesky Decomposition identification scheme following Weale and Wieladek (2016). The data set consists of monthly data of relevant macroeconomic variables to explore the impact of quantitative easing on inflation, and potential transmission channels through which the inflation rate is affected. Due to the time constraints, this paper is limited to study the main identified transmission channels by previous research, namely the portfolio balancing-, signalling-, and exchange rate channel. For the same reason, this paper is limited to solely study the domestic effects of the

quantitative easing programme, hence any indirect effects from other quantitative easing programmes are not explored.

This study has provided the following results. First, an asset purchase announcement shock worth 1 % of nominal GDP results in a maximum impact of 0.3923 % increase in inflation measured in CPI, along with a 0.1703 % increase in economic growth proxied by the GDP-indicator. The results are in line with prevailing studies of QE programmes in the United States and United Kingdom (Weale and Wieladek, 2014, 2016; Baumeister and Benati, 2013; Krishnamurti and Vissing-Jorgensen, 2011). In particular, the effects on economic activity and price level are identified to arise through the signalling channel. In line with prevailing studies, the estimates of this study suggest that the Swedish Riksbank's objective to increase the inflation rate was successful.

The contribution of this paper is twofold. First, studies of the impact of quantitative easing on small open economies are scarce. To the best of my knowledge, there is only one extensive study of the impact of the Swedish Riksbank's quantitative easing programme on inflation. The study is conducted by researchers from the Swedish Riksbank and estimates the direct and indirect effects of domestic and foreign quantitative easing programmes on the Swedish economy (Di Casola and Stockhammar, 2021). Given the statement by Kempf and Pástor (2020) that research conducted by central banks tend to find larger effects of quantitative easing, this paper contributes with an evaluation of the Swedish Riksbank's quantitative easing programme from an academic perspective. Second, there is a vast literature on the impact of quantitative easing on interest rates, however the effects on inflation and output are still under debate. By studying the impact of quantitative easing on the macroeconomy, this study complements and expands the prevailing literature on the macroeconomic effects of large-scale asset purchases which is of great importance when evaluating the Riksbank's decision of implementing the QE programme.

The rest of the paper is organised as follows. Section 2 presents a review of the prevailing literature of quantitative easing and inflation, how quantitative easing works and how it has been used as a monetary policy tool by central banks. Additionally, this section includes a critical discussion of some of the main research within the field. Section 3 describes the research design and econometric methodology. This section permeates with the limitations of the methodology set up and the acquired data. Section 4 consists of a presentation of the data

set and descriptive statistics. Section 5 presents the results of the study, which are later discussed in section 6. Lastly, section 7 concludes.

2. Theoretical Framework

The main objective with monetary policy is to maintain price stability by maintaining a low and stable rate of inflation. This is primarily done by conventional monetary measures, which refers to a central bank's tool to regulate the liquidity conditions in the money market by adjusting the cost of borrowing. Here, it is of importance to denote that central banks do not directly lend money to the private sector, but steer key interest rates to provide monetary stimulus.

However, in times of economic crisis conventional monetary policy tools might not be enough measures to achieve the economic objectives. Central banks throughout the world have therefore responded to economic crises with both conventional and unconventional monetary policy tools. This paper examines unconventional monetary policy, and in particular the use of quantitative easing to achieve the economic objectives. Hence, the theoretical framework consists of a presentation of the use of quantitative easing and its transmission mechanisms and channels through which it theoretically stimulates economic activity. Lastly, the chapter finishes with a summarisation of results from previous studies within the field.
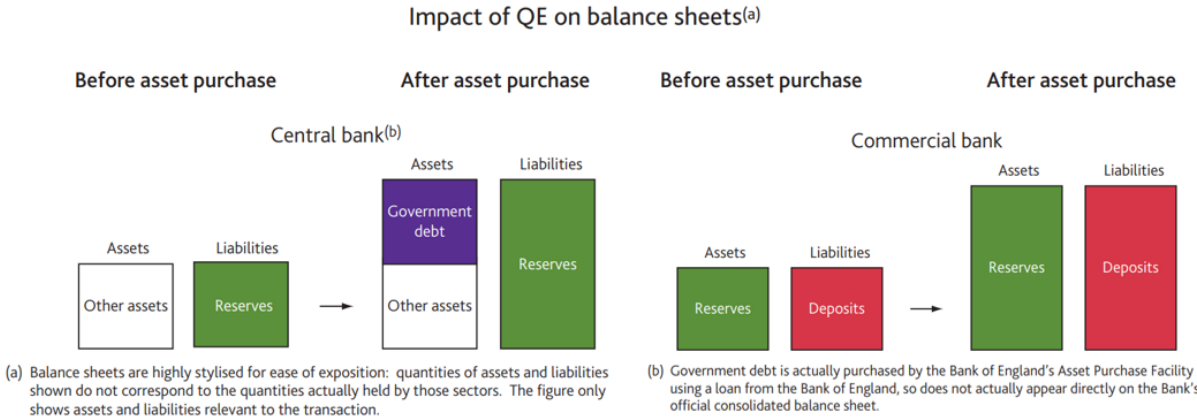
2.1 Quantitative Easing

In normal times, central banks steer key interest rates to provide monetary stimulus. By adjusting the interest rates, central banks can steer the level of liquidity in money markets and provide additional monetary stimulus in downturns. In the same way, central banks can put pressure on the inflation in upturns to hold a stable inflation rate. Following the Global Financial Crisis, a majority of advanced economies' central banks cut their policy rates radically to provide monetary stimulus. Still, commercial banks did not create enough money to meet the economic objectives, leading central banks to search for other measures.

The European Central Bank (2009) lists two reasons why the policy rate might not be a sufficient tool to combat economic distress. First, the policy rate loses its effectiveness in the zero lower bound. In severe economic downturns when the nominal interest rates are already lowered close to zero, the central bank's ability to stimulate economic growth are limited, as lowering the interest rates to negative territories cause market participants to hoard cash instead of urge spending. Under these circumstances, monetary stimulus cannot be achieved

by adjusting the short-term interbank interest rates anymore. Instead, the central bank must convey other measures which can affect the medium or long-term interest rate expectations. Second, the monetary policy transmission process can be impaired even when the policy rate is outside the zero lower bound. In these situations, the central bank must cut the policy rate even further than under normal conditions (European Central Bank, 2009).

When conventional monetary tools do not provide sufficient stimulus to the economy to meet the inflation target or other stated economic objectives, one alternative for central banks is to expand their balance sheets by implementing programmes of large-scale asset purchases (QE). The purchases usually consist of longer-term government or corporate bonds but can theoretically be any asset. When the central bank purchases government bonds, the bond yields reduce in parallel with the issued securities. The lower yields influence the economy through, inter alia lower interest rates for firms and households, which stimulate investment and spur the aggregated demand. In the figure below, McLeay et al. (2014) illustrate the impact of quantitative easing on the central and commercial banks' balance sheets. The mechanisms through which the monetary policy decisions affect key macroeconomic variables are described in section 2.

Figure 2: Impact of Quantitative Easing on Balance Sheets (McLeay et al., 2014)

However, the theoretical arguments of the impact of quantitative easing differs among economists. McLeay et al. (2014) argues for the effect as follows. A central bank's asset purchase increases the reserves with the corresponding amount to the purchase. The purchases normally consist of government and corporate bonds, where the sellers of the bonds are left with newly created deposits. With the new deposits, the sellers buy assets with higher yields

which raise the value of these assets and decrease the costs of raising funds for investments of the companies. In turn, this stimulates the overall economic activity (McLeay et al., 2014).

In sharp contrast, Eggertsson and Woodford (2003) argue that quantitative easing should not have any effects on the macroeconomy as a rational individual with no credit restrictions does not differentiate between assets held by a central bank and assets held by herself. For this reason, purchases of the government should not impose an urge among investors to rebalance their portfolios towards assets with higher yields, hence there should be no effects on the global economy.

2.1.1 Transmission Mechanisms of Quantitative Easing

Haldane et al. (2016) divides the transmission mechanism of large-scale asset purchases into two parts. In the first part, central banks expand their balance sheets by performing large-scale asset purchases. The expansion creates new reserves, with which the central bank can purchase short-term bills. In the second part, central banks swap their short-term bills to bonds with longer maturity. The extension of maturity of the holdings, creates transmission channels through which the asset purchases affect the economy (Woodford, 2012).

In theory, Bernanke argues that neither of these parts of the transmission mechanism should have a significant impact on the economy (Bernanke et al., 2004). In the majority of the economic models, an expansion of the supply of reserves does not impact the economy as they assume that there is no opportunity cost to hold reserves. Further, assuming that investors do not face any restrictions of their portfolio positions despite their budget constraints, a reallocation of assets between the central bank and institutional investors has no impact on the economy (Woodford, 2012). Instead, the effectiveness of quantitative easing relies on financial market frictions, hence we must depart from theory which assumes that the market is frictionless to understand the impact of quantitative easing on the macroeconomy.

2.1.2 Transmission Channels of Quantitative Easing

The prevailing literature of the transmission channels of quantitative easing is rich and discusses several channels through which quantitative easing affects the economy. As this paper focuses on exploring the quantitative easing effects on the macroeconomy, the paper is delimited to explore the main transmission channels of which asset purchases affect the economy: the *signalling*, *portfolio balancing* and *exchange rate channel* (Di Casola and Stockhammar, 2021; Haldane et al., 2016; Weale and Wieladek, 2016). All of the outlined transmission channels exist based on the assumption that the market functions imperfectly due

to either *information* or *market frictions*. Here, *information frictions* refer to asymmetric information where the public have less information than the central banks regarding changes in monetary policy. *Market frictions* on the other hand is based on the assumption that investors prefer some asset classes over others. As assets are not perfectly substitutable, this generates frictions on the market. Without these assumptions, the transmission channels would have little to no effect on the economy (Haldane et al., 2016).

2.2 The impact of Quantitative Easing through the Portfolio Balance Channel

The portfolio balance channel is based on the assumption that the market functions imperfectly due to *market frictions* and refers to the idea that QE affects the central banks' portfolio balance due to imperfect asset substitutability (Bernanke et al., 2004). When central banks make large-scale purchases of financial assets, this impacts the bank's balance sheet as the purchased assets can induce changes in duration and risk. For quantitative easing to have an effect through the portfolio rebalancing channel, investors cannot be indifferent with rebalancing portfolios (Joyce et al., 2012). Hence, this channel relies on the assumption that investors have a preferred-habitat demand, meaning they have preferences for certain bonds with specific maturities. Under this assumption, large-scale asset purchases induce investors to rebalance their portfolios by shifting from holding money to financial assets. The increased demand of asset holding, does in turn increase the asset prices and puts a downward pressure on the yields. According to this theory, the increased value of non-money assets stimulates the economy (Bernanke et al., 2004).

However, Bernanke et al. (2004) argue that the assumption of imperfect substitutability between money and financial assets does not necessarily hold when the policy rate is at the zero lower bound. In these situations, large-scale asset purchases inject liquidity to an economy where the demand for money is already filled. As the yields of short-term securities are pressured, money becomes substitutable as it by investors can be seen as a risk-free financial asset with zero nominal rate and no maturity. While Bernanke et al. (2004) highlights that the assumption may be violated in the zero lower bound, Krishnamurthy and Vissing-Jorgensen (2011) argues that there is always some substitutability on the financial market, independent of the demand of money. Investors tend to demand low-default-risk-assets and find these types of assets with certain maturities as substitutes.

Another key-assumption in the portfolio rebalancing channel relates to the pricing of the duration risk (Krishnamurthy and Vissing-Jorgensen, 2011). On the other side of the large-scale asset purchases are in general money market funds, pension funds and other institutions. In their trade of assets with long duration for bank deposits which are short-dated assets, their duration of their portfolio changes drastically. To rebalance the duration, they tend to reinvest the proceeds from the sale to other asset classes with longer maturities, e.g., corporate bonds. This tends to increase the price of long-term assets which reduces the premium and eases credit conditions for firms, which makes it easier for them to raise their funds. This increases economic activity as households who hold the assets have more money to consume and companies receive extra funding which can be used for investments (Joyce, 2012).

Given this background, central banks can steer the pattern of the yields on the assets by adjusting their supply. When they perform large-scale asset purchases, the expected returns on these assets decrease, which induce investors to rebalance their portfolios towards other imperfectly substitutable assets whose prices also increase (e.g., Joyce et al., 2012). It follows that investors are directly affected by the central banks' holdings of financial assets and rebalance their portfolios following the actions taken by the central bank (Carpenter et al., 2013; Joyce et al., 2012).

2.3 The impact of Quantitative Easing through the Signalling Channel

In contrast to the portfolio balance channel, the signalling channel is based on the assumption that the market functions imperfectly due to *information frictions*. When a central bank announces large-scale asset purchases, the announcements include information of the type of securities and the time period under which the purchases will be performed. In general, quantitative easing programmes are done over several years, which signals to the economy that the policy rate will not increase in the near future. The announcements of quantitative easing, rather than the actual purchasing of securities, decline the yields due to the market expectations (Weale and Wieladek, 2014; Bernanke et al., 2004).

In the signalling channel, central banks' announcements of large-scale asset purchases signal a commitment to keep the policy interest rates at the zero lower bound. The announcements are akin to forward guidance, as they provide information to the market participants from which they form their expectations of the future short-term interest rates. When a central bank announces asset purchases, market participants lower their expectations of the short-term interest rate, which in turn lowers the long-term interest rates (Christensen and Rudebusch,

2012). The lower long-term interest rates would increase the credit demand according to theory, thus stimulating the inflation in the economy.

The signalling channel has been examined in different ways by researchers, where many have provided evidence of this relationship to hold (Joyce et al., 2012; Bauer and Rudebusch, 2014; Weale and Wieladek, 2014, 2016; Krishnamurthy and Vissing-Jorgensen, 2011). There is however a discrepancy in how the effects from a signalling channel are studied. Krishnamurthy and Vissing-Jorgensen (2011) explore the channel by studying changes in prices of federal funds futures. Their assumption is that the impact on short-term rates should be greater than rates with longer maturities, as the market expectations are to hold the policy rate low in the near future. Their results suggest that signalling was an important channel for both assets deemed as safe and risky. Similarly, Joyce et al. (2011) study the signalling channel by examining the term premium in government bonds. They argue that the channel affects term premium of government bonds differently to instrument specific term premium, which enables them to distinguish between the effect of the signalling and portfolio balancing channel on the economy. As they find that the government bond purchases reduce bond supply and lower term premia, they argue that the results are an indication of the signalling channel to be present.

Vaguely, lower short-term interest rates after quantitative easing announcements could be indications of effects from a signalling channel. In contrast, lower long-term interest rates due to investors rebalancing their portfolio are rather implications of a presence of the portfolio balance channel. In presence of a signalling channel, the hypothesis here is that interest rate expectations of the short- and medium-term interest drop after a QE announcement. In contrast, a drop in long-term interest rates is rather a result of a portfolio balancing channel. However, the distinction between the channels has been drawn differently among economists. For instance, the study conducted by Joyce et al. (2011) is based on a market assumption that asset purchases only affect term premia specific to government bonds. Based on this assumption, they interpret movements in OIS rates as signalling effects, and movements in yield-OIS spread as evidence of the portfolio balance channel.

Subsequent work by Bauer and Rudebusch (2014) problematizes the market assumption by Joyce et al. (2011), hence also their inference about the effects from the portfolio balancing and signalling channel. As the study disentangles the effects only based on term premium in OIS rates and government bonds, Bauer and Rudebusch (2014) argue that they do not consider the nature of the market leading up to a flawed inference about the importance of the

channels. To account for the nature of the market, Bauer and Rudebusch (2014) divide the market into segmentations from which they measure the effects. They argue that the signalling effects operate through a local supply channel, leading to responses in instrument specific premia which can be seen by studying the responses of futures and OIS rates. In contrast, changes in term spread reflect the portfolio balance effects, also this on yield specific premia. Their distinction results in similar results to Joyce et al. (2011) but where the effects arising from the signalling channel are of larger magnitude. Overall, this implies that the ascribed effects of the different channels should be viewed carefully.

2.4 The impact of Quantitative Easing through the Exchange Rate Channel

Quantitative easing can also affect the macroeconomy through the exchange rate channel. When a central bank performs large-scale asset purchases, the price of domestic bonds increases and diminishes the yields of the bonds. The higher asset prices and lower yields decrease the demand of these bonds from foreign investors, leading to a depreciation of the domestic currency (Fawley and Neely, 2013). In turn, this impacts the price of goods and services in the economy. The intuition is that large-scale asset purchases make domestic assets cheaper in relation to substituting assets abroad, where the depreciated currency makes domestic consumers find foreign goods and services to be expensive. Not only do domestic consumers favour the domestic goods and services, but foreign consumers find the domestic goods to be cheaper as well. This increases the aggregate demand for domestic goods, and increases the inflation (Glick & Leduc, 2013).

Di Casola and Stockhammar (2021) argue that this channel is essential in small open economies. In their study of how domestic and foreign quantitative easing programmes have affected the Swedish economy, they find that the Swedish quantitative easing programme has had a significant impact on the Swedish exchange rate by depreciating the Swedish currency, leading to lower prices of domestic assets in relation to foreign. Additionally, Di Casola and Stockhammar (2021) consider potential spill-over effects of the European Central Bank's quantitative easing programme which occurred during the same period. Not surprisingly, they find that the QE announcements by the European Central Bank lowers the value of the Euro in relation to the Swedish krona, i.e., appreciates the Swedish krona.

2.5 Evidence of the Effects of Quantitative Easing

As quantitative easing has not been used for a long time, the empirical evidence of its effects on the economy is scarce. Seen to the prevailing literature within the field, studies seem to imply contradicting results on the effects on the macroeconomy. While some studies find positive effects on inflation and output, others find that quantitative easing has deflationary effects (Boehl et al., 2022).

As previously mentioned, studies published by central banks tend to imply more positive effects on the economy than studies conducted within academia. Seen to studies of quantitative easing in Sweden, the research is extremely limited. Instead, most literature regards the quantitative easing programmes in the United States, United Kingdom, and Euro Area. While the results from these studies can be useful in the decision making for the Swedish Riksbank and policy makers, the results should be viewed with caution as they are not fully applicable to the Swedish economy. Compared to large-scale economies, the Swedish economy is dependent on trading to a greater extent, causing the economy to be more vulnerable to negative shocks in import and export. During the period of the programme, the trade-to-GDP ratio was around 90%, a number which can be compared to approximately 60 % for the UK and 27 % for the US. Further, the shares of asset purchases were significantly higher in Sweden. At the end of the asset programme, the holdings of assets from the QE programme in relation to the outstanding stock corresponded to approximately 44%, compared to around 25 % for the European Central Bank.[1]

As the size of the programme and the types of economies differ significantly to Sweden, the results are not fully applicable. One of few studies of the Swedish asset purchase-programme is published by the Riksbank. The empirical strategy consists of a Bayesian Vector Autoregressive Model (BVAR) and examines the domestic and foreign quantitative easing programmes on the Swedish economy. In the study, they compare their results with the average effects from 48 studies of asset programmes in the United Kingdom, United States and Euro-area, and find that the impact on GDP is smaller in Sweden. They find that an asset purchase announcement by the Riksbank worth 1% of GDP increases the GDP by 0.16 % or 0.41% depending on the identification scheme used. The total effect on inflation is rather small, -0.06% or 0.17% depending on the identification scheme.

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[1] No data is found on the holdings of assets from the QE programme in relation to the outstanding stock in United Kingdom or United States

One of the most prominent studies of quantitative easing is conducted by Weale and Wieladek (2016), who study the impact of quantitative easing-announcements on the economic activity and price level in the United Kingdom and United States during 2009M3 to 2014M5. To do this, they use a BVAR-model with four identification schemes. The average effects of all schemes give a peak impact on GDP of 0.25 in the United Kingdom and 0.58 in the United States, with an impact on CPI of 0.62 and 0.32 respectively. In a discussion paper published for the Bank of England, Weale and Wieladek (2014) studies the large-scale asset purchases impact on the macroeconomy in the United Kingdom and United States with a Bayesian VAR-model. An asset-purchases worth 1 % of GDP increases the GDP in the United States with 0.36 %, and with 0.18 % in the United Kingdom. Seen to the inflation rate, the CPI increases with 0.38 % and 0.3 % respectively. Further, they find that the long-term government bond yields decrease with the large-scale asset purchases in the United States, and that the US dollar depreciates with announcements of asset purchases (Weale and Wieladek, 2014).

Several papers have studied the impact of large-scale asset purchases on government bond yields. In an event study, Krishnamurthy and Vissing-Jorgensen (2011) study how the US market responds to quantitative easing announcements by the Federal Reserve and find that it on average lowers the 10-year treasury bonds by 12-25 basis points. Similarly, Joyce et al. (2011) study the Bank of England QE programme where they during 2009 and 2010 purchased medium-and long-term government bonds for £200 billion. They estimate the government bond yields of 5-25 years to fall roughly 100 basis points.

2.6 Inflation Targeting

In January 1995, the Riksbank's inflation target was formally first implemented with the main objective to contribute to price stability. Up until 2017, the inflation target of two percent was set in terms of the consumer price index (CPI) but has since then referred to the consumer price index with fixed interest rates (CPIF). The inflation targeting can be seen as a guideline for the discretion a central bank has to maintain price stability, particularly in times of economic distress. A credible inflation target does also function as a benchmark for the market's expectation of the inflation, which enables firms and households to make grounded economic decisions. As the Swedish Riksbank's primary objective is to maintain an inflation rate at around two percent, policymakers are compelled to act to meet its target in the medium term. In theory, monetary policy is adjusted based on the difference between the forecasted

inflation and the target inflation rate. When a central bank's forecast of the future inflation path deviates significantly from the target, then larger adjustments need to be made (Swedish Riksbank, 2022).

Since the inflation target was introduced, the Swedish economy has experienced smaller fluctuations in the inflation rate along with higher real wages and output. According to the Swedish Riksbank, the inflation target has played a pivotal role for the economic growth and more stabilised inflation in Sweden (Swedish Riksbank, 2022). Seen to empirical studies of other countries which have adopted inflation targeting, similar results can be derived. Further, after the implementation of inflation targeting, countries overall experience not only less inflation volatility, but also lower inflation rates, declining interest rates and improved output volatility (Swedish Riksbank, 2022). These advantages are all interrelated. A more stable inflation anchors the long-run inflation expectations close to the inflation target, as the market is informed that the central bank strives for a certain level of inflation and will steer interests to reach the target. In turn, the expectations of a low, and positive inflation reduce the costs of disinflation (Martínez, 2008).

Even though there is much evidence supporting the positive effects, it is of great importance to raise some issues with inflation targeting. In light of the global financial crisis, Martínez (2008) argues that inflation targeting appears to show strong indications of a trade-off between monetary flexibility to make adjustments in fiscal policy and to maintain the inflation expectations anchored with the inflation target. During financial distress, he finds that inflation tends to deviate significantly from target which implies the framework of holding the inflation rate at a certain level may not be as beneficial in practice as it is in theory. To overcome this problem, one alternative could hypothetically be to have a flexible inflation target which is raised in times of financial distress. This postulates an open communication from authorities to the market, that they inform about the reason as well as the time horizon during which the inflation will deviate from target. While this strategy would impose monetary flexibility, it faces a challenge to keep the inflation expectations stable.

Though the Swedish Riksbank states that the economy has experienced smaller fluctuations in the economy, it is of importance to note that the Swedish inflation has overall deviated from its target and in particular in volatile periods. Since the Global Financial Crisis and up until the Covid-19 pandemic, inflation has been below target, leading central banks to cut policy rate and use unconventional monetary policies to steer the inflation rate. It should be questioned, and further studied however, when it is necessary for a central bank to intervene

in the economy to stimulate inflation. Some argue that an intervention is legitimate just as the inflation is below target, however this does not necessarily equal quantitative easing being the right tool to do it. Suggestively, the decision should rather be based upon the risks of using quantitative easing and put against the risks of having an inflation rate below target.

3. Empirical Method

3.1 Research Design

While the most prominent macroeconomic variables such as inflation and GDP are low frequency data, the range of suitable models for the data is scarce as most models cannot estimate effects if the frequency is too low. In prevailing studies of the macroeconomic effects of quantitative easing, economists tend to study the impact either with event studies through Dynamic Stochastic General Equilibrium (DSGE) models or vector autoregressive models. Event studies, and in particular DSGE-models, are commonly used in monetary and fiscal policy analysis in the explanation of historical time-series data but does also serve forecasting purposes (Krishnamurthy and Vissing-Jorgensen, 2011; Bernanke et al., 2004). Although event studies are prominent in monetary policy analysis, the technique suffers from several limitations in its application. For instance, Weale and Wieladek (2014) argue that it is difficult to identify the real economic effects in these types of empirical settings.

Others, such as Baumeister and Benati (2010), Haldane et al. (2016) and Weale and Wieladek (2014) employ different types of vector autoregressive models. One of the main advantages in the use of vector autoregressive models is the models' ability to capture potential effects even when the data is of low frequency. Further, a vector autoregression model specified in structural form allows to estimate and identify causal relationships, which is of particular interest in the study of potential transmission channels. In comparison to the event studies, these models can overcome the difficulties with identifying the real economic effects given that the identification schemes rely on a Cholesky Decomposition scheme where inflation and economic growth are unrestricted (Weale and Wieladek, 2014).

To estimate the effects of the quantitative easing programme conducted by the Swedish Riksbank during 2015-2019, a Structural Vector Autoregression Model is used. The empirical strategy follows Weale and Wieladek (2016), but with the following modifications. First, Weale and Wieladek (2016) use a Bayesian Vector Autoregression Model to estimate the effects of quantitative easing on macroeconomic variables. However, the empirical model in

this paper consists of a Structural Vector Autoregression Model instead. This modification is done due to practical constraints, as a Bayesian Vector Autoregression Model is out of the scope in this paper. Second, the vector of endogenous variables is adjusted for the purpose of the study. A detailed explanation of the adjustments is presented in section 3.2.

3.2 Econometric Model

The baseline model is estimated with monthly data given by the following equation:

$$Y_t = \alpha_c + \sum_{k=1}^{L} A_k Y_{t-k} + e_t \qquad e_t \sim (0, \Sigma)$$

where Y_t is a vector of the following set of endogenous variables at time t: the Swedish price level, the Swedish GDP indicator, the Swedish Riksbank's asset purchases, the term spread and the Swedish Krona real exchange rate, A_k is an array of coefficients associated with the corresponding lagged vector for lag k and e_t is a vector of residuals at time t.

The vector autoregression model estimates the dynamic relationship between the asset purchases and each of the macroeconomic variables in the vector Y_t. This allows us to interpret the effects of asset purchasing on inflation and economic growth. As there is no available data of the Swedish GDP growth measured on a monthly basis, the Swedish GDP indicator is included as a proxy in the estimation of economic growth. To account for conventional monetary policy performed during the period, a variable for term spread is constructed instead of just including the yield on the 10-year government bond as in Weale and Wieladek (2016). Here, the term spread is defined as the difference between the 10-year and the 3-month government bond yields. By further imposing identifying restrictions on the dynamic correlation between the variables, we can further identify any causal relationships and transmission channels.

To test for cointegration of any variables within the data set, the Johansen procedure is followed. More precisely, the work process is done in the following steps. First, the order of integration of the variables is determined with an Augmented-Dickey-Fuller test, hereby referred to as an ADF-test. The test is based on the null hypothesis of a unit root, meaning the time series is only stationary under the alternative hypothesis. Seen to the results of the ADF-test, all variables are integrated at order zero except the price level and exchange rates which are integrated at order one, i.e., are stationary under the first-order difference. As some variables share the same order of integration, an Engle-Granger is performed to test if any

share the same stochastic trend. The results indicate that none of the variables share the same stochastic trend, meaning there is no cointegration.

Second, the VAR(p) model is identified with deterministic variables and exogenous regressors. In the selection of the lag length, several methods can be used. Some studies rely on information criteria, such as the Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (SC/BIC) or the Hannan-Quinn (HQ) Criterion, while other rely on economic theory and previous literature and determine the lag length from previous models. While economic theory can be used as guidance, the choice of lag length is crucial when modelling the data, where too many lags increase the forecasting errors and omitting lags may impose estimation bias. For this reason, the model relies on a statistical criterion which functions as an estimator of the optimal lag length.

In this paper, the choice of lag length is given by the lag order which minimises the Schwarz Bayesian Information Criterion (SC/BIC), which suggests that the optimal lag length is two. Further, to test if any of the variables are cointegrated, a trace- and maximum eigenvalue-test with the identified VAR(p) is performed. From the results, we can lastly check the rank to determine how the variables are optimally measured. The range of coefficients which are related to the one-lagged vector of variables are presented by A_k. Further, the residuals are tested for normality with a Jarque-Bera test. Given the results, they are presumed to follow a normal distribution along the variance-covariance matrix.

From the prevailing literature presented in section 2, the large-scale asset purchases are assumed to have a positive effect on economic activity and inflation (Joyce et al., 2011; Baumeister and Benati, 2013; Bernanke et al., 2004; Weale and Wieladek, 2014, 2016). In the model specification, the hypothesis is that the coefficients of the GDP indicator and CPI are positive if quantitative easing stimulates activity in the economy.

Existing research has studied the signalling channel in different ways. Weale and Wieladek (2014, 2016) study the Overnight Index Swap rates in the investigation of the signalling effect, while Krishnamurthy and Vissing-Jorgensen (2011) study the changes in prices of the federal funds futures contracts. The latter study compares the price of the federal funds future contracts with different maturities and argues that the price of the contracts with long-maturity rates should have been less affected than the contracts with intermediate maturity for the signalling channel to exist. Recalling the theory of the signalling channel, Weale and

Wieladek (2014) argue that announcements of quantitative easing induce a downward pressure on the short-term interest rates, which in turn lowers the long-term interest rates.

In this study, we examine the existence of the signalling effect by studying the interest rate expectations from the 1-month STIBOR rate. To do this, we adjust the baseline model by replacing the term spread with the 1-month STIBOR rate. In the presence of a signalling channel, Krishnamurthy and Vissing-Jorgensen (2010) states that interest rates at short maturity are mostly affected, as QE announcement communicates to the market that the policy rates will remain low in the near future. However, as the announcements do not communicate any information about the interest rates in the medium and long term, these interests are not targeted in the channel. Following the existing research of QE programmes, the signalling effect is examined by the Swedish equivalent Overnight Index Swap (OIS) rate, namely the 1-month Stockholm Interbank Offered Rate (STIBOR). Based on the theory of the signalling effect, the assumption is that the 1-m STIBOR rate will fall in response to a quantitative easing announcement shock.

It is of importance to denote the difficulties to study the real effects of the channel (Weale and Wieladek, 2014). First, it is difficult to distinguish between the effects from the signalling and the portfolio balancing channel. Second, as the large-scale asset purchases are done simultaneously with the forward guidance policy, it is difficult to distinguish whether the effects are a result of the asset purchases or the policy. For this reason, the interpretation of the signalling effects should be done carefully.

Lastly, the examination of the existence of the portfolio balancing channel is performed in the following way. According to economic theory, large-scale asset purchases are assumed to lower the long-term government bond yields through the portfolio rebalancing channel. Hence, the existence of the portfolio balancing channel is studied in the baseline model by looking at the term spread. If the portfolio balancing channel exists, the coefficient of term spread is expected to be negative in response to the asset purchases. Seen to the exchange rate channel, the Swedish krona is expected to depreciate in response to quantitative easing.

3.2.1 Identification Scheme

One of the main difficulties in the use of structural VAR-models regards the interpretation of the shocks, as the orthogonal and structural economic shocks can be difficult to disentangle from the reduced form shocks. To overcome this problem, a replication of the Cholesky

Decomposition Scheme formulated in Weale and Wieladek (2014) is applied to the empirical strategy. Based on previous literature, the GDP-indicator and inflation are left unrestricted as researchers have provided contradicting results of whether the variables respond to large-scale asset purchases. Further, a potential response in GDP and inflation are not assumed to be direct but rather have a lagged reaction. In contrast, the government bond yields, hence the term spread, exchange rates and 1-month STIBOR rate are assumed to respond immediately to asset purchases as market participants adjust their expectations as soon as new information hits the market. For this reason, the Cholesky Decomposition Scheme lists the GDP-indicator and inflation first, followed by the asset purchases and lastly the term spread and interest rate expectations.

Table 1: Identifying restrictions for the baseline model.
Cholesky Decomposition Scheme

	Log CPI	GDP-indicator	Asset Purchases	Term Spread	Log Exchange Rates	STIBOR
Log CPI	1	0	0	0	0	0
GDP-indicator		1	0	0	0	0
Asset Purchases			1	0	0	0
Term Spread				1	0	0
Log Exchange Rates					1	0
STIBOR						1

4. Data

In order to examine potential effects of the Swedish Riksbank's quantitative easing programme during 2015-2019 on the Swedish inflation rate, the sample includes data of the effective purchases along with a vector of macroeconomic variables. The econometric model consists of data at a monthly frequency and covers the time period from when the Swedish Riksbank first implemented its quantitative easing programme up until 2019. Even though the Swedish Riksbank proceeded with asset purchasing the following years, the QE programme between 2015-2019 was explicitly aimed to stimulate the inflation rate and is therefore the focusing time period of this study. Further, to study the transmission channels specified in

section 2.1.2, data of the announcements of quantitative easing as well as the share of asset purchases are included.

Following Weale and Wieladek (2016), the Swedish Riksbank's asset purchases are measured by taking the ratio of the cumulative announced purchases by the Riksbank and dividing it by the annualised nominal GDP as of December 2014, i.e., the last month before the programme was implemented. This is done to minimise any endogeneity effects arising from contemporaneous levels in GDP. The data of the asset purchases are retrieved from the Swedish Riksbank, and data of the GDP level is acquired from Statistics Sweden. Further, the vector of macroeconomic variables includes data of the monthly GDP indicator, the consumer price index (CPI), the real exchange rate of the Swedish krona, the 10-year and the 3-month government bond yields and the asset purchases performed during the time period. Here, the monthly GDP indicator is included as a proxy for economic activity and the consumer price index is included as a proxy for inflation. Data of the GDP-indicator and CPI are acquired from Statistics Sweden, while the remaining variables are retrieved from the Swedish Riksbank. Furthermore, the real exchange rate of the Swedish krona serves the purpose to measure the exchange rate transmission mechanism. Here, the Swedish krona is measured in relation to the United States Dollar and the Euro and are chosen as the United States and the European Union are Sweden's main trading partners. Data of the exchange rates are retrieved from the Swedish Riksbank as a monthly average based on published quotations for daily fixing rates. Further, the term spread, which is defined as the difference between the 10-year and the 3-month government bond yields, accounts for conventional monetary policy performed during the time period studied.

Data of the monthly GDP indicator is given by Statistics Sweden calculated on the use- and supply side of the economy. While the indicator is compiled similar to the regular GDP data provided by Statistics Sweden, the indicator uses earlier estimates of economic statistics compared to the regular GDP statistic. This generates an estimation error, however as the mean absolute error is less than 0.3 percentage points during the time period, the errors are considered to be small (Statistics Sweden, 2020). As there is no available data of GDP measured monthly, the GDP indicator serves as the most appropriate estimate of economic activity based on its frequency and low estimation error.

Several studies of quantitative easing have studied the signalling effect by looking at the Overnight Index Swap (OIS) rates (Weale and Wieladek 2014, 2016). Studies of the European

Central Bank's asset purchase programme have focused on the EONIA swap rates, likewise, have studies of the quantitative easing programme in the United Kingdom looked at the London Interbank Offered Rate, LIBOR (Haldane et al., 2016). Based on the prevailing studies, the signalling effect is studied by looking at the corresponding Overnight Index Swap (OIS) rate in Sweden, namely the Stockholm Interbank Offered Rate 1-month (STIBOR) rate. Up until 2020, STIBOR was used as an interest rate benchmark frequently used in FX derivatives and other financial contracts with variable interests. The rate is defined as "[…] a measure of the interest rate applied by panel banks for unsecured lending in Swedish krona (SEK) to leading banks." (Swedish Financial Benchmark Facility). Data of STIBOR is acquired from the Swedish Riksbank with a T/N (Tomorrow/Next) of 1 month.

5. Results

In this section, results from the baseline model and adjusted model are presented, along with the functioning and existence of the exchange rate, portfolio balancing, and signalling channels. The section begins with a presentation of the baseline model, from which we get results of the impact of quantitative easing on the economy and the existence of the exchange rate and portfolio balancing channel. To study the signalling channel, the baseline model is adjusted where the term spread is replaced with interest rate expectations by including data of the 1-month STIBOR rate. The results from the adapted model and the existence of the transmission channel are presented. Lastly, the section sums up with a brief presentation of the robustness checks performed to verify the obtained results in the models.

5.1 Baseline Model

The results from the baseline model are reported by impulse response functions to the Swedish Riksbank's quantitative easing shocks based on a Cholesky Decomposition scheme. Figures 3 and 4 indicate an overall expansionary effect on the Swedish economy, as the GDP-indicator and CPI increase in response to a QE shock. The positive and significant response of the variables to the asset purchases indicate that the announcements have a positive impact on economic activity and price level. Similar to the results in the study by Di Casola and Stockhammar (2021), economic activity and price level seem to increase despite a higher term spread and the Swedish krona appreciating in relation to the Euro. This indicates that the effect on economic activity and price level is not a result of an exchange rate effect, but rather suggests that the effects come from other transmission channels. Overall, the positive responses in inflation and GDP after asset purchase announcements are in line with prevailing

studies (Baumeister and Benati, 2010; Weale & Wieladek, 2014; Di Casola and Stockhammar, 2021).

The response of a higher term spread after a shock in QE could be explained by spill-over effects from foreign quantitative easing programmes. Even though the spill-over effects were out of scope to study, related literature provides evidence of such effects from the European Central Bank's asset purchase programme performed during the same time. Di Casola and Stockhammar (2021) find that the long-term interest rates in the Euro area were reduced following the ECB's QE programme. Meanwhile, the term spread in Sweden rose due to increased Swedish long-term interest rates.

As the asset purchase programme (APP) in the Euro area was active during the same time as the Swedish quantitative easing programme, the direct and indirect effects from the APP in the Euro area are difficult to disentangle from the effects of the Swedish QE programme. For this reason, it is possible that the positive effects of the Swedish QE programme that are found in this study are not only a result of the Riksbank's asset purchases, but also the European Central Bank's. Hence, the empirical strategy might suffer from omitted variable bias, as the positive effects may in fact be lower than what is implicated as the estimates might also ascribe the effects from coinciding foreign quantitative easing programmes. Overall, the results indicate that quantitative easing has positively affected the economic activity and price level in Sweden. However, the potential omitted variable bias is of importance to highlight, nonetheless as other studies, inter alia Di Casola and Stockhammar (2021), find indications of such spill-over effects.

Moreover, the maximum impact of a quantitative easing announcement to a value of 1% of the Swedish GDP in December 2014 on the price level is 0.3923 % and 0.1703 % in economic growth. As with the impulse response functions, the estimates are based upon the Cholesky Decomposition scheme. These results are in line with other studies on the topic. For instance, the study by Weale & Wieladek (2014), an asset purchases announcement with a value of 1 % of GDP increased the inflation rate with 0.50 % in the United States, while the inflation rate in the United Kingdom with 0.84 %. Similarly, Di Casola and Stockhammar (2021) find that the large-scale asset purchases by the European Central Bank with the same worth of announcements in terms of GDP increased the Swedish price level with 0.22% or 0.23% depending on identification scheme. Seen to the effects from the Swedish Riksbank on the price level, they are lower with -0.06 or 0.17% depending on the imposed restrictions.

5.2 Transmission Channels

Prevailing literature have studied effects through the portfolio balancing channel in various ways, inter alia by looking at term spreads and changes in government bonds with longer maturities (Di Casola and Stockhammar, 2021; Weale and Wieladek, 2016). Overall, it tends to be the main identified transmission channel and has shown to stimulate economic growth by lowering the long-term rates in response to asset purchases. Following Di Casola and Stockhammar (2021), the portfolio balancing channel is here examined by studying the response in term spread after a QE announcement. Signs of the existence of portfolio balancing effects are according to theory shown in lowered long-term interest rates, leading to smaller deviations between the long- and short-term interest rates. For this reason, the hypothesis is that the term spread would decrease following an asset purchase announcement if the portfolio balancing channel exists. Seen to the impulse response function in the term spread, it does not show any evidence of lower term spreads. Hence, the results do not indicate any existence of the portfolio balancing channel (see figure 5).

Instead, it rather implies that the economic activity is stimulated through the signalling channel (see figure 8). In contrast to the portfolio balancing channel which lowers the long-term interests, the signalling channel is distinct as it assumes to lower the interest rate expectations. By adjusting the baseline model and replacing the term spread with 1-month STIBOR rate, the results can provide indications of the presence of a signalling channel. Seen to the impulse response functions, the reference rate drops in value as a direct response of the Swedish QE programme. These results are in line with the results of the QE programme in the United Kingdom during 2009-2013 provided by Weale and Wieladek (2014), which find the signalling channel to be the most prominent channel through which quantitative easing impacts the economy.

Further, as Sweden is a small open economy highly dependent on trade, the country is vulnerable to changes in exchange rates. In 2021, the exports of goods and services from Sweden amounted to 45.5 %, with the European Union and United States as two main trading partners. For this reason, potential effects on the Swedish economy arising from the exchange rate channel are examined by studying the response of the Swedish krona in relation to the United States Dollar and the Euro. From the results, it appears that the Swedish krona appreciates in relation to the Euro, while remains rather unchanged to the United States

Dollar. The results are in sharp contrast to theory of the exchange rate channel, which states that the existence of such a channel would depreciate the domestic currency.

As earlier mentioned, the appreciation of the Swedish krona in relation to the Euro could potentially be due to a reversed exchange rate effect as indicated by Di Casola and Stockhammar (2021). Di Casola and Stockhammar (2021) study both the effects of the QE programme conducted by the Federal Reserve and the European Central Bank but do only find results of a spill-over effect through the exchange rate channel in the former. Similarly, from the impulse response functions in this study the Swedish krona in relation to the United States Dollar remained stable despite a QE shock (see figure 6). In sharp contrast, the Swedish krona appreciated in relation to the Euro (see figure 7). These results are in line with Di Casola and Stockhammar (2021), from which the conclusion is that the exchange rate of the Swedish quantitative easing programme does not seem crucial. However, it provides some indications of spill-over effects through the exchange rate channel from the European Central Bank's asset purchase programme.

5.3 Robustness

In this study, quantitative easing has been proxied with the effective purchases by the Swedish Riksbank. To further explore the signalling channel, quantitative easing has also been proxied by the announced asset purchases during the time period studied. While the announced asset purchases allow exploration of the signalling channel, it is also used to verify the results. In a comparison between the proxies, the results are overall similar with the same direction of the effects. Seen to the estimated effects, the proxy with the announced purchases indicates slightly larger effects. One explanation to this difference could particularly be due to the existence of the signalling channel, where the market expectations of the asset purchases impact the economic activity to a greater extent than the asset purchases themselves.

Further, it is common that small vector autoregressive models suffer from omitted variable bias (Weale and Wieladek, 2014). In general, quantitative easing programmes are limited to a few years resulting in limited sample periods, hence the studies of QE tend to be vulnerable to omitted variable bias. Also, studies of quantitative easing are in particular argued to suffer from omitted variable bias as large-scale asset purchases tend to coincide with sharp cuts of policy rates or significant changes in fiscal policy. Not only do other changes in domestic policy happen together with the implementation of quantitative easing but it also tends to

coincide with foreign QE programmes and shifts in monetary policy as well. For this reason, it can be difficult to disentangle the effects of quantitative easing from the effects of other monetary policy tools.

Due to the limited time frame, only a few robustness checks have been performed. To check whether the changes in monetary policy rate during the time period might have impacted the estimates, the Swedish policy rate is included as an additional variable to the model. Further, the sample period of the model has been extended with 12 months prior to the implementation of the quantitative easing programme where asset purchases were made to a very small scale, as well as 12 months post the programme which was solely characterised by reinvestments and no announcements. Seen to the results from the robustness checks, the main results are confirmed as no significant changes appear with the changes.

6. Discussion

The results of the study indicate that the Swedish Riksbank's quantitative easing programme during 2015-2019 have had positive effects on the economic activity and price level. This indicates that the objective with the programme was successful. However, there are some important remarks which are of great importance to highlight in the interpretation of the results. While the results indicate positive effects on inflation, this does not necessarily imply that quantitative easing is the optimal strategy in times of low inflation. Based on the potential problems with quantitative easing presented in the theoretical framework, the theoretical arguments play an important role in the decision of whether quantitative easing should be implemented.

For this reason, the results should be interpreted as an indication that the policy could be targeted and implemented under certain circumstances but should be done with caution. Even though the study provides evidence of the advantages of quantitative easing to stimulate the inflation rate, the risks with embarking on the policy measure are not explored in this study. Also, having it in mind that large-scale asset purchases are still a novel strategy, the evidence of the medium- and long-term effects are scarce. In light of today's economy which is characterised with high inflation despite significant raises of the policy rate, it is not unlikely that the high inflation is a partial aftermath of the last years' large-scale asset purchases.

Given the results of this study together with the theoretical arguments presented by the International Monetary Fund (2022), the topic requires further studies of its medium and long-

term effects. Until then, the decision to implement quantitative easing programmes should be done with great caution and limited to situations where the policy tool is the very last measure to confront macroeconomic instability. With this being said, quantitative easing could still be an appropriate strategy in some circumstances, in particular as the results indicate that the inflation rate and economic activity responded positively to the programme. However, the decision to embark on a QE programme, the type of assets to purchase, and the length of the programme, should be taken upon a series of considerations. A primary consideration regards the domestic and global economic conditions, in particular any deflationary pressures and level of the policy rate. As the policy tool is not easily reversible, these considerations should be carefully studied as opting out from a QE programme can damage the credibility of the central bank. For this reason, the announcements should suggestively be modest in size in the beginning and limited to use solely for reaching macroeconomic stability.

7. Conclusion

The application of quantitative easing became widespread after the financial crisis of 2007-2008, when several central banks had policy rates in the zero lower bound and were forced to resort to other monetary policy tools to combat the crisis. To bring the economies out of recession, the United States, United Kingdom, and the Eurozone undertook quantitative easing programmes to stabilise the economic contractions and rebalance the functioning of the financial markets. As the monetary policy form is still novel, the sample availability is limited and its medium- and long-term effects are therefore not yet fully explored. Seen to the short-term effects, the uncertainty of the results is high due to spill over effects from contemporaneous monetary policy tools. Further, it may be argued that small open economies like Sweden are subject to foreign spill-over effects from large macroeconomic events and policy changes.

In 2015, the Swedish Riksbank announced that a quantitative easing programme would be implemented with the main objective to stimulate inflation. This paper examines this programme by studying its impact on the Swedish inflation rate, and the transmission channels through which it affects inflation. As quantitative easing as a monetary policy tool has been argued for having debatable effects on the inflation rate, this paper evaluates the programme's objective and impact on the economy. The data set covers the time period from 2015 to 2019, under which the Swedish Riksbank expressed that the intention with the asset purchases was to specifically target the inflation. Further, the data is measured on a monthly

basis, hence consists of 48 observations. To study the transmission channels, the data set includes data of government bond yields, term spread, exchange rates, 1-month STIBOR rate and the GDP-indicator.

In context of the Swedish Riksbank's quantitative easing programme during 2015 and 2019, this paper provides evidence that the large-scale asset purchases during the period contributed to higher Swedish inflation rate and economic activity. In particular, the asset purchases have affected the inflation rate and economic activity through the signalling channel. This paper shows that the inflation rate increased by approximately two percentage units during the time period, with a maximum effect of 0.3923 % increase after an asset purchase shock worth 1 % of the Swedish GDP. Overall, the results indicate that the quantitative easing programme was successful in terms of its objective. These results coincide with several studies, among them Joyce et al. (2012), Di Casola and Stockhammar (2021) and Weale & Wieladek (2014, 2016). In particular, the result on the transmission channels is in line with the results of the QE programme in the United Kingdom by Weale & Wieladek (2014), as they illustrate that the asset purchases mainly transmit to the economy through the signalling channels. As a result, one can argue that the programme was successful in the way that the inflation increased following the asset purchases, without taking its potential risks and side-effects into consideration.

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Appendices

Table 2: Descriptive Statistics

Variable	Mean	Median	Max	Min	Std. Dev.	Obs.
CPI	1.18	1.40	2.3	-0.4	0.84	48
GDP-indicator	0.25	0.30	3.4	-2.8	1.21	48
Term Spread	0.93	0.95	3.7	-2.6	1.50	48
EUR/SEK	9.68	9.54	10.46	9.21	0.39	48
USD/SEK	8.56	8.53	9.21	8,00	0.33	48

Table 3: The Swedish Riksbank's Purchase Announcements during 2015-2019

Date	Purchase Announcements
February 2015	10 billion SEK
March 2015	30 billion SEK
April 2015	40-50 billion SEK
July 2015	45 billion SEK
October 2015	65 billion SEK
April 2016	45 billion SEK
December 2016	30 billion SEK
April 2017	15 billion SEK

Table 4: Data Description

Variable	Transformation	Source
CPI Price Level	log	Statistics Sweden
GDP-indicator		Statistics Sweden
EUR/SEK	log	Swedish Riksbank
USD/SEK	log	Swedish Riksbank
10-year Government Bond Yield		Swedish Riksbank
3-month Government Bond Yield		Swedish Riksbank
1-month STIBOR rate		Swedish Riksbank
Asset Purchase Announcements		Swedish Riksbank
Effective Asset Purchases		Swedish Riksbank

Figure 3: Real macroeconomic effects. Impulse response function of inflation to asset purchases of one Cholesky standard deviation.
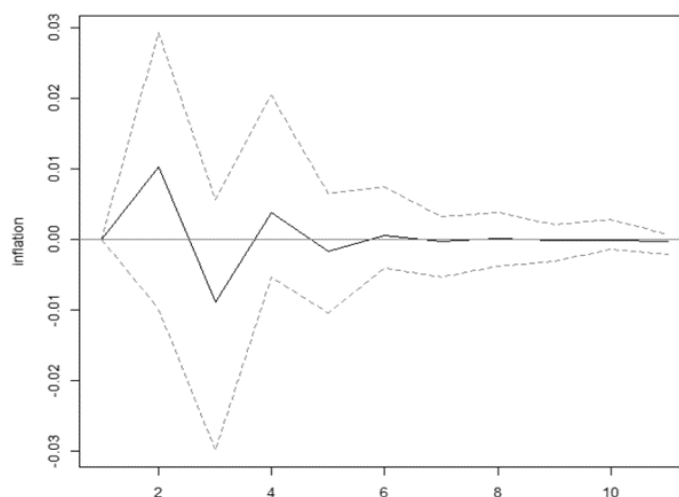
Figure 4: Real macroeconomic effects. Impulse response function of GDP to asset purchases of one Cholesky standard deviation.
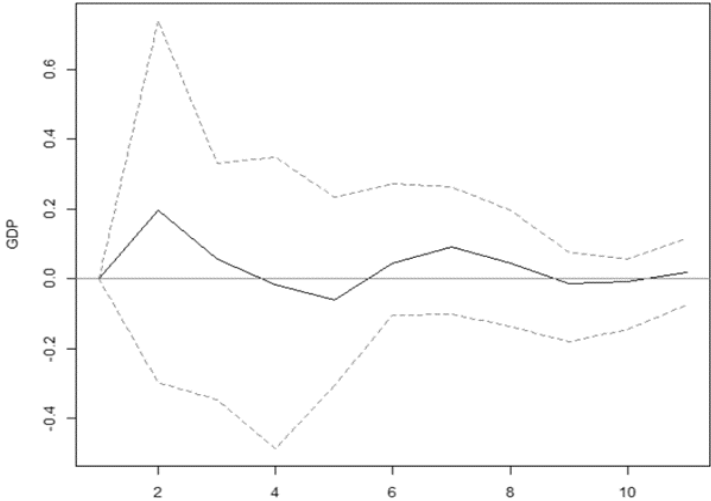
Figure 5: Portfolio Balancing Channel. Impulse response function of term spread to asset purchases of one Cholesky standard deviation.
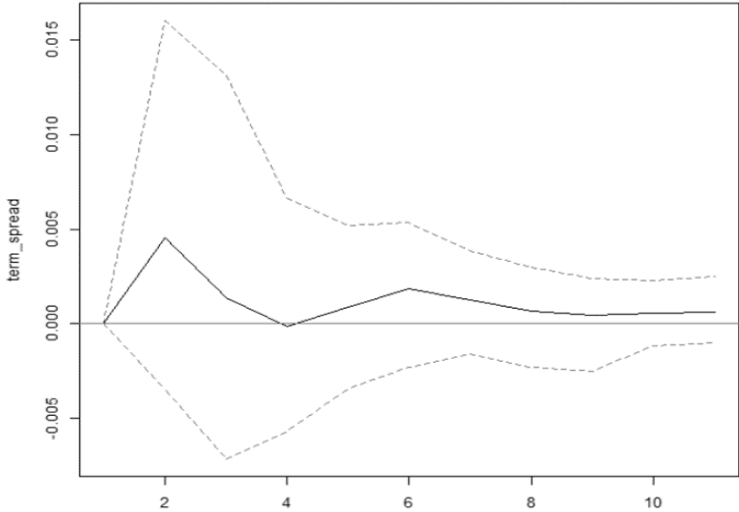
Figure 6: Exchange Rate Channel. Impulse response function of USD/SEK to asset purchases of one Cholesky standard deviation.
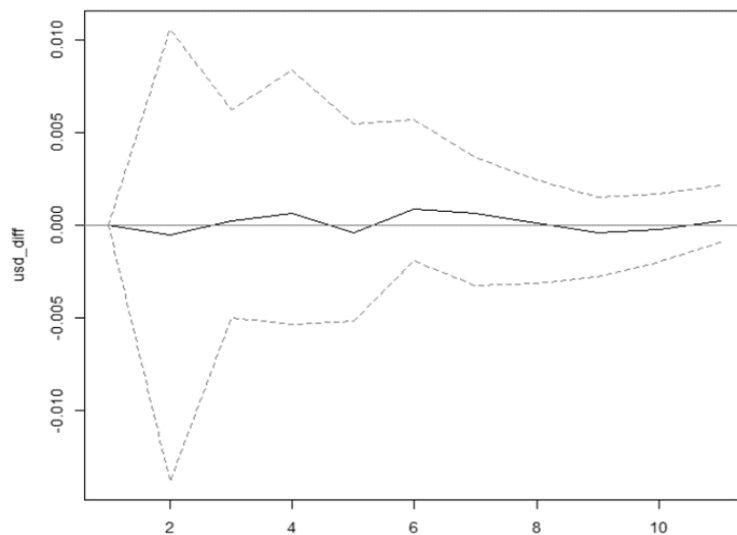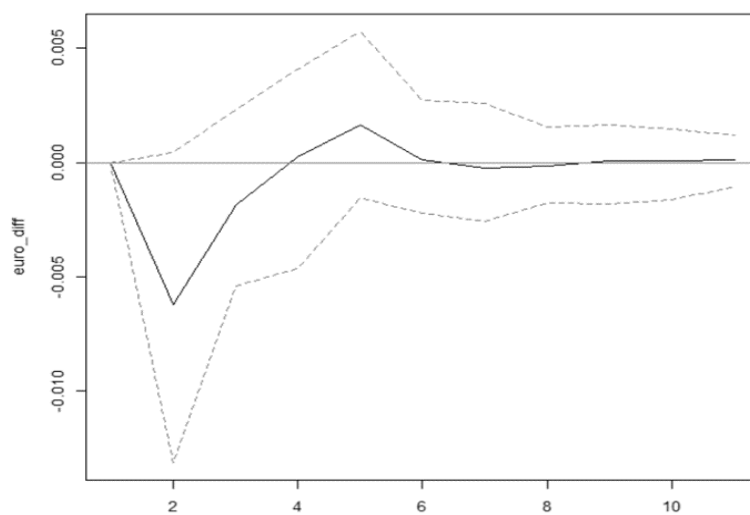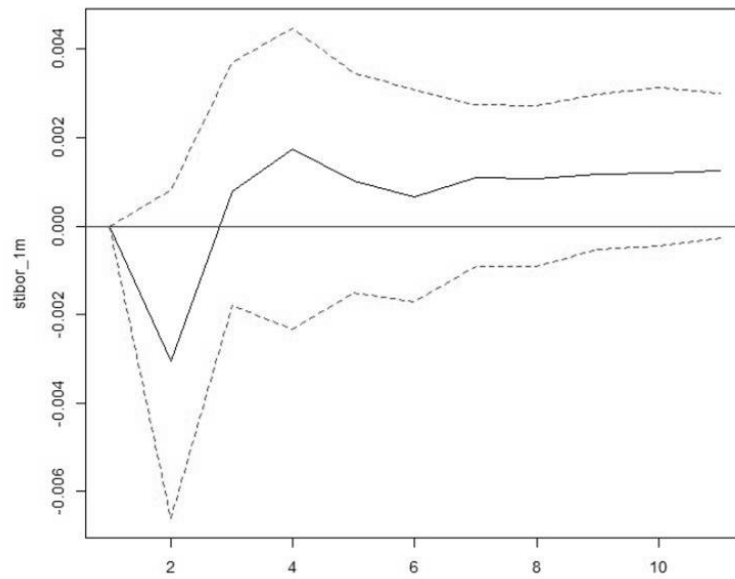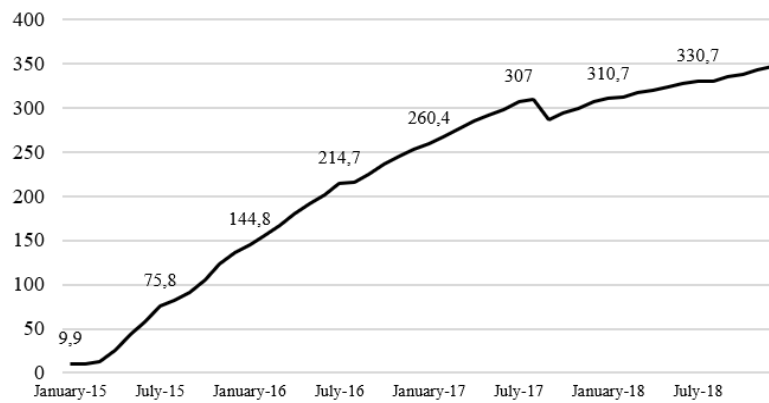

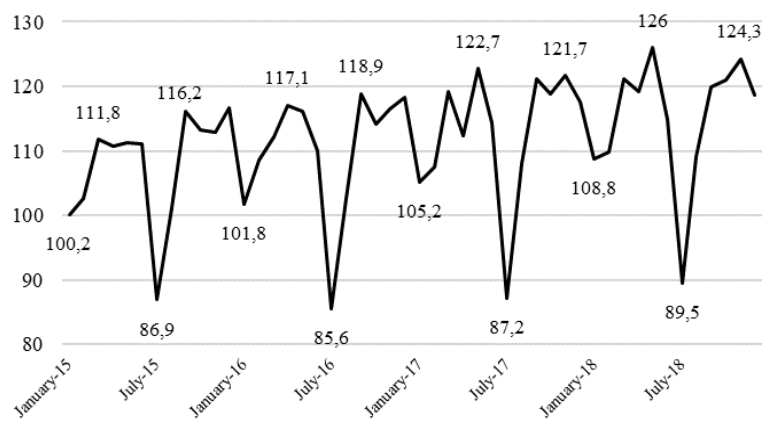Figure 7: Exchange Rate Channel. Impulse response function of Euro/SEK to asset purchases of one Cholesky standard deviation.

Figure 8: Signalling Channel. Impulse response function of the 1m STIBOR to asset purchases of one Cholesky standard deviation.
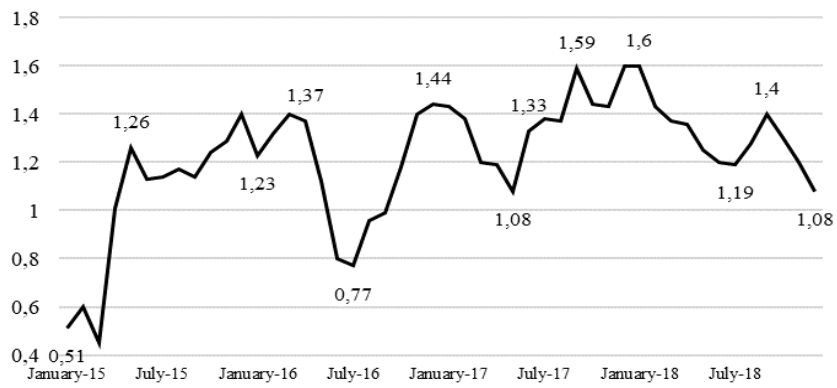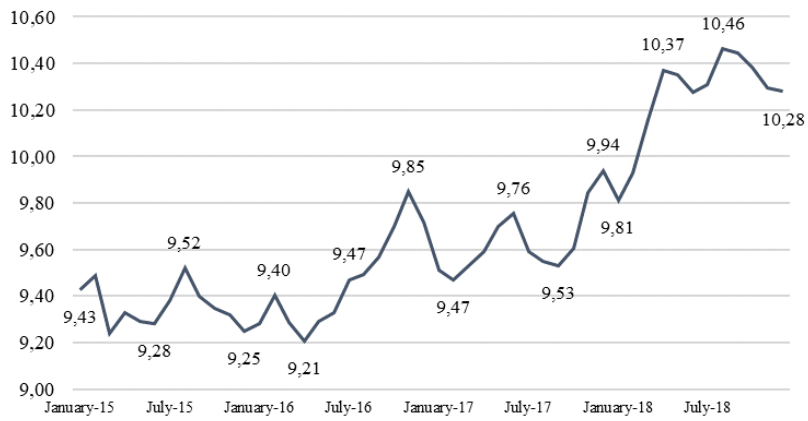

Quantitative Easing

GDP

Term Spread

Euro/SEK

USD/SEK