SCHOOL OF ECONOMICS AND MANAGEMENT

Quantitative Easing and Fiscal Policy

Anton Johnsson

Bachelor's Thesis

January 2023

Department of Economics

Lund University

Supervised by Fredrik N G Andersson

Abstract

This thesis investigates if fiscal policy and quantitative easing (QE) can interact to raise the inflationary effect from central bank asset purchases. This is done by applying a distributed lag model on a set of macroeconomic variables for Sweden and the United States. The results show strong signs of interaction between the two policies in the U.S. but weaker and less clear results in Sweden. The overall results indicates that the outcome of policy actions can vary greatly depending on the direction of the respective actions. QE purchases can result in overshooting the inflation target while expansive fiscal policy is conducted or be rendered useless if fiscal policy is contractionary. These are findings that can inspire to further research that could be of great importance for policy makers.

keywords: quantitative easing, fiscal policy, inflation, United States, Sweden

Table of Contents

1. Introduction

Quantitative easing (QE) has become a widely used monetary policy tool by many central banks in response to the global financial crisis of 2008-09. The Swedish central bank, The Riksbank, started their first QE programme in 2015 and The Federal Reserve, the central bank of the United States, started with QE in late 2008 (The Federal Reserve, 2008; The Riksbank, 2022). This unconventional instrument is not new but has seen limited utilisation before the financial crisis when the conventional tool of interest rate changes was more efficient. When central banks responded to the financial crisis, they did so by cutting short term rates so low that the rates started to approach or did reach the effective lower bound after which they cannot provide further stimulus. Yet, the need for monetary stimulus was still present which led the central banks to make use of QE (De Fiore and Tristani, 2019; Woodford, 2016). When performing QE, the central bank buys large amounts of securities from the financial sector which should bring the end result of higher inflation (McLeay et al, 2014).

In these modern times of inflation targeting, fiscal and monetary policy are often treated as two separate tools working independently from each other. Central banks are given specified targets concerning inflation and apply monetary policy accordingly. Fiscal policy is at the same time given a passive role of debt stabilisation and is not intended to affect inflation (Leeper, 2018). However, in response to the Covid-19 pandemic this trend changed with governments releasing large amount of fiscal stimulus (De Soyres, Santacreu and Young 2022). At the same time QE purchases increased to unprecedented levels making the pandemic a period of both highly expansionary fiscal and monetary policy in a mix as opposed to pre-pandemic years (Gustafsson, 2022). By the second year of the pandemic, 2021, the inflation reached levels never seen during earlier QE programmes and continued to advance close to double digit levels in 2022, reaching far above the 2 per cent target both in Sweden and the U.S. (BLS, 2022; The Riksbank, 2022). Several studies, such as Ankargren and Shahnazarian (2019), have examined the interaction between fiscal and monetary policy and found that the policies can interact with each other.

This study seeks to examine the mix of quantitative easing and fiscal policy in the U.S. and Sweden to determine if the inflationary effect from QE has been strengthened by the interaction with fiscal policy. To do so, several macroeconomic related variables are used in a distributed lag model with time lags of the regressors to be able to model the effect over time. The results points towards both strong and weak interaction depending on the country.

Furthermore, the results show that the inflationary pressure from QE has been higher during times of crisis when both QE and fiscal policy has been used more extensively, and that the fiscal policy can completely offset the effect from QE if not being conducted appropriately.

The disposition of the thesis is as follows: section 2 describes the mechanisms of quantitative easing and looks at some evidence, section 3 and 4 specifies the model and data set, section 5 presents and discuss the results and section 6 concludes.

2. Quantitative easing and empirical evidence

When the short term nominal rate was lowered towards its effective lower bound the central banks started implementing QE purchases. The purchases are mainly conducted towards long-term government bonds, primarily from the non-bank financial sector thereby increasing the supply of money, raising asset prices, and reducing long term interest rates. The result should be higher wealth and an increased tendency of borrowing which raises the demand and spending and subsequently inflation (Joyce et al, 2010; McLeay et al, 2014). According to Woodford (2016) this should have similar stimulative effect as interest rate changes but remain feasible at the effective lower bound. To better understand the workings of quantitative easing it is worth exploring the transmission mechanisms of QE to see why it should result in higher inflation even at times when the conventional monetary policy tool of interest rate policy is exhausted. It is also worth to survey some empirical evidence on the effect of QE and the interaction between monetary and fiscal policy.

2.1 How quantitative easing operates

Quantitative easing, like conventional monetary policy, influence the real economy through various transmission channels. The more important transmission channel that has a direct impact on market dynamics and assets prices is the so-called portfolio balancing or rebalancing channel which Bauer and Rudebusch (2013), Bernanke (2010) and Bowdler and Radia (2012) all consider to be the most effective or the main channel through which QE carry on its effect. The concept is that when the central bank buys assets, the sellers are left with cash in place of the assets. The new liquidity is not likely to be a preferred substitute to the assets since assets yields return while cash do not, so the sellers now hold more cash than they seem favourable. To correct for this, the sellers will use the new cash to buy other assets to replace the sold ones and hence try to rebalance their portfolios. When they buy these new assets, they do so from some other investors who now become sellers who, in the same way, end up with more cash and subsequently also want to rebalance their portfolios and so on. This process raises asset prices and reduce the yields on those assets (Bowdler and Radia, 2012). This gain in asset prices increases the net wealth of asset holders and should stimulate spending, resulting in higher inflation (Joyce, Tong and Woods, 2011). Furthermore, there is also an interest rate effect according to Bowdler and Radia (2012) who explains that the price to which banks can acquire capital is related to the risk free rate, or the yield, of the same maturity that they intend to borrow at. When the yield falls, so does the interest that the banks pay to finance their operations. In addition, assets prices vary with interest rates and thereby carry an interest rate risk which market participants demand compensation for, a so called term premia. This puts a spread on interest rates over expected policy rates, but when the central banks buy long term assets, they reduce the overall risk of higher future interest rates carried by those assets which should reduce the term premia and subsequently long term interest rates (Bowdler and Radia, 2012; Joyce, Tong and Woods, 2011). Thereby reducing the interest rates through two channels. This reduced cost of financing should enable banks to lower their rates on loans towards households and companies who then increase their borrowing to invest and consume, increasing their spending and thereby aggregate demand and inflation. The demonstration of the rebalancing channel shows that it can cause inflationary pressure through both a wealth effect and an interest rate effect reducing the cost of capital.

Another channel that does not have a direct impact on asset prices, but rather expectations, is the so-called signalling channel. By the action of conducting QE, the central bank supplies the market participants with information about the future direction of monetary policy. The central bank might have communicated its intention to keep rates low and by performing assets purchases it is signalling its dedication to do so (Bowdler and Radia, 2012). If the central bank later were to raise interest rates while still holding assets, they would loose on those assets and given the assumption that they want to avoid losses to a greater extent, the purchases of long-term securities indicates that the central bank intends to keep rates lower for an extended period. This might strengthen the inflation expectations (Krishnamurthy and Vissing-Jorgensen, 2011).

There are further channels thought to have less prominent effect such as the liquidity channel and the bank lending channel. The liquidity channel operates when the financial markets are not functioning normally and are subject to illiquidity thereby imposing a risk that an asset cannot be realised when intended. The holders of assets require a risk premia to compensate for this risk of illiquidity (Bowdler and Radia, 2012). When performing QE purchases, the central bank increases the liquidity of the market and the risk premia may fall, with a raise in asset prices as consequence leading to a positive wealth effect. This may however only occur while purchases are being made and does not propagate through time (Joyce, Tong and Woods, 2011).

The bank lending channel is yet another medium through which the increased borrowing could take place, in addition to that of the rebalancing channel. When the central bank purchase assets from non-bank institutions they do so through banks acting as intermediaries. The banks gain in central bank reserves and deposits towards the sellers, meaning they now carry more liquid assets which they may want to use to extend more loans towards their customers, thereby increasing spending (Joyce, Tong and Woods, 2011).

The list is not a complete collection of the transmission channels of QE but serves as a demonstration of how the effects of asset purchases depends on several factors and movements in markets and investors' decisions and also how it may be exposed to lags associated with the lags of changes in interest rates and money supply explained by Friedman (1972) and Goodhart (2001).

2.2 Transmission lags of monetary policy

Transmission lags of monetary policy is the concept that the transmission mechanism of policy with its channels described earlier is subject to time lag (Goodhart, 2001). The more specific type of lag of interest in this thesis is the one between implementation and effect of the policy action. Lags of monetary policy is something that has been well known for some time, Friedman (1972) presents results showing that changes of interest rate and money supply do in fact operate with time lag and he also finds that the policy takes longer to affect prices than it takes to affect output. His results are confirmed and updated by Batini and Nelson (2002) who finds that the time of the lag has not changed significantly despite advancements in policy undertaking and market structure. They further stress the point that the evidence of lags of monetary policy is so commonly accepted that central banks have adopted a regular time frame to consider when deciding on policy measures. Although there is no consensus between central banks on the exact time frame.

2.3 Empirical evidence

The research on the interaction between fiscal policy and quantitative easing is scarce. There is however available research on the effects of quantitative easing alone, and the interaction between fiscal and monetary policy. Matousek et al (2019) studied the effects of QE in Japan who was the first real implementor of quantitative easing in 2001. They used a VAR model that allows for lagged variables to investigate the impulse response from QE shocks on real GDP and inflation, but also on bank holdings and leverage on over 100 regional banks to examine the bank lending channel, between 2000 and 2015. They did find that the QE shocks were followed by increased leverage and security holdings among banks, suggesting that the bank lending channel is functioning in practice. They also found that there is a statistically significant impact on both GDP and inflation following QE, with the impact on GDP being small but positive with peak impact after 1.5 years after the shock. The positive effect on inflation was 0.25 per cent and also peaked after 1.5 years with the effect carrying on for an additional 1.5 years.

The more specific effect of the flattening of the yield curve following reduced long term yields after QE purchases was examined by Baumeister and Benati (2013) who looked at the QE purchases in the U.S. and the U.K. 2007-2009. They looked at the GDP growth, GDP deflator indicator and the spread between yields of long-term treasury bonds and the policy rate using a structural VAR model with time varying parameters. They take the flattening of the yield curve from QE as given and studies what effect this ought to have. By defining shocks as a fixed reduce in the spread that does not affect short-term rates, they try to imitate the effective lower bound environment and examine to what extent a flattening of the yield curve affects the economy when the short-term rate cannot move lower. They found a strong positive effect on both output growth and inflation similar for both countries under the period examined. A peak of 2.2 per cent on GDP and 1.7 per cent on inflation both happened three quarters after the shocks, indicating that the reduced yields and QE do give results at the effective lower bound.

Thus, from these examinations of the three countries it does seem like quantitative easing can influence the level of inflation through different channels. However, the magnitude of the effectiveness and time horizon varies in the studies, but this could be the result of them examining different channels and QE programmes, not making the studies identical. The aspect of time lag is present and advocated for in all cases, but the length of the lagged effect varies between the studies.

As mentioned, there is a limited amount of research on the interaction between QE and fiscal policy, there is however research on the interaction between fiscal and monetary policy in general over periods that partly include quantitative easing. One of them is Ankargren and Shahnazarian (2019) who focused on examining the actual interactions between fiscal and monetary policy in Sweden during the period 1997-2018. They used a structural vector autoregressive model with time varying parameters on a set of variables including output, inflation and government net lending. They then used impulse response functions to analyse shocks in monetary/fiscal policy and shocks in demand and supply. They found that following a shock in one of the types of policy, the policies act as substitutes to each other, but in the case of a demand or supply shock the two policies instead work as complements to each other. This suggests that the policies can influence one another in both directions depending on whether they are the source of the shock or if they are responding to a shock in demand/supply. The authors themself highlight the fact that fiscal policy can support monetary policy at the effective lower bound.

Another study by Molteni and Pappa (2017) found evidence of policy interaction in the U.S. between 1973 and 2012. Over this period, they studied over 100 macroeconomic variables also in a time varying type of VAR model. They estimated an impulse response function from a shock in monetary policy occurring at the time of a fiscal policy shock in the real economy. The results indicated that an expansionary shock in fiscal policy can strengthen the outcome of a contemporaneous expansive monetary policy shock or mitigate the negative effect if the monetary shock is contractionary, although the results varied depending on the source of the fiscal shock and throughout the period dependent on the policy regime in place.

While there seem to be evidence on the interaction of the two policies the strength of the interaction appears to be dependent on the policy structure in place by the time of the shock and the type of interaction dependent on the source of the shock. There is no clear direction on the relationship between the policy shocks but there is evidence of interaction, still at the effective lower bound. The research thus points to QE itself being effective through some of the channels explained earlier, and that fiscal policy can interact with monetary policy at the effective lower bound, although with ambiguous results. With these indications as inspiration this thesis will examine if fiscal policy has strengthened the inflationary effect from quantitative easing. The study will be conducted on two countries, the United States and Sweden. The reasons for choosing these two are (1): they have both applied QE programmes and (2): they have both altered their fiscal policy during periods of crisis. The reason for not choosing Europe and the ECB is that there is no centralised fiscal authority for the European Monetary Union.

3. Model

To try to determine the effect fiscal policy has on the effect of quantitative easing a distributed lag model, a type of dynamic regression model, will be used.[1] The reason for the choice of model depends on the characteristics of the effects following policy changes found in the previous section. As presented, policy changes do not give immediate effect on the economy due to different transmission lags, being the delay from implementation of the policy to the change in the economy. Thus, it is most likely that the inflation today is the outcome of policy changes from previous periods. To account for this the model needs to be able to regress inflation on variables with different time lags. The distributed lag model is a dynamic regression model which allows for the inclusion of different lags of the explanatory variables as regressors and is hence a suitable candidate (Wooldridge, 2016). This makes it possible to estimate the effect of policy changes over time.

The main objective of this thesis is to investigate if fiscal policy can influence the effect of QE. An interaction variable between QE and fiscal policy will be included to answer this question. The data points of the interaction variable are constructed simply by multiplying each observation of QE with the corresponding observation of fiscal policy, that is, $QE_1 * F_1$, $QE_2 * F_2$, and so on, where F_t denotes fiscal policy.

When modelling with lagged variables it is important to select the correct lag length to avoid the problem of omitted variables, that is, not including a variable that should be included, in this case a lag length. This would cause biased estimates of the included variables and invalid standard errors of coefficients (Dougherty, 2011). Different information criteria can be used to determine the optimal lag length, Stock and Watson (2016) among others suggest that the Bayesian or Schwarz Information Criterion (BIC) is the preferred candidate for optimal lag selection of macroeconomic variables in small samples. However, this resulted in a lag length of zero for all variables of interest, which is of no use for this study. The Akaike Information Criterion (AIC) was instead used to specify the lag lengths, Dougherty (2011) explains that the AIC penalises free parameters less and will therefore select a higher order of lag and that this may in practice yield better results. The lag selection was autogenerated by minimising the AIC value.[2] The models are of asymmetric lag, meaning that the variables can have different lag lengths. For the U.S. model the maximum lag length is four, and for the Swedish model it is five.

[1] Eviews Version 12 is the software used
[2] Automated lag selection was done by built in functions in Eviews

The model for the U.S. is:

$$CPI_t = \beta_0 + \beta_1 QE_t + \beta_2 QE_{t-1} + \beta_3 QE_{t-2} + \beta_4 QE_{t-3} + \beta_5 F_t + \beta_6 F_{t-1} + \beta_7 F_{t-2} + \beta_8 QE \times F_t + \beta_9 QE \times F_{t-1} + \beta_{10} QE \times F_{t-2} + \beta_{11} QE \times F_{t-3} + \sum_{n=12}^{37} \beta_n x_i + \sum_{k=38}^{40} \beta_k D_j + \epsilon_t \tag{1}$$

where *CPI* is the inflation at time *t*, *QE* is the quantitative easing with three lags, *F* is the fiscal policy lagged up to two time periods, and *QExF* is the interaction between quantitative easing and fiscal policy with three lags. The sum $\sum_{n=12}^{37} \beta_n x_i$ consists of six control variables with lag lengths of three or four, totalling 26 of them. The sum $\sum_{k=38}^{40} \beta_k D_j$ includes three dummy variables to correct for outliers in data.

For Sweden the model is:

$$CPIF_t = \beta_0 + \beta_1 QE_t + \beta_2 QE_{t-1} + \beta_3 QE_{t-2} + \beta_4 QE_{t-3} + \beta_5 QE_{t-4} + \beta_6 F_t + \beta_7 F_{t-1} + \beta_8 F_{t-2} + \beta_9 F_{t-3} + \beta_{10} F_{t-4} + \beta_{11} F_{t-5} + \beta_{12} QE \times F_t + \beta_{13} QE \times F_{t-1} + \beta_{14} QE \times F_{t-2} + \beta_{15} QE \times F_{t-3} + \beta_{16} QE \times F_{t-4} + \beta_{17} QE \times F_{t-5} + \sum_{n=18}^{52} \beta_n x_i + \epsilon_t \tag{2}$$

CPIF represents inflation at time *t, QE* is the quantitative easing with four lags, *F* is the fiscal policy with five lags, and the interaction variable *QExF* is lagged up to five time periods. The sum $\sum_{n=18}^{52} \beta_n x_i$ consists of six control variables, this time with four or five lags totalling 35 in the Swedish model.

For both models the six control variables are, nominal GDP, unemployment, the central bank policy rate, oil price, electricity price and the nominal exchange rate.

Some diagnostics have been carried out on the residuals to determine the robustness of the models, with the first being a test for heteroscedasticity. Homoscedastic error terms, or residuals, meaning that the residuals have a constant variance is one assumption of the ordinary least squares (OLS) principle. The estimates of standard errors are calculated under this assumption. If this assumption is not met and there is presence of heteroscedasticity, the estimates of the regression may be biased and the coefficients misleading (Dougherty, 2011). A White test, with the null hypothesis of homoscedastic error terms, was used to test for heteroscedasticity. The null hypothesis could not be rejected at any level for either of the models, suggesting that the residuals are not heteroscedastic and that this should not be a source of concern.

When dealing with time series data there is the possibility of autocorrelation. Autocorrelation violates the assumption of independence of error terms from the values of other observations. One possible cause of autocorrelation is that the residuals include the variation from an omitted variable that influences the dependent variable. This is particularly of interest for this study since it would indicate that the number of lags included are insufficient, so to establish the absence of autocorrelation is one way of establishing that sufficient lags have been incorporated into the model (Dougherty, 2011). Additionally, with autocorrelation present, estimates may still be unbiased but inefficient, standard errors would be incorrect and statistical inference would therefore be misleading. To detect autocorrelation a Breusch-Godfrey serial correlation test was carried out. It has the ability to test for higher orders of serial correlation (to match the order of lags in the models) (Wooldridge, 2016). The null hypothesis of no serial correlation could not be rejected for any of the cases, none of the two models show signs of autocorrelation. With this result I draw the conclusion that the order of lags has been correctly specified. A complete presentation of test statistics can be found in the appendices.

4. Data

The data used in the models consists of quarterly observations of nine variables. The sample period for Sweden is from the fourth quarter of 2006 to the second quarter of 2022. For the U.S., the sample period reaches from the first quarter of 2004 to the third quarter of 2022. The reason for choosing a starting point before the implementation of QE is to include more observations. The specific choice of starting point has been limited to the oldest available observation of data and the endpoint of the sample is the latest available observation by the time it was collected. The variables used are CPI, CPIF, size of QE, fiscal balance outcome, oil price, electricity price, nominal GDP, unemployment rate, nominal exchange rate, the nominal short-term policy rate by the central banks and lastly, the interaction between QE and fiscal balance outcome. All the variables have in some way been transformed or handled from its raw measurement to be of use in the models and to match one another, in the following each variable will be described in its entirety.

4.1 Dependent variable

Inflation is the dependent variable in this model. The centrals banks' benchmarks for inflation targeting have been used as measurement for inflation. In the case of the United States and

The Federal Reserve this is the CPI and in Sweden, the CPIF is used by the Riksbank (The Federal Reserve, 2021; The Riksbank, 2018). The data was retrieved as indexes and converted to quarterly percentage change. Both measurements have also been seasonally adjusted to correct for seasonal variations.

4.2 Explanatory variables

Quantitative easing is the main variable of interest for this study. The data on QE from the U.S. is retrieved from The Federal Reserve's post *"Securities held outright"* in their presentation of total assets. This post also includes other securities than the ones bought in QE programmes, meaning that changes in the data could be due to other factors than the change in QE purchases. Unfortunately, this is the closest measurement on QE released from the U.S. or the Federal Reserve. The Swedish Riksbank is more precise and the post on holdings of securities in Swedish crowns from the Riksbank's weekly timeseries report of assets and liabilities has been used as source for QE purchases. The gathered data was for total amount held at the end of each quarter but has been taken in proportion to nominal GDP for every observation to show the relative size of the QE. Finally, first difference was calculated so that the data shows the percentage unit change in held amount quarter to quarter.

Fiscal policy is the other variable of interest in this study. To measure fiscal policy the overall government fiscal balance was used for both countries respectively since this represents the net outcome of the government income and spending (Eurostat, 2018). The data was retrieved as monthly fiscal balance outcome and converted to quarterly outcome by summing the monthly outcomes in each quarter. This was also taken in proportion to GDP to show the quarterly outcome in percent of GDP to better reflect the relative size of the fiscal policy. Seasonal adjustment has been carried out and deficits have been registered as positive values to represent expansionary actions.

The model also includes six additional variables to serve as control variables. Oil is one of the control variables. Apart from being included in the CPI as different derivatives of oil, oil also serves as an input for a variety of products and services consumed daily such as agricultural products or transportation. Changes in oil prices can therefore put pressure on consumer prices and inflation (San Francisco Fed, 2007). The variable for oil shows quarterly percentage change, calculated from the price index. The oil types used are WTI crude for the

U.S. and Brent crude for Sweden since these are the benchmarks for the respective regions (EIA, 2014). Both are seasonally adjusted.

The price of energy or electricity is also included in the CPI/CPIF and similar to oil prices, electricity prices do also cause indirect effects on prices of other goods included in the measurement of inflation (BLS, 2019; & SCB, 2022). Therefore, the price of electricity has also been included in the models. The data chosen to represent electricity prices for the U.S. is the average city price since this is the main category including all subcategories. The data was collected as monthly average and transformed to quarterly average and then percentage change quarter to quarter. As for Sweden, the electricity market is divided in to four areas with different prices and for simplicity reason the area with the most consumers, which is area SE3, has been used (Swedish Energy Agency, 2019). The data was retrieved as monthly average to all consumers and was converted to quarterly average and then quarterly percentage change in price level. Both measurements have also been seasonally adjusted.

According to the Bank of England (1999), the changes in the output gap are usually followed by changes in inflation. The nominal GDP has been included as a control variable for that reason. For the measure of GDP, the quarterly level of nominal GDP was converted to percentage change and seasonally adjusted for both the U.S. and Sweden respectively.

Unemployment also has an impact on inflation, with one of the ways being as viewed from the perspective of the Phillip's curve which shows a negative relationship between inflation and unemployment (Burda & Wyplosz, 2017). Unemployment has therefore also been included in the model. The data on unemployment rate used for the U.S. is total aggregate of all subcategories of unemployment rate presented in per cent and has been seasonally adjusted. For Sweden, the unemployment rate is measured as the share of unemployed in the total workforce and has also been seasonally adjusted.

The exchange rate also has an impact on inflation. Movements in the exchange rate alters the country's competitiveness, consequently affecting the prices of imports and exports which impacts prices on the domestic market (Krugman, Obstfeld, & Melitz, 2018). The exchange rate has been converted to quarterly percentage change. For Sweden, the USD/SEK pair has been used since the U.S. dollar is the most traded currency, and for the U.S. the EUR/USD pair represents the exchange rate since euro is the second most traded currency after the U.S. dollar (BIS, 2022).

Finally, the nominal interest rate was also included since it is the conventional monetary policy tool for inflation targeting used by the two central banks. The federal funds rate was used as data for the nominal interest rate for the U.S. and the policy rate (former "styrräntan") of the Riksbank was used in the Swedish model. The data shows the average level of interest rate during each quarter.

4.3 Endogeneity problem and solution

As explained by Andersson and Kilman (2021), economic policy changes are made partly to influence economic outcomes, but the economic outcomes then lead to changes in the same policy tool further ahead. Economic policy thus contains unexpected changes, so called shocks, which is what we want the data to represent, but due to the resulting movements in the economy the data also includes endogenous changes. The latter causes an endogeneity problem that may ruin the statistical inference of the model by causing biased coefficients (Ramey, 2016). In the data set for this study, this endogeneity problem presents itself in the three variables for policy: QE, nominal interest rate and fiscal policy. Therefore, these variables have been handled further until reaching their final form.

Andersson and Kilman (2021) who builds on from the work of Romer and Romer (2004) provides a method of solving this problem by separating the endogenous and exogenous movements from the measurement. This is done by first regressing the policy variable on a set of macroeconomic variables representing changes in the economic environment. The changes in the policy variable which can be explained by the other variables included are characterised as endogenous movements. The movements in the policy variable that cannot be explained by the other variables are captured in the residuals and are the exogenous movements defined as the shocks that are of use for representing economic policy in regression models. For the policy variables in this study this has been performed by regressing the policy variable on the outcome of the policy variable itself, GDP, unemployment, and inflation all from the previous period as

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 GDP_{t-1} + \beta_3 U_{t-1} + \beta_4 \pi_{t-1} + \epsilon_t \tag{3}$$

where π represents *CPI* or *CPIF, U* unemployment and *y* being one of the variables for policy, *QE*, *F,* or *I*. The resulting residuals, ϵ_t, should consist of the exogenous movements and are what is then being used to represent the policy variable in the model.

4.4 Stationarity

Time series data consists of observations over time which makes it possible that the data is trending with time in some way. In data that follows a stationary process the statistical properties do not change over time; the expected value and variance of an observation is the same throughout the whole time series. Such data show no trend or seasonality. Non-stationary data however do not have constant statistical properties and can be seen to trend over time or include seasonal patterns. Using data that follows a non-stationary process could result in spurious regression results, possibly causing misleading evidence of a statistical relation between variables (Dougherty, 2011).

To check for the presence of non-stationarity in the gathered dataset, an augmented Dickey-Fuller test for unit root has been done on the final form of all variables. The presence of a unit root is a property of a kind of non-stationary process and may suggest that the process in non-stationary (Wooldridge, 2016). When tested, the null hypothesis of the presence of a unit root was rejected on the 5 per cent level for all variables, that is, none of the variables show signs of non-stationarity in its final form.

Below is a table with all the variables, their definition and source. The data descriptives can be found in the appendix along with visualisation of the data.

Table 1. List of variables

Variable	Representation	Source
CPI	Quarterly percentage change of the CPI index	BLS - U.S. Bureau of Labor Statistics
CPIF	Quarterly percentage change of the CPIF index	SCB - Statistics Sweden
QE	The residuals, ϵ_t, from equation (3) with *QE* representing y. Showing aggregated QE purchases in relation to nominal GDP. Presented as quarterly percentage unit change.	United States: The Federal Reserve System Sweden: The Riksbank

F	The residuals, ϵ_t, from equation (3) with *F* representing *y*. Quarterly overall fiscal balance outcome in per cent relative to nominal GDP (deficit as positive value)	United States: Bureau of the Fiscal Service Sweden: The Swedish National Financial Management Authority
QExF	The interaction variable between *QE* and *F*	
I	The residuals, ϵ_t, from equation (3) with *I* representing *y*. The respective central bank policy rate as average percentage level each quarter	United States: The Federal Reserve System Sweden: The Riksbank
GDP	Quarterly percentage change of nominal GDP	United States: Bureau of Economic Analysis Sweden: SCB - Statistics Sweden
U	Unemployment at each quarter as a percentage rate	United States: BLS - U.S. Bureau of Labor Statistics Sweden: SCB - Statistics Sweden
OIL	Quarterly percentage change of the oil price index, Crude WTI for the U.S. and Crude Brent for Sweden.	OPEC and EIG via The World Bank. Same source for both countries
P	Quarterly percentage change in electricity price from Quarterly city average for the U.S. and quarterly	United States: BLS - U.S. Bureau of Labor Statistics Sweden: SCB - Statistics Sweden

	average in electricity area 3 for Sweden	
EX	Quarterly percentage change of the exchange rate at the end of each quarter, EUR/USD for the U.S. and USD/SEK for Sweden	United States: Eurostat Sweden: The Riksbank

5. Results

When interpreting the outputs of the models there are two further things that need to be considered. It is firstly the interaction term and, secondly, the interpretation of the lags. The table below presents the results of the models, after which the interpretation of the interaction term will be covered to begin with, followed by the lag interpretation.

Table 2. Regression results

Variable	U.S. Model	Swedish Model
QE (0)	-0.131*	-0.034
	(0.075)	(0.050)
QE (-1)	-0.103	-0.002
	(0.084)	(0.058)
QE (-2)	0.208**	0.184**
	(0.082)	(0.064)
QE (-3)	0.134*	0.012
	(0.067)	(0.054)
QE (-4)		-0.101*
		(0.053)
F (0)	0.016	-0.036
	(0.072)	(0.032)
F (-1)	0.086	0.045
	(0.095)	(0.042)
F (-2)	0.300***	-0.001
	(0.093)	(0.047)

F (-3)		-0.020
		(0.050)
F (-4)		-0.023
		(0.044)
F (-5)		0.027
		(0.031)
QExF (0)	-0.016	0.023
	(0.015)	(0.024)
QExF (-1)	0.308***	-0.003
	(0.103)	(0.024)
QExF (-2)	-0.037	0.025
	(0.024)	(0.020)
QExF (-3)	0.033**	0.001
	(0.015)	(0.016)
QExF (-4)		-0.022
		(0.016)
QExF (-5)		-0.023
		(0.015)
$\boldsymbol{R^2}$	0.958	0.964
Adjusted $\boldsymbol{R^2}$	0.908	0.776
White test	0.815	0.339
Breusch-Godfrey test	0.652	0.483

Note: Standard errors in parenthesis. P-values: *P<0.1 **P<0.05 ***P<0.01

Control and dummy variables are not presented since they are not needed to interpret the results.

5.1 Interaction interpretation

It is now that the full understanding of the interaction variable will be of use, namely how it will allow the inflationary effect of quantitative easing in the model to depend on the simultaneous level of fiscal policy. To find the marginal effect that the different lags of QE have on inflation the equations (1) and (2) from section 3 are differentiated with respect to the different lags of QE respectively. The derivative will consist of the coefficient in front of the QE variable plus the coefficient in front of the interaction variable with the same lag times the value of fiscal policy (*F*). By applying the estimated coefficients of the parameters from table 2, the marginal effect for each lag of QE can be found. By doing so on equation (1) for the U.S. model with respect to QE_t the result is:

$$\frac{\partial CPI_t}{\partial QE_t} = \beta_1 + \beta_8 \cdot F_t = -0{,}131 - 0{,}016 \cdot F_t \tag{4}$$

where β_i are the parameters being estimated by the model and F_t is the level of fiscal policy in time period *t*. The expression (4) of the derivative show that the effect of QE in the model depends on the level of fiscal policy. In the demonstrated case this is interpreted as one unit of expansionary fiscal policy weakens the inflationary effect from one unit QE with 0.016 percentage points.

By repeating the procedure for all lag lengths by simply changing the variable which the differentiation is done with respect to, and doing so for both models, equation (1) and (2) from section 3, all the marginal effects can be found and are:

Table 3. Marginal effects

	Marginal effect in time *t* from one unit QE	
QE in different lags	U.S. Model	Swedish Model
(0)	$-0.131 - 0.016 \cdot F_t$	$-0.034 + 0.023 \cdot F_t$
(-1)	$-0.103 + 0.308 \cdot F_{t-1}$	$-0.002 - 0.003 \cdot F_{t-1}$
(-2)	$0.208 - 0.037 \cdot F_{t-2}$	$0.184 + 0.025 \cdot F_{t-2}$
(-3)	$0.134 + 0.033 \cdot F_{t-3}$	$0.012 + 0.001 \cdot F_{t-3}$
(-4)		$-0.101 - 0.022 \cdot F_{t-4}$

5.2 Lag interpretation

What is of interest for this study is the cumulative effect the lags of QE have on inflation for different levels of fiscal policy, or expressed differently, what is the long run cumulative effect of one unit of QE for different levels of fiscal policy at the same period. This is what Wooldridge (2016) defines as the Long-run Propensity, which is simply the sum of all coefficients. The convenient thing about this approach is that the result from each lag can be interpreted as the change in inflation during that quarter from the policy in *one* initial period, thus the result can be used to answer the question of what a change in policy today would yield in cumulative effect at the end of the modelling period, rather than explaining that the inflation of today is the outcome of *several* policy changes in the past. This allows for the measurement of one unit QE with only *one* change in fiscal policy. The concept is best visualised in an example; assume that the central bank conducts one unit of QE purchases and that the government simultaneously conducts fiscal policy to some level *F,* both at $t = 0$. With the results from the U.S. model in table 3, this would propagate through time as follows:

The initial inflationary effect without lag would be:	$-0.131 - 0.016 \cdot F_0$
The effect occurring during the first quarter would be:	$-0.103 + 0.308 \cdot F_0$
During the second quarter:	$0.208 - 0.037 \cdot F_0$
During the third quarter:	$0.134 + 0.033 \cdot F_0$

and the cumulative effect, or Long-run Propensity, on inflation at the end of the horizon, which is $t = 3$ for the U.S. model, is the sum of all these quarterly effects. Table 4 below shows the cumulative Long-run Propensity for both models.

Table 4. Long-run Propensity

Model	Long-run Propensity
United States	$0.108 + 0.288 \cdot F_0$
Sweden	$0.059 + 0.024 \cdot F_0$

The method to fully make use of the interaction term and lags has now been specified and these results can now be subject to analysis.

Concerning the low level of significance from the regression results in table 2, it must be mentioned that Wooldridge (2016) explains this to be a feature often present when including lags due to multicollinearity caused by the correlation of the lagged variables. This makes the estimates of the coefficients imprecise, but the estimated Long-run Propensity will often be good. With this clarification of the estimates together with the positive robustness tests from section 3 and the determination of stationary data series in section 4.4, the focus is now shifted towards analysing the result from the perspective of the research question of whether fiscal policy has amplified the inflationary effect of quantitative easing.

5.3 U.S. Results

Again, stating the cumulative inflationary effect from QE for the U.S: $0.108 + 0.288 \cdot F_0$, the inflationary effect from one unit QE alone is 0.108 per cent after three quarters which, although positive, cannot be considered much since one unit QE in the model is setup as a change in the purchased amount of securities equivalent to 1 per cent of GDP. This means that if the central bank would like to increase the inflation by 1 percentage point, they would need to purchase securities of an amount equivalent to roughly 10 per cent of GDP.[3] However, if also considering interaction with fiscal policy, the inflationary effect from one unit QE increases with 0.288 percentage points for every contemporaneous unit of deficit in the fiscal budget balance, which is also set up as equivalent to 1 per cent of GDP so that the two represent the same amount. That is, one unit of expansionary fiscal policy makes the inflationary effect from one unit of QE over 3.5 times higher, from 0.108 to 0.396 per cent. To accomplish an increase in inflation of 1 percentage point would only require a purchase of securities amounting to 2.5 per cent of GDP when fiscal policy equal 1 per cent of GDP rather than the 10 per cent of QE when no fiscal policy is present. This indicates that fiscal policy does increase the inflationary effect of QE up to three quarters according to this model, so much in fact that the contributory effect from fiscal policy on QE is much higher than the effect from QE alone.

By applying the observations of QE and fiscal policy in the data set on the equation on cumulative effect from table 4, the model's inflationary prediction of the policy conducted under the sample period can be illustrated. Since the equation is for one unit of QE it can simply be multiplied by the level of QE at the same observation point as the fiscal policy (F):

[3] Out of the 75 observations of QE in the data set, only one is higher than 3 per cent

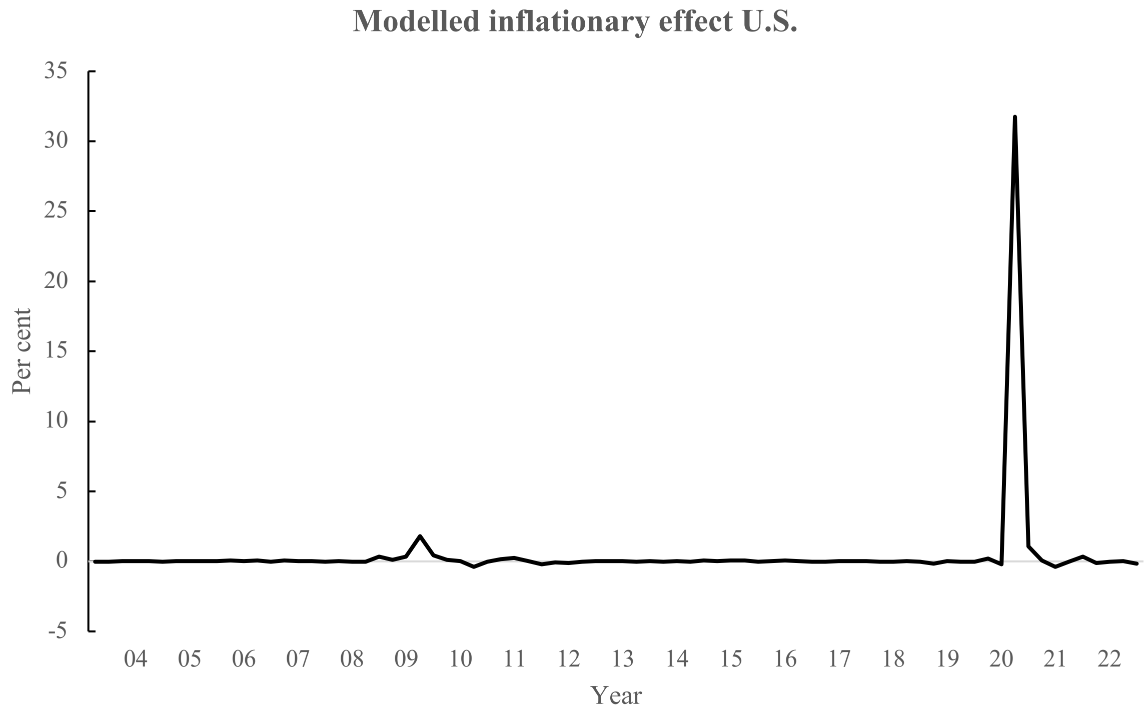


Figure 1. The equation $QE_t(0.108 + 0.288 \cdot F_t)$ with the U.S. data set on QE and F as input.

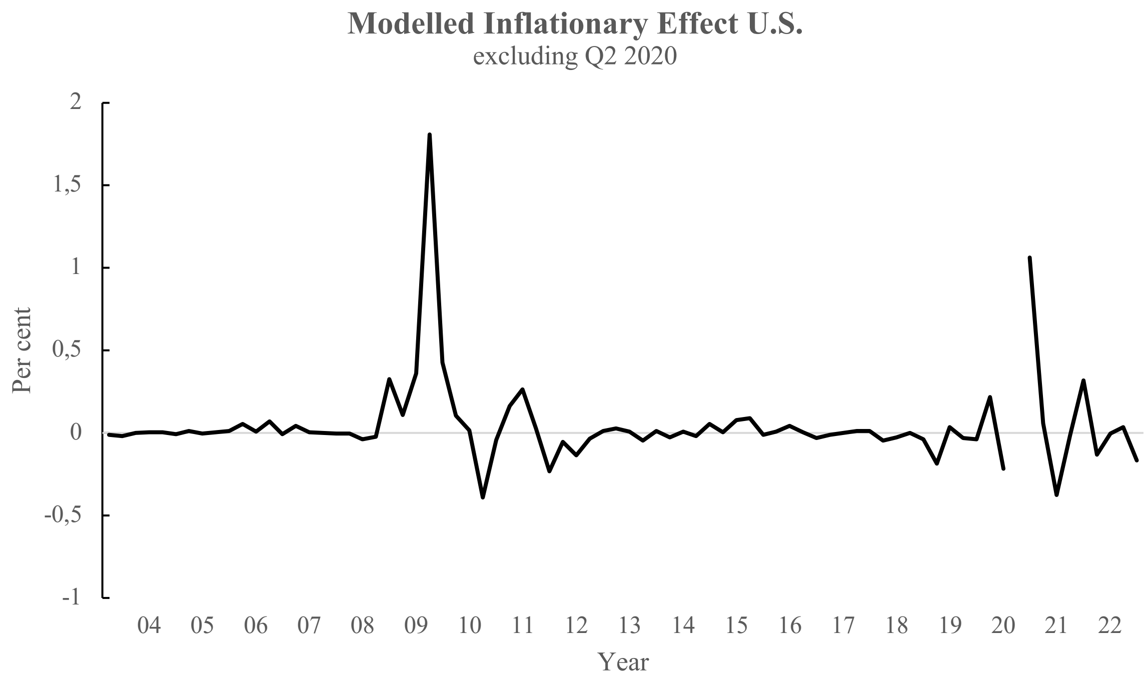


Figure 2. The same results as figure one, excluding the massive impact of Q2 2020 for better visualisation.

From figure 1 it can be observed that the massive expansion of both QE purchases and budget deficit in response to the Covid-19 pandemic which took place in Q2 2020 is estimated by the model to have produced an inflationary pressure of above 30 per cent. Bear in mind that this effect should cumulate three quarters later during Q1 2021 and the seasonally adjusted data on quarterly change in the CPI for this study indicates that the increase of the CPI during the same quarter was 1.2 per cent (visualisation of the CPI can be found in the appendix). This is nowhere near the 30 per cent suggested by the model but still a sizeable move considering the yearly target change is 2 per cent.

In figure 2, Q2 2020 has been removed to better visualise the rest of the period. Looking at the years of the pandemic compared to the years prior, it is a clear picture that the increased policy actions also caused movements of greater magnitude, including deflationary movements. This highlights the possibility that the effectiveness of QE could be inhibited if the fiscal authorities conduct policy in the opposite direction. The same can be said about the policies during the financial crisis 2008-09, causing an overall greater inflationary pressure.

5.4 Sweden Results

The cumulative result for the Swedish model $0.059 + 0.024 \cdot F_0$ is weaker than for the U.S. model with the positive effect from the interaction with fiscal policy being around ten times weaker than in the case of the U.S. One unit of fiscal policy raises the effect of one unit QE by a factor of 1.4, still a sizeable factor but the effect is only 0.024 percentage points. Contemporaneous conducting of QE and expansionary fiscal policy both equivalent to 1 per cent of GDP would only result in a cumulative inflationary effect from QE of 0.083 per cent over one year. Looking at figure 3 below on the estimated inflation outcome from QE, the expansionary actions to counter the effects from the pandemic seem to have resulted in higher inflationary pressure with the biggest cumulative effect from one quarter being only 1 per cent compared to the 30 per cent in the U.S. model. Overall, the movements are greater and more positive after 2015 when Sweden started using quantitative easing and there are still some sizeable cumulative inflationary effects indicated by the model, several of them being up towards 0.4 per cent. However, I refer this to the sheer size of the QE purchases and not to the interaction between the policies since the QE purchases at these quarters are all equivalent to a sum above 3 per cent of GDP while the fiscal deficit is more modest at 1 per cent of GDP. The more interesting observation to make concerning interaction is that there are quarters, such as Q3 2021, where the QE purchases amount to over 6 per cent of GDP, being one of the biggest observations, but there is a fiscal surplus so large that it makes the overall cumulative effect from that quarter negative. This suggest that the fiscal policy do interact with the quantitative easing and can waste the effort if not coordinated accordingly.

Although there are some clear effects on inflation to be observed this is mainly because the policy actions have been large, not that the single unit effect or interaction effect is big. The cumulative effect from interaction is well below 0.1 per cent and examining the quarterly effects separately indicates that the interaction is almost zero with one and three quarters lag. This makes it hard to draw the conclusion that fiscal policy boosts the efficiency of quantitative easing in Sweden. Viewing the results from the perspective of interest for this study, the interaction, the results are weak.

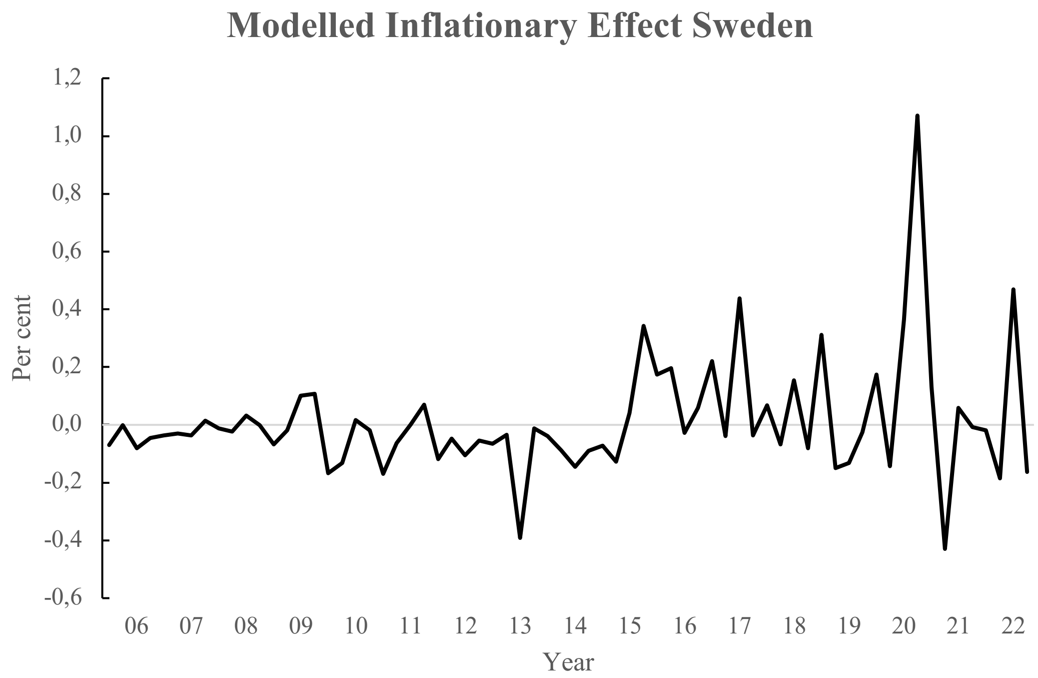


Figure 3. $QE_t(0.059 + 0.024 \cdot F_t)$ with the Swedish data set on QE and F as input.

5.5 Discussion

The purpose of this study was to examine if the fiscal policy interacts with quantitative easing to increase the inflationary effect of the latter. The general inflationary outcome of the two policies over a period has also been explored. Considering the research question, the results from the U.S. are highly positive, the fiscal policy and QE do interact in both directions similar to what Molteni and Pappa (2017) reviewed earlier found between fiscal policy and monetary policy in general. Important to take away from these results is that the two policies should not be viewed as independent from each other, which has been the case for many policy institutions when conducting policy (Leeper, 2018). The policies should be coordinated in times of crisis to not work against each other or overdo the outcome. The estimated effect of the policy outcomes in the sample period showed that the increased policy mix in times of crisis did cause some large estimated inflationary effects, but also that the effect could change sign or be weakened by an inappropriate policy mix. Furthermore, the results from Baumeister and Benati (2013) that QE alone did have inflationary effect in the U.S. was found also in this model, although not as strong but still with positive effect. Important when viewing and assessing these results is that the sample period is relatively short only being 75 observations and quantitative easing has only really been used for the last 10-15 years and often used in times when the financial markets are not fully functional. Further studies in the future when more data might be available may be equipped with better conditions to achieve more reliable results.

When viewing the results from the Swedish model from the standpoint of the research question, the results are not nearly as clear as for the U.S. model. The additional effect from interaction is much lower than the effect from QE alone, which is already low itself. The estimated inflationary outcome over the sample period is more likely to be the result of increased policy actions rather than the two interacting. The most interesting observations are the times the inflation was not high despite QE purchases being extensive, due to the counteracting contractionary fiscal policy. This suggests that the interaction, despite being low, is still important to consider when conducting a mix of policy. This observation is in line with the suggestion by Leeper (2018) that the ineffectiveness of Swedish expansionary monetary policy could be explained by fiscal policy being deflationary, though he never establishes this relation.

Why the results for Sweden are so weak can be partly, again, because of the short sample period, which is even shorter for the Swedish model, 63 observations. Another explanation is that Sweden is a small open economy that is affected by the economic conditions surrounding it. Stockhammar and Österholm (2014) found that fluctuations in U.S. policy expectations had an impact on Swedish GDP growth. Di Castola and Stockhammar (2021) found that the QE purchases conducted by the European Central Bank had a significant effect on Swedish inflation. This is an additional aspect the policy makers need to consider when deciding on policy actions more than making sure that the policies do not counter each other.

Future studies that want to determine the inflationary effect in Sweden from domestic policy actions would do wise to control for foreign policy actions that would shadow the effects from the domestic ones.

6. Conclusion

The inflation has changed from modest levels in both Sweden and the U.S. under periods of quantitative easing before the Covid-19 pandemic, to levels of inflation far above the target level during the pandemic. Meanwhile, the fiscal authorities abandoned the passive stance of fiscal policy to address the negative economic impact from the pandemic, making the policy climate much different from former periods with quantitative easing. With this development as background, this thesis has aimed at determining if there is an interaction between QE and fiscal policy that succeeds to raise the inflationary pressure from quantitative easing.

By examining the subject through a dynamic regression model on data from Sweden and the U.S. and compiling the long run effects some results were found. The results indicates that QE purchases by the Federal Reserve became much more inflationary if the fiscal authorities simultaneously conducted expansionary fiscal policy actions. But this strong effect can be reversed if the role of fiscal policy is deflationary and render the QE purchases useless. This should be taken into serious consideration by policymakers in the future. The assumption that the two policies can operate independently from each other could result in policy actions that overshoots the inflation target or, vice versa, that the inflation target remains difficult to reach. These observations are in line with some of the empirical evidence reviewed in this thesis and might suggest that this is an area of research that is not yet fully understood and carry high research value.

The results on Sweden does not suggest that the Riksbank and the fiscal authorities overall have been very successful at raising inflation through their policy tools despite the Riksbank conducting sizeable amounts of QE. The most prominent result is that the policies also in Sweden benefit from coordination, suggesting that there might be an interaction present after all. The biggest shortcoming of the Swedish model which probably play a significant role for the weak results is the fact that it only includes domestic variables despite Sweden being a small open economy highly affected by the surrounding economies. This makes it important for future studies to extend their data set to include foreign variables when performing similar examinations on Sweden.

A more general shortcoming for both models is the lack of available data on QE, making the sample period short since it is a relatively new policy tool that has not been utilised before the 21st century. Future studies on the same subject may find it easier to access data and find better results making quantitative easing worth keep studying.

References

Andersson, F.N.G. and Kilman, J. (2021). A Study of the Romer and Romer Monetary Policy Shocks Using Revised Data. *Department of Economics, Working Paper No. 2021:19,* Lund University School of Economics and Management.

Ankargren, S. and Shahnazarian, H. (2019). The Interaction Between Fiscal and Monetary Policies: Evidence from Sweden. *Sveriges Riksbank, Working Paper Series No. 365.*

Bank of England. (1999). The transmission mechanism of monetary policy. *Bank of England Quarterly Bulletin,* May 1999.

Batini, N. and Nelson, E. (2022). The Lag from Monetary Policy Actions to Inflation: Friedman Revisited. *Bank of England, External MPC unit discussion Paper No. 6.*

Bauer, M. and Rudebusch, G. (2013). Monetary Policy Expectations at the Zero Lower Bound. *Federal Reserve Bank of San Francisco, Working Paper Series No. 2013-18.*

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

Bernanke, B.S. (2010). *The Economic Outlook and Monetary Policy.* Speech: at the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming, Available at: https://www.federalreserve.gov/newsevents/speech/bernanke20100827a.htm

BIS - Bank for International Settlements. (2022). Triennial Central Bank Survey, *Bank for International Settlements, Monetary and Economic Department,* OTC Foreign Exchange Turnover April 2022.

BLS - U.S. Bureau of Labor Statistics. (2019). *Common Misconceptions about the Consumer Price Index: Question and Answers.* CPI Publications. Available at: https://www.bls.gov/cpi/factsheets/common-misconceptions-about-cpi.htm [Accessed: 21 December 2022]

BLS - U.S. Bureau of Labor Statistics. (2022). *BLS data tools: Graphics for Economic News Releases, 12-month percentage change, Consumer Price Index*. Available at: https://www.bls.gov/charts/consumer-price-index/consumer-price-index-by-category-line-chart.htm [Accessed: 19 December 2022].

BLS - U.S. Bureau of Labor Statistics. (2022). *BLS data tools: Inflation and Prices, Consumer Price Index - CPI.* Available at: https://www.bls.gov/data/#prices [Accessed: 15 November 2022]

BLS - U.S. Bureau of Labor Statistics. (2022). *BLS data tools: Electricity per KWH in U.S. city average.* Available at: https://beta.bls.gov/dataViewer/view/timeseries/APU000072610 [Accessed: 15 November 2022]

BLS - U.S. Bureau of Labor Statistics. (2022). *BLS data tools: (Seas) Unemployment Rate.* Available at: https://beta.bls.gov/dataViewer/view/timeseries/LNS14000000 [Accessed: 15 November 2022]

Bowdler, C. and Radia, A. (2012). Unconventional monetary policy: the assessment. *Oxford Review of Economic Policy,* Vol. 28, No. 4, Oxford: Oxford university press, pp. 603-621

Burda, M., & Wyplosz, Charles. (2017). *Macroeconomics a european text*, 7th edition, Oxford: Oxford university press, pp. 334-339

Bureau of Economic Analysis. (2022). *Tools: National Data: National Income and Product Accounts - Gross Domestic Product.* Available at: https://apps.bea.gov/iTable/?reqid=19&step=2&isuri=1&categories=survey#eyJhcHBpZCI6MTksInN0ZXBzIjpbMSwyLDMsM10sImRhdGEiOltbImNhdGVnb3JpZXMiLCJTdXJ2ZXkiXSxbIk5JUEFfVGFibGVfTGlzdCIsIjUiXSxbIkZpcnN0X1llYXIiLCIyMDA4Il0sWyJMYXN0X1llYXIiLCIyMDIyIl0sWyJTY2FsZSIs [Accessed: 15 November 2022]

Bureau of The Fiscal Service. (2022). *Monthly Treasury Statement.* Available at: https://fiscal.treasury.gov/reports-statements/mts/current.html [Accessed: 15 November 2022]

De Fiore, F. and Tristani, O. (2019). (Un)conventional Policy and the Effective Lower Bound. *Monetary and Economic Department, Working Paper No. 804,* Bank for International Settlements.

De Soyres, François. Santacreu, A.M. and Young, H. (2022). *Fiscal policy and excess inflation during Covid-19: a cross country view*. The Federal Reserve, FEDS notes. Available at https://www.federalreserve.gov/econres/notes/feds-notes/fiscal-policy-and-excess-inflation-during-covid-19-a-cross-country-view-20220715.html [Accessed: 16 December 2022]

Di Castola, P. and Stockhammar, P. (2021). When domestic and foreign QE overlap: evidence from Sweden. *Sveriges Riksbank Working Paper Series No. 404.*

Dougherty, C. (2011). *Introduction to econometrics,* fourth edition, New York: Oxford University Press.

EIA - U.S. Energy Information Administration. (2014). *Benchmarks play an important role in pricing crude oil.* Available at: https://www.eia.gov/todayinenergy/detail.php?id=18571 [Accessed: 21 December 2022]

Eurostat. (2018). *Glossary: Fiscal balance.* Eurostat Statistics Explained. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Fiscal_balance [Accessed: 21 December 2022]

Eurostat. (2022). *Data Browser: Euro/ECU exchange rates - quarterly data.* Available at: https://ec.europa.eu/eurostat/databrowser/view/ERT_BIL_EUR_Q__custom_3858118/default/table?lang=en [Accessed: 15 November 2022]

Federal Reserve Bank of San Francisco. (2007). *What are the possible causes and consequences of higher oil prices on the overall economy?* Publications. Available at: https://www.frbsf.org/education/publications/doctor-econ/2007/november/oil-prices-impact-economy/ [Accessed: 21 December 2022]

Friedman, M. (1972). Have Monetary Policies Failed? *The American Economic Review,* Vol. 62, No. 1/2, pp. 11-18

Goodhart, C.A.E. (2001). Monetary transmission lags and the formulation of the policy decision on interest rates. *Federal Reserve Bank of St. Louis,* vol.83, pp. 165-186

Gustafsson, P. (2022). An event study of the effects of asset purchases on financial prices during the pandemic. *The Riksbank, Staff memo,* pp. 1-23

Joyce, M. Lasaosa, A. Stevens, I. and Tong, M. (2010). The financial market impact of quantitative easing. *Bank of England, Working Paper No. 393.*

Joyce, M. Tong, M. and Woods, R. (2011). The United Kingdom's quantitative easing policy: design operation and impact. *Bank of England, Bank of England Quarterly Bulletin,* Vol. 51(3), pp. 200-212

Krishnamurthy, A. and Vissing-Jorgensen, A. (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. *National Bureau of Economic Research, Working Paper No. 17555.*

Krugman, P. Obstfeld, M. & Melitz, M. (2018). *International Economics Theory and Policy,* eleventh edition, Harlow: Pearson Education, pp. 379-382

Leeper, E.M. (2018). Sweden's Fiscal Framework and Monetary Policy. *National Bureau of Economic Research, Working Paper No. 24743.*

Matousek, R. Papadamou, S.T. Sevic, A. and Tzeremez, N.G. (2019). The Effectiveness of Quantitative Easing: Evidence from Japan. *Journal of International Money and Finance,* Elsevier, Vol. 99(C).

McLeay, M. Radia, A. and Thomas, R. (2014). Money creation in the modern economy. *Bank of England, Bank of England Quarterly Bulletin,* Vol. 54(1), pp. 14-27

Molteni, F. and Pappa, E. (2017). The Combination of Fiscal and Monetary Policy Shocks: A TVP-FAVAR Approach. *European University Institute, Economic Working Papers,* MWP 2017/13.

Ramey, V. (2016). *Macroeconomic Shocks and Their Propagation. Handbook of Macroeconomics* volume 2, Elsevier, pp. 71-162

Riksbank. (2018). *Monetary Policy: The inflation target.* Available at: https://www.riksbank.se/en-gb/monetary-policy/the-inflation-target/ [Accessed: 21 December 2022]

Riksbank. (2022). *Purchases of government bonds.* Available at: https://www.riksbank.se/en-gb/monetary-policy/monetary-policy-instruments/purchases-of-government-bonds/ [Accessed: 12 December 2022].

Riksbank. (2022). *Statistics: Search interest & exchange rates.* Available at: https://www.riksbank.se/en-gb/statistics/search-interest--exchange-rates/?g130-SEKUSDPMI=on&from=09%2F08%2F2012&to=09%2F11%2F2022&f=Month&c=cAverage&s=Comma [Accessed: 16 November 2022]

Riksbank. (2022). *Tidsserier avseende befolkningen ej i arbete, 15-74 år, kvartal.* Available at: https://www.scb.se/hitta-statistik/statistik-efter-amne/arbetsmarknad/arbetskraftsundersokningar/arbetskraftsundersokningarna-aku/pong/tabell-och-diagram/icke-sasongrensade-data/tidsserier-avseende-befolkningen-ej-i-arbete-1574-ar-kvartal/ [Accessed: 16 November 2022]

Riksbank. (2022). *The Riksbank's assets and liabilities, the Weekly Report.* Available at: https://www.riksbank.se/en-gb/statistics/riksbanks-balance-sheet/the-riksbanks-assets-and-liabilities-the-weekly-report/ [Accessed: 16 November 2022]

Romer, C.D. and Romer, D.H. (2004). A New Measure of Monetary Shocks: Derivation and Implications. *The American Economic Review,* vol.94(4), pp. 1055-1084

SCB - Statistics Sweden. (2022). *Inflation rate according to CPIF was 9.5 percent in November 2022.* Finding statistics - Consumer Price Index (CPI). Available at: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/prices-and-consumption/consumer-price-index/consumer-price-index-cpi/pong/statistical-news/consumer-price-index-cpi-november-2022/

SCB - Statistics Sweden. (2022). *GDP expenditure approach.* Electronic data file, SCB - Finding statistics. Available at: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/national-accounts/national-accounts/national-accounts-quarterly-and-annual-estimates/pong/tables-and-graphs/tables/gdp-quarterly/ [Accessed: 16 November 2022]

SCB - Statistics Sweden. (2022). *Inflation rate according to CPIF, annual changes, percent.* Available at: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/prices-and-consumption/consumer-price-index/consumer-price-index-cpi/pong/tables-and-graphs/consumer-price-index-with-fixed-interest-rate-cpif-and-cpif-xe/cpif-annual-changes/ [Accessed: 19 December 2022]

SCB - Statistics Sweden. (2022). *Electricity prices and electricity contracts: Monthly values.* Available at: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/energy/price-trends-in-the-energy-sector/electricity-prices-and-electricity-contracts/ [Accessed: 16 November 2022]

SCB - Statistics Sweden. (2022). *Statistical database: Consumer Price Index with fixed interest rate (CPIF).* Available at: https://www.statistikdatabasen.scb.se/pxweb/en/ssd/START__PR__PR0101__PR0101G/KPIF/ [Accessed: 16 November 2022]

Stock, J.H. & Watson, M.W. (2016). *Dynamic Factor Models, Factor-Augmented Vector Autoregressions, and Structural Vector Autoregressions in Macroeconomics, Handbook of Macroeconomics.* volume 2, Elsevier, pp. 415-525

Stockhammar, P. and Österholm, P. (2014). Effects of US Policy Uncertainty on Swedish GDP Growth, *National Institute of Economic Research, Working Paper No. 135.*

Swedish Energy Agency. (2019). *Här sker elproduktion och elanvändning i Sverige*. Available at: https://www.energimyndigheten.se/globalassets/om-oss/lagesrapporter/elmarknaden/2019/mars/har-sker-elproduktion-och-elanvandning-i-sverige.pdf [Accessed: 16 November 2022]

The Federal Reserve. (2008). *Federal Reserve announces it will initiate a programme to purchase the direct obligations of housing-related government-sponsored enterprises and mortgage-backed securities backed by Fannie Mae, Freddie Mac, and Ginnie Mae.* Available at: https://www.federalreserve.gov/newsevents/pressreleases/monetary20081125b.htm [Accessed: 19 December 2022].

The Federal Reserve. (2021). *Monetary Policy Principles and Practice - Monetary policy: What Are Its Goals? How Does It Work?* Available at: https://www.federalreserve.gov/monetarypolicy/monetary-policy-what-are-its-goals-how-does-it-work.htm [Accessed: 21 December 2022]

The Federal Reserve (2022). *Factors Affecting Reserve Balances - H.4.1.* Available at: https://www.federalreserve.gov/datadownload/Build.aspx?rel=h41 [Accessed xxx]

The Swedish National Financial Management Authority. (2022). *Monthly outcome of the central government budget.* Available at: https://www.esv.se/statens-ekonomi/prognos-och-utfall/utfall-for-statens-budget/ [Accessed: 16 November 2022]

The World Bank. (2022). *World Bank Commodity Price Data.* Electronic data file, World Bank Open Data. Available at: https://thedocs.worldbank.org/en/doc/5d903e848db1d1b83e0ec8f744e55570-0350012021/related/CMO-Historical-Data-Monthly.xlsx [Accessed: 15 November 2022]

Woodford, M. (2016). Quantitative Easing and Financial Stability. *National Bureau of Economic Research, Working Paper No. 22285.*

Woolridge, J.M. (2016). *Introductory Econometrics A Moderna Approach,* sixth edition, Boston: Cengage Learning, pp. 314-316

Appendices

Appendix A

United States model descriptive statistics

	Mean	Median	Std.dev	Min.	Max.	N
Dependent variable						
CPI	0.633	0.611	0.772	-3.031	2.646	75
Independent variables						
QE	0.005	-0.301	1.479	-3.129	10.712	75
F	0.070	-0.212	1.344	-1.556	9.917	75
QExF	1.630	0.114	12.274	-1.434	106.234	75
I	0.041	0.011	0.397	-1.324	1.184	75
GDP	1.058	1.134	1.672	-8.828	8.788	75
U	-0.029	-0.100	0.940	-3.100	6.600	75
OIL	3.293	4.644	18.876	-60.130	51.671	75
P	0.839	0.546	1.467	-1.629	5.772	75
EX	-0.243	-0.304	4.535	-11.383	11.222	75

Appendix B

Swedish model descriptive statistics

	Mean	Median	Std.dev	Min.	Max.	N
Dependent variable						
CPIF	0.472	0.402	0.569	-0.769	2.763	63
Independent variables						
QE	0.076	-0.964	3.305	-12.147	10.701	63
F	0.019	-0.442	2.787	-5.459	10.410	63
QExF	0.324	0.609	7.198	-23.840	25.549	63
I	-0.007	-0.008	0.337	-1.705	0.499	63
GDP	1.248	1.194	1.775	-6.968	6.757	63
U	7.478	7.694	0.917	5.894	9.438	63

OIL	2.677	3.534	19.451	-58.026	55.551	63
P	5.635	1.957	30.612	-50.171	104.278	63
EX	0.608	0.136	5.047	-8.365	23.217	63

Appendix C

Test for unit root

	Augmented Dickey-Fuller Test p-value	
Variable	U.S.	Sweden
CPI/CPIF	0.000***	0.0372**
QE	0.000***	0.0028***
F	0.000***	0.000***
QExF	0.000***	0.000***
I	0.027**	0.001***
GDP	0.000***	0.000***
U	0.000***	0.003***
OIL	0.000***	0.000***
P	0.000***	0.000***
EX	0.000***	0.000***

P-values: *P<0.1 **P<0.05 ***P<0.01

Appendix D

Robustness tests

	Test p-value	
Test	U.S.	Sweden
White test	0.815	0.339
Breusch-Godfrey test	0.652	0.483

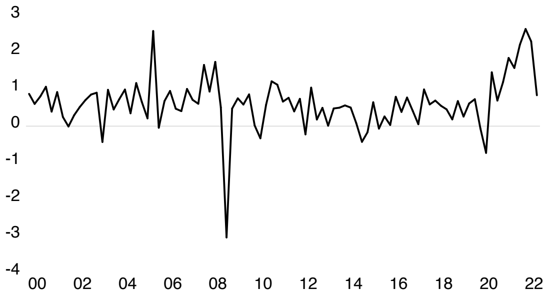
P-values: *P<0.1 **P<0.05 ***P<0.01

Appendix E

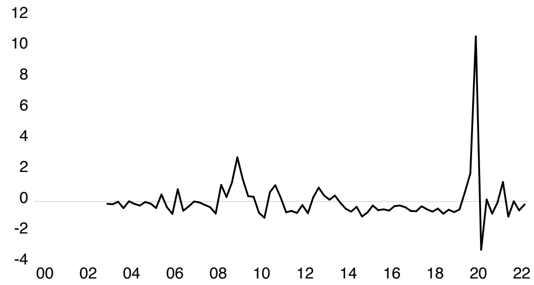
Graphs of U.S. data

All graphs show year on the x-axis and per cent on the y-axis

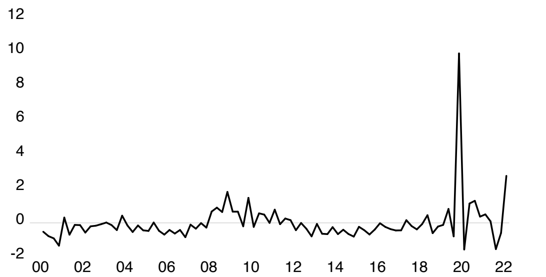
CPI



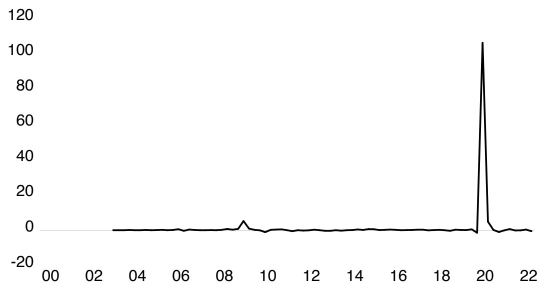
QE



F

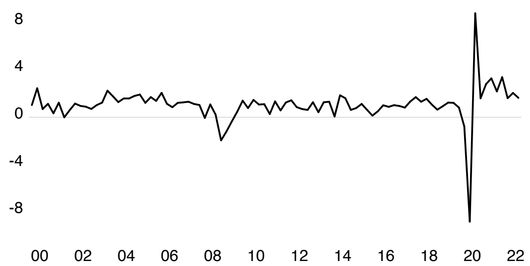


QExF

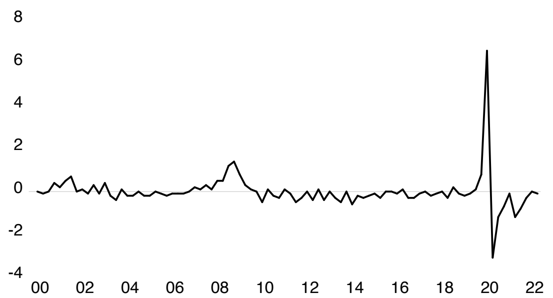


Policy rate (I)

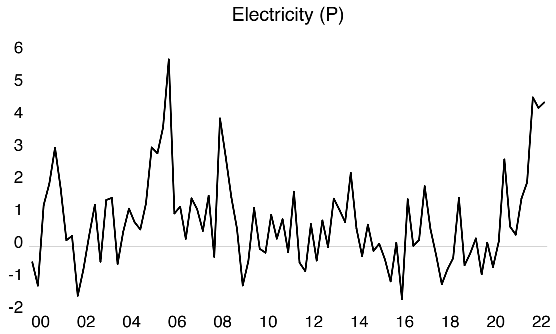
GDP

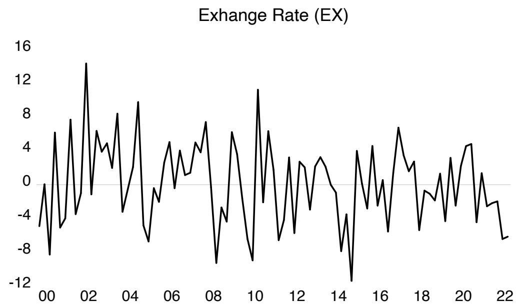


Unemployment (U)



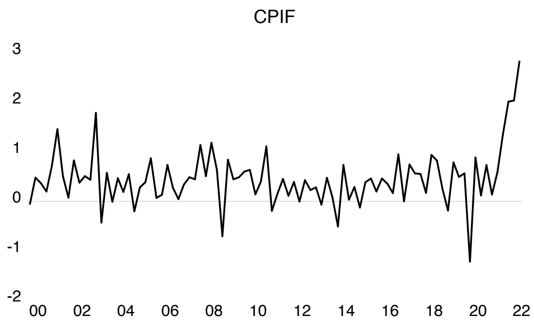
OIL

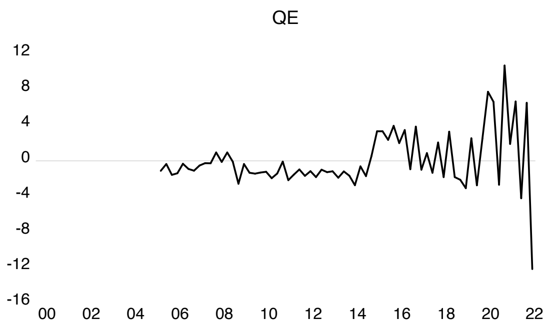


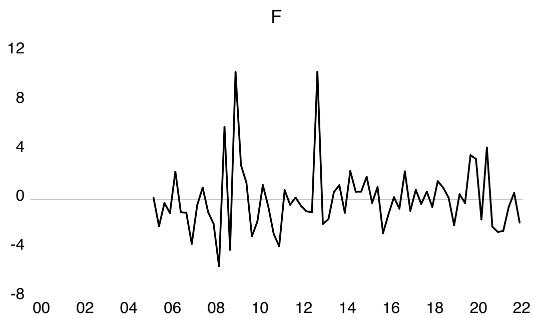


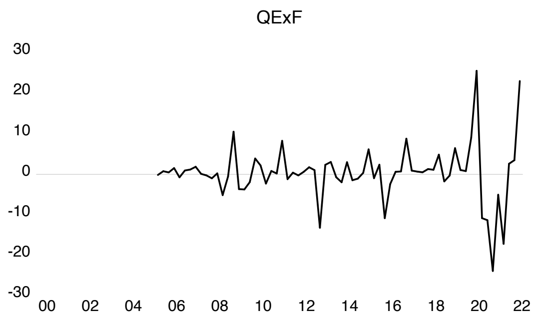
Appendix F
Graphs of Swedish data

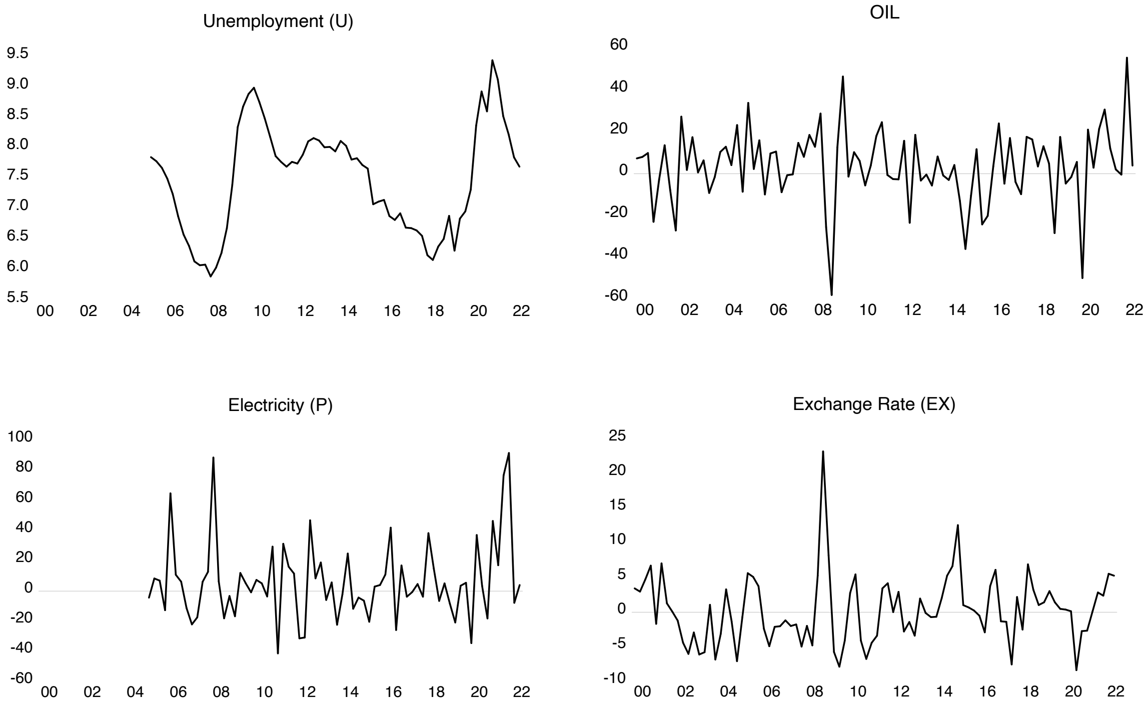
All graphs show year on the x-axis and per cent on the y-axis










Unemployment (U)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
00 02 04 06 08 10 12 14 16 18 20 22
OIL
60
40
20
0
-20
-40
-60
00 02 04 06 08 10 12 14 16 18 20 22
Electricity (P)
100
80
60
40
20
0
-20
-40
-60
00 02 04 06 08 10 12 14 16 18 20 22
Exchange Rate (EX)
25
20
15
10
5
0
-5
-10
00 02 04 06 08 10 12 14 16 18 20 22