DALARNA UNIVERSITY

Thesis

Bachelor's degree

Effectiveness of monetary policies

A study of the Swedish repo rate between 1994 and 2019

Author: Christoffer Bjerknesli
Supervisor: Catia Cialani
Examiner: Lena Nerhagen
Subject/main field of study: Economics
Course code: NA2008
Credits: 15 hp
Date of examination: 4 June 2020

Dalarna University – SE-791 88 Falun – Phone +4623-77 80 00

Abstract:

The repo rate, which is the key interest rate, set by the central banks has been declining for many years and hitting zero in Sweden in late 2014. We analyse the effectiveness on the economy from a change in the repo rate, comparing two time periods with high and low repo rate environments. We use quarterly data on GDP and its components, between 1994 and 2019. For analysing the effectiveness, we use multiple Auto Regressive Distributed Lag (ARDL) modelling to compute a total of 12 models. In our findings, we saw that the effectiveness of a change in repo rate has been increased in the low repo rate environment, making it harder to increase the rate without harming the economy but also increasing the effect of a decrease in the repo rate. Also, we found that the investment component of GDP may exhibit extra high effectiveness in the low repo rate environment. This method of analysing the repo rates impact on the economy could be used for decision makers regarding monetary policies.

Keywords: repo rate, effectiveness, auto regressive distributed lag model, coefficients, GDP, monetary policies.

Table of contents

1. Introduction

Interest rates have been fluctuating in the zero-lower bound for years, and some research has been made on investigating if the stimulus from monetary policies has been suffering from diminishing effectiveness.

In Sweden, monetary policies, and therefore the key interest rate (repo rate), are set by the central bank Riksbanken (Sveriges Riksbank, 2020). The repo rate has been declining from two percent in late 2011 and hitting zero in October 2014. After that, the rate has been moving sideways at -0.5 percent for three years before slowly making it back towards zero in early 2020. Riksbanken's main target when adjusting monetary policies is for inflation to be at 2% which is achieved through influencing the financial conditions that affect resource utilisation and therefore inflation (Sveriges Riksbank, 2020). In Riksbanken's toolbox for keeping the inflation at target and stabilizing the economy, the repo rate has been the main tool for decades, but in recent years they have turned towards more unconventional monetary policies, such as quantitative easing (Sveriges Riksbank, 2017).

What if the Swedish economy and its transmissions channels, which affects output, have lost effectiveness from monetary stimulus in the form of repo rate changes during this time compared to when rates were higher and could be used as a "go-to tool" for boosting the economy? If so, can we measure the loss of effectiveness?

Our definition of effectiveness is by how much economic indicators (GDP, investment, consumption etc) is affected from a change in the repo rate when comparing a period of relatively high repo rates to an environment where repo rates fluctuate around zero.

The purpose of this thesis is to estimate the percentage change in effectiveness on Gross Domestic Product (GDP) and its components and therefore on the economy, when the repo rates fluctuates in the zero lower bound compared to higher rates. Compared to previous literature that have used Vector Auto-Regressive (VAR) models for similar research questions, we are estimating multiple Auto Regressive Distributed Lag models (ARDL) to address the problem at hand. The reason for this is mainly, that we focus our thesis on comparing the effectiveness of a dependent variable (repo rate) on the independent variable (GDP, investment, consumption etc) between two time periods without restrictions or influence from other variables. Secondly, we want to introduce the use of the simpler autoregressive model for comparing effectiveness of repo rates, in high and low repo rate climates.

This paper focuses on the Swedish economy and data is gathered that reflects the state of the Swedish economy. The time frame and gathered data for this paper is quarterly based and is collected from the 3rd quarter 1994 until the 4th quarter 2019, which is divided into two equal time periods.

To the best of our knowledge, there has not been any research done in the field on the effectiveness of changes in repo rate at different levels of repo rates in Sweden. The earlier work done has been focused on to what extent a shock in repo rate affects indicators such as GDP, inflation, and investment, but not how the shock is affecting at different levels of repo rates (Uhlig, 2005; Hopkins, Lindé & Söderström, 2009; Altavilla, Burlon, Gianetti & Holton, 2019; Baldi & Lange, 2019). The results from this study contributes to the literature by introducing a simpler model for estimating the effectiveness of repo rate changes to the economy. Furthermore, we show that compared to earlier studies, our results indicate that using the repo rate may still be a sufficient tool for boosting the economy.

The rest of this paper is organized as follows. In Section 2, a literature review will be presented followed by a brief explanation on the transmission channels. In Section 3, we describe the methodology and data used. In Section 4, we present the results of our analysis. In Section 5, we discuss the results. Finally, in Section 6 we draw conclusions of our findings.

2. Literature review

In this Section, we will present the literature and earlier work conducted in the field followed by a brief explanation of the transmission mechanism in *Section 2.1.* The literature on the effectiveness of repo rates is rather scant. This could be the case due to that repo rates fluctuating in the zero lower bound is a new phenomenon and has only been relevant for a few years. The literature regarding repo rates is mainly driven by central banks, which to the best of our knowledge does not express the changes between time periods but focuses on outcomes at a precise moment in time.

From economic theory, we know that two main forces are used when stimulating an economy, fiscal and monetary policies (Leeper, 2018). Fiscal policies are set by the government and monetary policies by the central bank. Petrevski, Trevonski and Tashevska (2019) made an interesting contribution to the literature when studying the macroeconomic effects from fiscal and monetary policies in Macedonia, a small open economy, with the use of a Vector Auto-Regressive (VAR) model. Their findings suggested that a mix of restrictive fiscal and modest monetary policy expansion has a positive effect on economic activity, in contrast to expansionary fiscal policy and restrictive monetary policy which makes output to fall (Petrevski et al., 2019). In addition, in the event of a contractionary monetary policy shock, it only affects real GDP by a small fraction (moving it up or down by 0.2%) (Uhlig, 2005). The results found by Uhlig (2005) was that the commodity price index (CPI) falls more quickly than the GDP price deflator when monetary policy is contractionary.

However, complications for monetary policy interactions occur to be present when interest rates reach the zero-lower bound, which is the rate around zero percent where further cuts will not be a sufficient method to use (Altavilla, Burlon, Gianetti & Holton, 2019). Borio & Hofmann (2017) find that monetary transmission is less effective in an environment of consistently low interest rates. Through revision of existing literature they find that the reduced effectiveness may be because of two main reasons; Headwinds, which make the comeback from a balance sheet recession harder due to inflated debts and will weaken demand; Non-linearities, where consistent low interest rates can have adverse effect on loans and consumptions due to future expectations (Borio & Hofmann, 2017). Even so, Altavilla et al. (2019) conclude, using confidential balance sheet data of banks in the Euro zone, that banks with a sound balance sheet can successfully transfer negative rates to the borrowers and hence increase their lending which, introduces a corporate finance channel in the transmission channel and increasing investments from firms. The increase of investment by firms arises from transferring the negative rates onto firms' deposits, who cannot convert their deposits into cash as easily as households and encouraging firms to invest in tangible or intangible assets instead. Moreover, according to Baldi and Lange (2019), the interest rate sensitivity of investment has decreased and become less responsive to monetary policy when comparing two periods, before and after early 1990.

When interpreting changes in an economy, the economic theory of the *transmission channels* is used to understand what is influenced by a change in the repo rate (Borio & Hofmann, 2017; Bernanke & Blinder, 1992).

A wide range of tools can be used for assessing the change in economic indicators that occur when the repo rate is changed. In the literature, the most common way to investigate these relationships is to use a Vector Auto-Regressive (VAR) model (Bernanke & Mihov, 1995; Bagliano & Favero, 1998; Petrevski et al., 2019; Jacobs, Ogawa, Sterken & Tokutsu, 2020). Examples of earlier studies that have used a VAR model include the investigation of the relationship between public dept ratios and economic growth rates (Jacobs et al., 2020), effects of monetary and fiscal policies (Petrevski et al., 2019) and measuring monetary policies based on reserve market indicators (Bernanke & Mihov, 1995).

In the case of Sweden, Riksbanken uses many different models when analysing the effects of how monetary policies influence the economy. They mostly use Ramses, which is a weighted average model that takes into account different assumptions. But Riksbanken also uses different VAR models, which is built up on statistical correlations. (Hopkins, Lindé & Söderström, 2009). Hopkins et al. (2009) show the relationship between a shock in repo rate of 0.25 percentage points and how different economic variables react to this change, using both Ramses and VAR models.

According to Hill, Griffiths and Lim (2017) an ARDL model can be used for forecasting and policy analysis. In our case, as we are focusing this paper on analysing monetary policies, we will in contrast to earlier researchers that have used VAR models, use the ARDL model for our analysis. Khan, Teng and Khan (2019) used the ARDL approach to test the long-run relation between macroeconomic variables on the exchange rate between US dollars and Chinese Yen. They used yearly time series data for the Chinese economy from 1980 to 2017 and their findings suggested that GDP and openness in trade have a positive effect on the exchange rate while interest rates and inflation have a negative effect. Furthermore, Hatmanu, Cautisanu and Ifrim (2020) used the ARDL approach to investigates the short-run influence of interest rates, real exchange rate and the business climate in Europe on the economic growth in Romania. Their findings suggested that the economic growth in Romania is positively influenced by the exchange rate and negatively by the interest rate.

2.1 Transmission mechanism

In this Section, we will present the transmission mechanism in the economy and the main channels within the mechanism. We will explain how a change in the repo rate affects economic agents through the four main transmission channels and how it through these channels, steers the economic activity.

When Riksbanken decides on how to stimulate the economy, their main tool is to use the repo rate (prime rate) for adjusting expectations on inflation and output levels in the future. When Riksbanken makes a change in the repo rate, it affects the general view on interest rates (Hopkins et al., 2009). They can in the short run, through the transmission mechanism, have a direct effect on the real economy regarding consumption, investments, production, employment, and inflation (Hopkins et al., 2009). In the long run, monetary policies have a small or limited effect and is regarded neutral and only effects the rate of inflation.

The transmission mechanism shows how the change in the repo rate affects different parts of the economy. As shown in *Figure 1*, we can follow how central banks expect the change in repo rate will affect the economy.

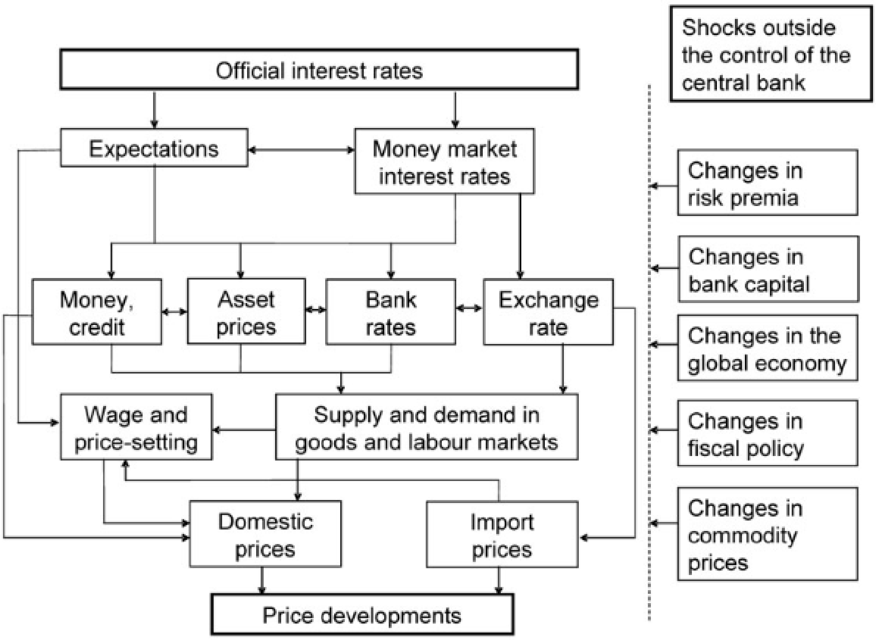

Figure 1- Transmission mechanism (European Central Bank, n.d.)

Through the interest channel, when Riksbanken increases the repo rate, the overall interest level in the economy increases which makes it more beneficial to save money and less beneficial to lend more money. This will make households to hold on to money and lend less, which will result in a loss of consumption and an increase in savings. Companies may put expansions on hold due to higher loan costs. This will make demand for goods and services to go down, which will push down prices and, in the end, leads to lower inflation. (Hopkins et al., 2009).

As monetary policies change, due to a change in interest, demand for both real and financial assets will change, via the credit channel. Today's value of future payments in financial assets, such as dividend or face values, has to be recalculated when interest rates change. Since both real and financial assets are used as collateral for bank loans, the drop in prices and value for these assets will make banks more restrictive when admitting new loans. As banks loan rates increase or decrease, it will as a consequence make households and firms consumption and investment to influence in the opposite direction of the change. Instead of admitting new loans, banks can view it more beneficial to invest in shares or bonds. In total, as asset prices fluctuate, the overall demand and inflation will have an opposite direction as the change of the repo rate. (Hopkins et al., 2009).

In an open economy, as is the case for Sweden, a change in monetary policies will affect the exchange rate, through the exchange rate channel. An increase in interest rates will make the Swedish economy more interesting for investors, which will increase the demand for Swedish currency and therefore increase the value of the crown. *Ceteris paribus*, an appreciation of the Swedish crown will make goods produced in Sweden more expensive in relation to foreign goods. This will make the demand for foreign goods to increase, and hence the exports will decrease as imports increase. Furthermore, an appreciation of the currency will have a direct effect on inflation as prices on imported goods decreases, inflation decreases. (Hopkins et al., 2009).

The cost channel is a bit different compared to the other channels since it could have a direct impact on inflation. The effects of an increase in interest rates could directly affect companies' costs, since they are in some part funded by loans. Because of increased costs for the companies, they could directly increase prices to compensate for the costs, which would increase inflation. Compared to the other channels, this is an opposite force on inflation. (Hopkins et al., 2009).

To summarize, a change in the repo rate will, after passing through the four main transmission channels (interest channel, credit channel, cost channel & exchange rate channel) affect the economy in various ways. The components of GDP, consumption, investment, import, and export are all impacted by this change and will adjust to a change in repo rate.

3. Data and Methodology

In this Section, we will present the data and in *Section 3.1* the methodology that will be applied in our analysis.

Data are represented by the Swedish GDP (Gross Domestic Product) and its components (*Table 1)* and the repo rate. GDP and its components are measured in MSEK and the repo rate is measured in percentage points. We use time series data from the third quarter of 1994 to the fourth quarter of 2019. The datasets used was gathered from SCB's and Riksbanken's websites (SCB, n.d.; Sveriges Riksbank, n.d.). We have a total of 102 observations at a quarterly basis.

Table 1 - Variables used for modelling

Variable	**Model Specification**	**Period 1 (1994Q3-2007Q1)**	**Period 2 (2007Q2-2019Q4)**
Gross Domestic Product	GDP	GDP_1	GDP_2
Household Consumption	C_H	C_H_1	C_H_2
Public Consumption	C_P	C_P_1	C_P_2
Investment	I	I_1	I_2
Import	IM	IM_1	IM_2
Export	EX	EX_1	EX_2
Repo rate	R	R_1	R_2

As was described in *Section 2.1* about the transmission channel and its relation to the repo rate, the data used for analysis is related to the economy's supply and demand in the goods and service market and is affected through the different channels explained earlier. Since we want to measure if there has been a change in effectiveness, as a result from a change in the repo rate, on the economy as the rates has declined towards zero, we have divided the observations into two time periods. The first period is from 1994 3rd quarter until the 2007 1st quarter and the second period are 2007 2nd quarter until 2019 4th quarter. The break of early 2007 was selected because we wanted the two time periods to have the same amount of observations. Furthermore, the two periods reflect an interest rate environment of either high or low repo rates as the first period has the mean above 4 percent and the second period below 1, see *Figure 2.*

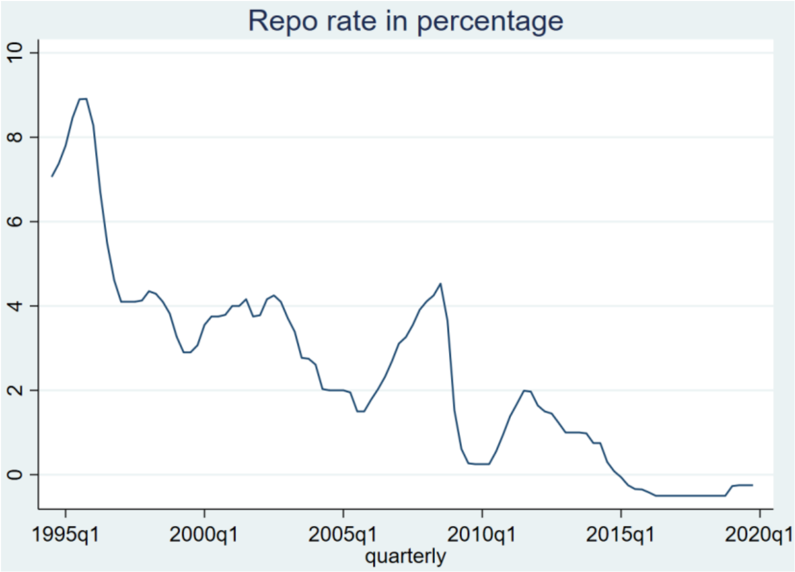

Figure 2 - Swedish Repo rate

The repo rate set by Riksbanken has been in a declining trend since the beginning of our sample period. Some short spikes upwards can be notices but they have been followed with new lows, and since the end of 2014 it has moved sideways below zero. Gross domestic product and its components have been moving in a slight upward trend and seem as we see in *Figure 3*, inhibit a stationary behaviour with a small trend.

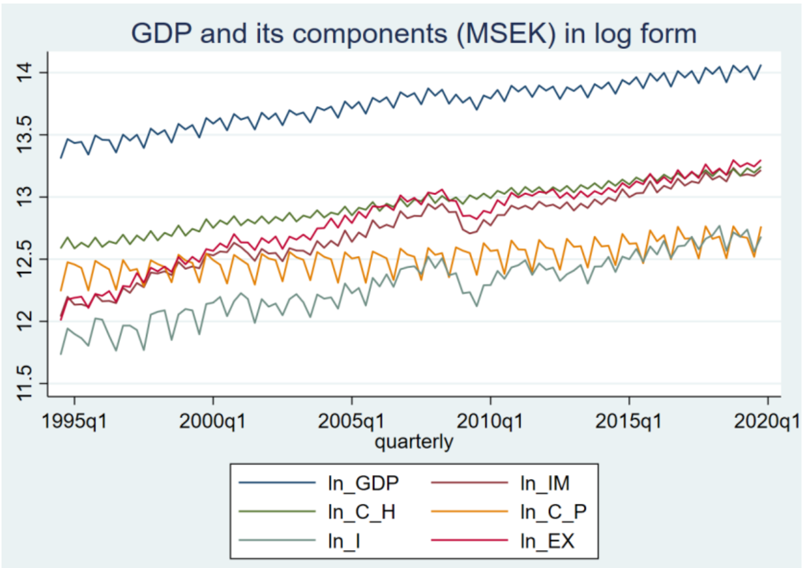

Figure 3 - GDP and its components

3.1 Auto Regressive Distributed Lag Model

We use multiple Auto Regressive Distributed Lag (ARDL) models to analyse the relationship between the dependent variables (BNP, C_H, C_P, I, IM, EX) and the independent variable represented by the repo rate (R).

Let us consider a general ARDL (p, q) model.

$$y_t = \delta + \theta_1 y_{t-1} + \cdots + \theta_p y_{t-p} + \beta_0 x_t + \beta_1 x_{t-1} + \cdots + \beta_q x_{t-q} + u_t \quad (1)$$

In *Formula 1*, y_t is the dependent variable at time t, and y is represented by gross domestic product (GDP), household consumption (C_H), public consumption (C_P), investment (I), import (IM) and export (EX). δ is the constant, θ is the coefficient for y at p lags, β is the coefficient for x at q lags and u_t is the error term. The amounts of lags for each variable is represented by p and q. In an ARDL (p, q) model, the dependent variable, y, is explained with past values of itself but also current and past values of x, the independent variable.[1]

We construct multiple ARDL models for our analysis, in total twelve models will be presented. Each model will take the form of a general ARDL model with the repo rate as an independent variable in all twelve models, six models per time period.

To ensure that our models are the best estimated ones and that they are stable, Dickey-Fuller, White's and Breusch-Godfrey test will be applied to the variables and the finished models. Before testing, we convert all the dependent variables to logs (repo rate is used in level since it is expressed in percentage points and goes to zero at some points and the log of zero cannot be defined).

3.2 Tests

We use Dickey-Fuller test to check for stationarity in the variables, to ensure that the variables are either cointegrated of order 1 or 0, and not order 2 (Dickey & Fuller, 1979). A stationary variable is a variable that fluctuates around a mean and does not have a clear trend and are said to be stationary *I*(0). When variables have a mean or variance that change over time, they are

[1] For further explanations of the model (Hill, Griffiths & Lim, 2017)

considered nonstationary. As we take the first difference of a nonstationary variable and it is shown to be stationary, it is said to be stationary *I*(1).

In general, nonstationary time-series variables should not be included in a regression model. But there is an exception to this rule, if the variables are *I(1)* and has a linear combination that also is I(1) and their regression error is stationary I(0), they are said to be cointegrated. Cointegration means that the variables share a stochastic trend and they do not diverge too far from each other. (Hill, Griffiths & Lim, 2017).

When using a multiple regression model, a relevant measure for accuracy is R^2, which shows how variation in the dependent variable can be explained by all the explanatory variables in the model (Hill, Griffiths & Lim, 2017). The formula for R^2 are presented in *Formula 2.*

$$R^2 = \frac{SSR}{SST} = \frac{\sum_{i=1}^{N}(\hat{y}-\bar{y})^2}{\sum_{i=1}^{N}(y_i-\bar{y})^2} = 1 - \frac{SSE}{SST} = 1 - \frac{\sum_{i=1}^{N}\hat{e}_i{}^2}{\sum_{i=1}^{N}(y_i-\bar{y})^2} \quad (2)$$

Moreover, we will also use Akaike information criterion (AIC) and Schwarz criterion, also known as Bayesian information criterion (SBIC) for selecting the best fitted model. These estimates minimize the sum of squared errors with a penalty for adding an extra variable. These criterions are suitable for comparing models that have the same dependent variable. (Hill, Griffiths & Lim, 2017).

$$AIC = \ln\left(\frac{SSE}{N}\right) + \frac{2K}{N} \quad (3)$$

$$SBIC = \ln\left(\frac{SSE}{N}\right) + \frac{Kln(N)}{N} \quad (4)$$

We use White's test (WT) for testing if there is heteroskedasticity among the standard errors (Hill, Griffiths & Lim, 2017). With White's test we want to fail to reject the null hypothesis that there is no homoskedasticity.

We apply Breusch-Godfrey (BG) test for serial correlation among the errors. As is the case with White's test, we want to fail to reject the null, which is that there is no first-order serial correlation.

4. Results

In this section, we will present the results from our 12 ARDL models, 6 models per period. Firstly, we will present the models attributes, i.e. number of lags and goodness of fit. Secondly, we will present the models results from post-tests, i.e. test statistic results for White's test (WT) and Breusch-Godfrey test (BG). Furthermore, in *Section 4.1* and *Section 4.2*, we will present a brief overview of how the models for each period were selected and the results from post-tests in table form.

Since we are considered of the effectiveness of the repo rate, we will focus on the coefficients for repo rate and their effect on the dependent variable. Our main focus will be on comparing the coefficients between the two time periods. From *Section 4.3* and further on, we will only focus on the coefficients. For a detail over the complete models see *Appendix A*.

Our Dickey-Fuller test indicates that all of the dependent variables are *I*(0) and the independent variable are *I*(1) at a 1 percent significant level. Thereafter, we estimated the amounts of lags for each variable that minimizes the information criterion (AIC, SBIC). When the lags have been identified, we combine the models with its coefficients and number of lags that yield the lowest information criterion and has the highest R^2 with the greatest number of significant coefficients.

4.1 Period 1 Models

A summary is presented for the final models from equation 1, estimated for period 1 (P1) and are expressed with respective test-score in *Table 2*.

Table 2 - Estimated models for period 1

Period 1	*Model*	R^2	*AIC*	*SBIC*	*WT*	*BG*
GDP	AR(4)DL(2)	0.9912	-270.86	-256.06	0.7636	0.0348
C_H	AR(4)DL(1)	0.9888	-227.96	-265.00	0.2065	0.0006
C_P	AR(4)DL(0)	0.9674	-236.24	-225.14	0.0187	0.0449
I	AR(4)DL(2)	0.9091	-137.14	-122.34	0.2341	0.1864
IM	AR(4)DL(1)	0.9705	-174.54	-161.59	0.4215	0.0001
EX	AR(4)DL(1)	0.9847	-187.12	-174.16	0.5629	0.0066[2]

[2] Based on 51 observations.

All of our P1 models take the form of four autoregressive lags for the dependent variable. The independent variable (repo rate) has been modelled from zero lags up to two lags, with regards of the model. Without losing the statistical significant of all the coefficients, which could have been done by adding or losing a variable to generate a better result for some of the tests, we have built models that have the lowest AIC and SBIC score and an R^2 higher than 0.9 in all of our models. With an R^2 over 0.9 we can be sure that our models explain the dependent variable to 90 percent.
In the post-estimation of the models, we can with the White's test, see that all of our models in P1 except for public consumption (C_P) fail to reject homoskedasticity among the errors at a 5 % significant level. This indicates that for C_P there are heteroskedasticity among the errors. Furthermore, the Breusch-Godfrey test indicates that first order serial correlation may be the case for all models except for the model explaining investment in P1.

The post-estimation results indicate that our models may not be the best models for estimation, but since we are interested in how well our models describe the dependent variable and will in *Section 4.3* compare the coefficients for current and lagged values of repo rate (R), we are more concerned that our coefficients are statistically significant.

4.2 Period 2 Models

In *Table 3,* we present the final models from equation 1, estimated for period 2 (P2) with their respected goodness of fit and post-test scores.

Table 3 - Estimated models for period 2

Period 2	*Model*	R^2	*AIC*	*SBIC*	*WT*	*BG*
GDP	AR(4)DL(3)	0.9801	-259.95	-243.29	0.4664	0.0029
C_H	AR(4)DL(1)	0.9917	-317.43	-304.47	0.0747	0.0039
C_P	AR(4)DL(0)	0.9841	-259.51	-248.41	0.4409	0.4333
I	AR(4)DL(3)	0.9285	-153.84	-137.19	0.3676	0.0181
IM	AR(4)DL(2)	0.9656	-197.15	-182.35	0.3565	0.2533
EX	AR(4)DL(2)	0.9698	-211.51	-194.86	0.3636	0.9907[3]

[3] Based on 51 observations.

As the results shown in *Section 4.1*, all of our models show high R^2 results. The average R^2 score is even higher for P2, which indicates that the models explain the dependent variable even better in comparison with P1. The models are also chosen to minimize the information criterions AIC and SBIC.

The post-estimation tests indicate that all models fail to reject the existence of homoskedasticity at a 5 % significant level, shown by the results for White's test. Furthermore, the Breusch-Godfrey test indicates that, by rejecting the null hypothesis, investment (I), growth domestic product (GDP), and household consumption (C_H) might have heteroskedasticity among the errors.

As said in previous section, we are accepting these test statistics since we are interested in the significant level of the coefficients for repo rate (R) and its influence on the dependent variable, and by modelling the models even further resulted in less significant coefficients.

4.3 Comparing coefficients

Before we compare the models between the periods and its coefficients for repo rates, we want to highlight that since we have used log form for our depended variable and repo rate is expressed in level form, a one unit (1% of repo rate, because it is modelled with percentage points) change will have an effect on the dependent variable as *Formula 5.*

$$\%\Delta y = 100 * \beta_t * \Delta x_t \qquad (5)$$

On the left side of *Formula 5*, we have a percentage change in the dependent variable y, as a result of a change in the independent variable x (repo rate) at time t multiplied by the coefficient at time t (β) and multiplied by a 100. So, according to the formula when we read the coefficients from our tables, they can be translated into the percentage effectiveness on the dependent variable as repo rate is raised by one 1 percent.

We start by comparing the effect on household consumption between the two periods. Both of the models yielded 1 lag for R and had the similar properties in post-testing. The coefficients for P1 are statistically significant at 5% for lag number 1 (L1) but not at lag order zero (L0). Both of the coefficients for P2 are statistically significant at 1%. In P1, at L1, repo rate affect household consumption with a negative 1.11 percent (*Table 4*).

Table 4 - Coefficients for repo rate on household consumption

	Dependent variable: C_H		*Period 1*	
Lag order	Coefficient	P-value	Std. Error	95% CI
0	0.0042	0.359	0.0046	-0.0050 / 0.01365
1	-0.0111	0.020	0.0045	-0.0204 / -0.0018
			Period 2	
0	0.0095	0.004	0.0031	0.0031 / 0.0158
1	-0.0176	0.000	0.0031	-0.0241 / -0.0111

In P2, at L1, repo rate affects household consumption with a negative 1.76 percent (*Table 4*). From this, we can conclude that at L1, the effectiveness of a one percent change in repo rate will make household consumption to change in the opposite direction of the change in repo rate, by 0.65 (1.76 - 1.11) percent more in P2 than P1. This is an increase of effectiveness by 58.1 percent for repo rate at L1.

Even though L0 in P1 is not statistically significant, we can compute the total impact of L0 and L1 from a change in repo rate on household consumption by adding the coefficients together. The total effect in P1 is 0.0042-0.0111 = -0.0069 = -0.69%. Total effect in P2 is -0.0081 = -0.81%. The increase of effectiveness in P2 is 18.8%.

For public consumption, we cannot report statistically significant coefficients (*Table 5)*. Both models expressed zero lags for repo rate, which combined with the significant level of the coefficients expresses a low relationship between the C_P and R in the model. However, without being statistically significant, both coefficients are indicating a reverse relationship towards the dependent variable. The coefficient for P2 (-0.32%) has greater impact on the dependent variable than the coefficient in P1 (-0.17%). Even though that the coefficients are statically significant, we want to suggest that the effectiveness from a change in repo rate is 85.5 % higher in P2 compared to P1.

Table 5 - Coefficients for repo rate on public consumption

	Dependent variable: C_P		*Period 1*	
Lag order	Coefficient	P-value	Std. Error	95% CI
0	-0.0017	0.473	0.0023	-0.0064 / 0.0030
			Period 2	
0	-0.0032	0.246	0.0027	-0.0086 / 0.0022

In *Table 6*, we have expressed the coefficients for repo rate from the models for investment in the two periods. There is no clear way in comparing the results due to different number of lags in the models. In P1, L2 is statistically significant and has an opposite impact on investment as repo rate is changes by one percent. In P2, at L3 the impact on of a change in repo rate is statistically significant.

Table 6 - Coefficients for repo rate on investment

	Dependent variable: I		*Period 1*	
Lag order	Coefficient	P-value	Std. Error	95% CI
0	-0.0045	0.884	0.0311	-0.0676 / 0.0584
1	0.0786	0.146	0.0530	-0.0286 / 0.1859
2	-0.0807	0.009	0.0295	-0.1405 / -0.0209
			Period 2	
0	0.0431	0.083	0.0242	-0.0058 / 0.0922
1	-0.0362	0.418	0.0443	-0.1259 / 0.0534
2	0.0591	0.193	0.0446	-0.0311 / 0.1495
3	-0.1031	0.000	0.0252	-0.1541 / -0.0521

The last coefficient in the models are statistically significant, and the R^2 indicates that the dependent variable is explained by 90% of the variables in the models for both periods. Furthermore, White's test had similar results for investment in both periods and in combination with low information criteria we want to express that the total impact could be computed even though that the number of lag are different in the models. When we sum up the total chain of impact in the two periods and compare the results, repo rate has a 3% greater impact on investment in P2 (-3.7%) than in P1 (-0.67%) This is an increase of effectiveness by over 452%.

For import, the situation is similar as it where for investment. From the models we have different number of lags for repo rate in the two periods. However, for import, as seen in *Table 7,* L0 is statistically significant at 10% in both periods and L1 for P1 and L2 for P2 are statistically significant at 5%. This indicates that for import, our results are more reliable than it was for investment. The direct impact of a change in repo rate, explained by the coefficient L0, has a 22.77% higher effectiveness in P2 than P1.

Table 7 - Coefficients for repo rate on import

	Dependent variable: IM		*Period 1*	
Lag order	Coefficient	P-value	Std. Error	95% CI
0	0.0282	0.053	0.0141	-0.0003 / 0.0569
1	-0.0466	0.003	0.0147	-0.0764 / -0.0167
			Period 2	
0	0.0347	0.029	0.0153	0.0037 / 0.0656
1	0.0129	0.628	0.0264	-0.0405 / 0.0663
2	-0.0626	0.001	0.0171	-0.0973 / -0.0280

Even though we cannot compare the coefficients of L1 and L2 from the models and simultaneous say that they are statistically significant, we have summed up the total impact on import from a change in repo rate and compared the results. For P1, our results suggest that the total impact of a change in repo rate on import are 0.0282-0.0466= -0.0184= -1.84%. For P2, with the same calculation we get -0.0151 = -1.51%. In total, the effectiveness of a change in repo rate was 21.2 percent more in P1 compared to P2.

Comparing the two models' coefficients for repo rate against export, shows that for P1, L1 are statistically significant at 5% and for P2 both L0 and L3 are statistically significant (*Table 8*). When computing the total chain of impact from the coefficients, we sum up a total of -1.68% in P1 and -1.76% in P2. This indicates that repo rate in P2 has a 4.76% higher effectiveness on export compared to P1.

Table 8 - Coefficients for repo rate on export

	Dependent variable: EX		*Period 1*	
Lag order	Coefficient	P-value	Std. Error	95% CI
0	0.0139	0.274	0.0125	-0.0114 / 0.0393
1	-0.0307	0.022	0.0128	-0.0567 / -0.0047
			Period 2	
0	0.0365	0.014	0.0141	0.0079 / 0.0651
1	-0.0290	0.234	0.0240	-0.0777 / 0.0195
2	0.0092	0.706	0.0242	-0.0398 / 0.0582
3	-0.0342	0.026	0.0147	-0.0641 / -0.0044

Lastly, we compare the results from estimating the relationship between repo rate and GDP. For P1 repo rate influences GDP with two lags, with L2 being statistically significant at 1%. For P2, repo rate is expressed with 3 lags and both L0 and L3 are statistically significant at 5%. The total chain of impact is -0.62% for P1 and -1.79% for P2. We calculate an 189% higher effectiveness from a change in repo rate in P2 compared to P1 for the depending variable GDP. Coefficients are displayed in *Table 9.*

Table 9 - Coefficients for repo rate on GDP

	Dependent variable: GDP		*Period 1*	
Lag order	Coefficient	P-value	Std. Error	95% CI
0	-0.0017	0.820	0.0075	-0.0169 / 0.0135
1	0.0154	0.233	0.0127	-0.0103 / 0.0411
2	-0.0199	0.008	0.0071	-0.0342 / -0.0055
			Period 2	
0	0.0167	0.050	0.0082	0.0000 / 0.0333
1	-0.0208	0.167	0.0147	-0.0507 / 0.0091
2	0.0238	0.110	0.0145	-0.0056 / 0.0534
3	-0.0376	0.000	0.0077	-0.0533 / -0.0218

To sum up the results, see *Table 10*, we have summarized the results of total impact from a change in repo rate on the dependent variables, indifference of the lag length in the models between P1 and P2. There is a clear trend that for almost all our models, effectiveness of a change in repo rate is greater in P2 compared to P1. Although, import is not coherent with these results, as a change in repo rate has greater effectiveness in P1 than in P2.

Table 10 - Impact of repo rate on dependent variable and effectiveness summary

Dep. Variable	*Impact P1*	*Impact P2*	*Effectiveness*
C_H	-0.69%	-0.82%	18.8%
C_P	-0-17%	-0.32%	85.5%
I	-0.67%	-3.7%	452%
IM	-1.83%	-1.51%	(21.2%)
EX	-1.68%	-1.76%	4.76%
GDP	-0.62%	-1.79%	189%

5. Discussion of the results

In this Section, we will discuss the results from our analysis. We have shown that most of our indicating coefficients in the models are statistically significant and hence the results can be regarded as reliable to some extent.

In this paper, we have introduced a simpler model (ARDL model) than earlier research has used (VAR/VECM) to access the matter of how repo rates impacts the economic activity. The literature indicates that as repo rates has reached the zero lower bound, its use as a tool for central banks has been diminishing and therefore more unconventional monetary policies has been introduced. The introduction of these unconventional tools has been present during the second period of our data. This has probably had some impact on the results that does not clearly show from our analysis.

Our results present a variety of different combination of models, which all have both its positive and negative attributes. Some of them explain the dependent variable to a high percentage and some a bit less. They all (except for public consumption) have at least one coefficient that are statistically significant. This gives us reliability to some extent, but in a best case scenario all coefficients should have been statistically significant and with the same number of lags in both periods. In theory this might be accomplished, but as the world around us is in constant change, that all models should be static and similar between periods is more dreaming than reality.

The results shown in *Section 4.3* are in line with economic theory that was explained through the transmission mechanism. The dependent variables have an opposite direction of an increase in the repo rate. This gives us indications that the models used are presenting results that are coherent with the theory.

In relation to Uhlig (2005), who shows that GDP is affected by a small fraction from a contractionary monetary policy shock (up or down by 0.2%), we show that by increasing the repo rate by 1% would make GDP to fall by 0.62% in period one and 1.79% in period two. We have shown that the effectiveness of monetary policy shocks has increased in the second period compared to period one.

Contradictory to Baldi & Lange (2019) who state that investment has become less responsive to monetary policies, when comparing before and after 1990. We can, with our results presented by the chain impact from the independent variable on the dependent variable, argue for a higher effectiveness after 2007 compared before. This is especially the case for investment (increased effectiveness by 452%) but also the other variables. An exception in the results was for import that expressed higher effectiveness before 2007 compared to after. These results for all variables except import, show that a change in repo rate would have a greater impact in steering the economic activity in after 2007. If this is the case due to simultaneous unconventionally monetary policies or a misunderstood efficiency of conventional monetary policies is something that need further investigations in future studies.

Moreover, comparing our results of effectiveness regarding investment indicates that further lowering of the repo rate would have a great impact in period two compared to period one. In line with the findings of Altavilla, et al. (2019) the results from our study could be seen as further evidence that a low interest rate environment can increase investment by urging consumers and firms to invest or consume rather than hoard cash.

Furthermore, in the literature Borio & Hofmann (2017) explain the theory of headwinds and non-linearities in an environment of consistent low interest rates. From our results, we can notice that an increase of the repo rate from a low interest environment (period two) would slow down the economy more than it would in the high interest environment (period one). These findings strengthen the theory presented by Borio & Hofmann (2017).

The results presented in this paper suggest that the effectiveness of changes in the repo rate has changed when comparing high and low interest rate environments. An increase of the repo rate towards “normal” levels will be harder from today’s levels, which makes the use of unconventional monetary policies in combination to future raises even more necessary. Nonetheless, the results also indicate that further cuts of the repo rate would have significant results on stimulating the economy if necessary. These results are important for further understanding of how changes in the repo rate affects economic activity, when comparing high and low repo rate environments. It could be regarded as a useful insight on how conventional monetary policies can still be an efficient method used when we have reached the zero lower bound.

6. Conclusions

The purpose of this thesis was to answer if the effectiveness of a change in repo rates can be measured and if so, what is the effectiveness when comparing relatively high and low repo rate climates. Firstly, we have introduced the use of ARDL models as a way of measuring effectiveness of repo rate changes between two time periods, from 1994 until 2007 compared to 2007 until 2019, for the Swedish economy. Secondly, we found that effectiveness of a repo rate change has been greater in the second period, which is contrary to some earlier studies. Thirdly, we discovered that investment has had a much greater change in effectiveness than the other components of GDP.

The research has presented twelve models using the ARDL method, which all have been used to compare the coefficients of different lag lengths and the total impact of these lags on the dependent variable. Even though some of the coefficients were not statistically significant, the last lag in the series was always statistically significant. The total impact from the independent variable was summarized from a model that were regarded as a high representation of the dependent variable.

The results from this study can be used for future testing, regarding the impact that results from conventional monetary policies i.e. changes in the repo rate. This could be used as an alternative method for decision makers of the repo rate (central banks) and for evaluation the economical responses that occur from these changes. For further studies, we recommend extending this method of comparing effectiveness in more economies and compare the results with broader datasets. It would be interesting to see results of comparing two or more time periods using other models as well, for example VAR or VECM models.

References

Altavilla, C., Burlon, L., Giannetti, M., & Holton, S. (2019). *Is there a zero lower bound? The effects of negative policy rates on banks and firms.* ECB Working Paper Series No. 2289. Available at: https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2289~1a3c04db25.en.pdf (Accessed: 2020-05-21)

Bagliano, F.C., & Favero, C.A. (1998). Measuring monetary policy with VAR model: An evaluation. *European Economic Review*, Vol *42*(6), pp. 1069-1112.

Baldi, G. & Lange, A. (2019). The Interest Rate Sensitivity of Investment. *Credit and Capital Markets*, Vol *52*(2), pp. 173-190.

Bernanke, B.S. & Blinder, A.S. (1992). The federal funds rate and the channels of monetary transmission. *The American Economic Review,* Vol *82*(4), pp. 901-921.

Bernanke, B.S., & Mihov, I. (1995). Measuring Monetary Policy. NBER Working Papers No. 5145, National Bureau of Economic Research.

Borio, C. & Hofmann, B. (2017). *Is monetary policy less effective when interest rates are persistently low?.* Bis Working Papers No. 628

Dickey, D.A., & Fuller, W.A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, Vol *74*(366), pp. 427-431.

European Central Bank. (n.d.) *Transmission mechanism of monetary policy*. Available at: https://www.ecb.europa.eu/mopo/intro/transmission/html/index.en.html (Accessed: 2020-04-09)

Hatmanu, M., Cautisanu, C., & Ifrim, M. (2020). The impact of interest rate, exchange rate and European business climate on economic growth in Romania: An ARDL approach with structural breaks. *Sustainability,* Vol *12*(7). doi: 10.3390/su12072798

Hill, R. C., Griffiths, E. W., & Lim, G. C. (2017). *Principles of econometrics* (5^{th} edt.). Hoboken: Wiley.

Hopkins, E., Lindé, J., & Söderström, U. (2009). *Den penningpolitiska transmissionsmekanismen* (Penning- och Valutapolitik 2/ 2009). Available at:

http://archive.riksbank.se/Upload/Dokument_riksbank/Kat_publicerat/Artiklar_PV/2009/Hopkins_Linde_Soderstrom_2009_2.pdf (Accessed: 2020-04-09)

Jacobs, J., Ogawa, K., Sterken, E., & Tokutsu, I. (2020). Public debt, economic growth and the real interest rate: A panel VAR approach to EU and OECD countries. *Applied Economics*, Vol *52*(12), pp. 1377-1394. doi: 10.1080/00036846.2019.1673301

Khan, M.K., Teng, J., & Khan, M.I. (2019). Cointegration between macroeconomic factors and the exchange rate USD/CNY. *Financial Innovation*, Vol *5*(5). doi: 10.1186/s40854-018-0117-x

Leeper, E.M. (2018). *Sweden's fiscal framework and monetary policy* (Sveriges Riksbank Economic Review 2018:2). Available at: https://www.riksbank.se/globalassets/media/rapporter/pov/artiklar/engelska/2018/180917/er-2018_2-swedens-fiscal-framework-and-monetary-policy.pdf (Accessed: 2020-04-15)

Petrevski, G., Trenovski, B., & Tashevska, B. (2019). The effectiveness of fiscal and monetary policies in a small open economy – the case of Macedonia. *Post-Communist Economies*, Vol *31*(6), pp. 805–821. doi: 10.1080/14631377.2019.1607437

Sveriges Riksbank. (n.d.). *Sök räntor & valutakurser* [Dataset]. Retrieved 2020-03-15 from https://www.riksbank.se/sv/statistik/sok-rantor--valutakurser/?g2-SECBREPOEFF=on&from=1994-06-01&to=2020-05-07&f=Quarter&c=cAverage&s=Comma

SCB. (n.d.). *BNP kvartal 1993–2019:4 (publ.2020-02-28)* [Dataset]. Retrieved 2020-03-15 from https://www.scb.se/hitta-statistik/statistik-efter-amne/nationalrakenskaper/nationalrakenskaper/nationalrakenskaper-kvartals-och-arsberakningar/pong/tabell-och-diagram/tabeller/bnp-kvartal/

Sveriges Riksbank. (2017). *The Riksbank's strategy for a gradual normalisation of monetary policy* (Monetary Policy Report December 2017). Retrieved from https://www.riksbank.se/globalassets/media/rapporter/ppr/fordjupningar/engelska/2017/the-riksbanks-strategy-for-a-gradual-normalisation-of-monetary-policy-article-in-monetary-policy-report-december-2017

Sveriges Riksbank. (2020). *What has happened to the financial conditions since the autumn of 2018?* (Monetary Policy Report February 2020). Retrieved from https://www.riksbank.se/globalassets/media/rapporter/ppr/fordjupningar/engelska/2020/what-has-happened-to-the-financial-conditions-since-the-autumn-of-2018-article-in-monetary-policy-report-february-2020.pdf

Uhlig, H. (2005). What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics*, Vol *52*(2), pp. 381-419.

Appendix A

Period 1 (1994Q3-2007Q1)

$$\mathbf{lnGDP_t} = 1{,}1321 - 0{,}0133\mathrm{lnGDP}_{t-1} + 0{,}0159\mathrm{lnGDP}_{t-2} - 0{,}0155\mathrm{lnGDP}_{t-3} + 0{,}9337\mathrm{lnGDP}_{t-4} - 0{,}0017\mathrm{R}_t + 0{,}0154\mathrm{R}_{t-1} - 0{,}0199\mathrm{R}_{t-2}$$

$$\mathbf{lnIM_t} = 2{,}6091 + 0{,}1980\mathrm{lnIM}_{t-1} + 0{,}1799\mathrm{lnIM}_{t-2} - 0{,}2086\mathrm{lnIM}_{t-3} + 0{,}6309\mathrm{lnIM}_{t-4} + 0{,}0283\mathrm{R}_t - 0{,}0466\mathrm{R}_{t-1}$$

$$\mathbf{lnC\_H_t} = 1{,}33 + 0{,}0441\mathrm{lnC\_H}_{t-1} + 0{,}0933\mathrm{lnC\_H}_{t-2} - 0{,}0775\mathrm{lnC\_H}_{t-3} + 0{,}8401\mathrm{lnC\_H}_{t-4} + 0{,}0043\mathrm{R}_t - 0{,}0112\mathrm{R}_{t-1}$$

$$\mathbf{lnC\_P_t} = 1{,}5206 - 0{,}0335\mathrm{lnC}_{\mathrm{P}_{t-1}} - 0{,}0245\mathrm{lnC}_{\mathrm{P}_{t-2}} - 0{,}0239\mathrm{lnC}_{\mathrm{P}_{t-3}} + 0{,}9608\mathrm{lnC}_{\mathrm{P}_{t-4}} - 0{,}0017\mathrm{R}_t$$

$$\mathbf{lnI_t} = 1{,}1751 + 0{,}0630\mathrm{lnI}_{t-1} + 0{,}0162\mathrm{lnI}_{t-2} - 0{,}0217\mathrm{lnI}_{t-3} + 0{,}8514\mathrm{lnI}_{t-4} - 0{,}0046\mathrm{R}_t + 0{,}0787\mathrm{R}_{t-1} - 0{,}0807\mathrm{R}_{t-2}$$

$$\mathbf{lnEX_t} = 1{,}8456 + 0{,}2082\mathrm{lnEX}_{t-1} + 0{,}2434\mathrm{lnEX}_{t-2} - 0{,}2299\mathrm{lnEX}_{t-3} + 0{,}6406\mathrm{lnEX}_{t-4} + 0{,}0139\mathrm{R}_t - 0{,}0307\mathrm{R}_{t-1}$$

Period 2 (2007Q2-2019Q4)

$$\mathbf{lnGDP_t} = 3{,}2006 + 0{,}0038\mathrm{lnGDP}_{t-1} + 0{,}0212\mathrm{lnGDP}_{t-2} - 0{,}1088\mathrm{lnGDP}_{t-3} + 0{,}8557\mathrm{lnGDP}_{t-4} + 0{,}0167\mathrm{R}_t - 0{,}0208\mathrm{R}_{t-1} + 0{,}0239\mathrm{R}_{t-2} - 0{,}0376\mathrm{R}_{t-3}$$

$$\mathbf{lnIM_t} = 1{,}5337 + 0{,}2517\mathrm{lnIM}_{t-1} + 0{,}4198\mathrm{lnIM}_{t-2} - 0{,}2269\mathrm{lnIM}_{t-3} + 0{,}4399\mathrm{lnIM}_{t-4} + 0{,}0347\mathrm{R}_t + 0{,}0129\mathrm{R}_{t-1} - 0{,}0627\mathrm{R}_{t-2}$$

$$\mathbf{lnC\_H_t} = 1{,}5413 + 0{,}0417\mathrm{lnC\_H}_{t-1} + 0{,}3856\mathrm{lnC\_H}_{t-2} - 0{,}0861\mathrm{lnC\_H}_{t-3} + 0{,}5427\mathrm{lnC\_H}_{t-4} + 0{,}0095\mathrm{R}_t - 0{,}0177\mathrm{R}_{t-1}$$

$$\boldsymbol{lnC\_P_t} = 1{,}4512 - 0{,}0337 lnC\_P_{t-1} - 0{,}0216 lnC\_P_{t-2} - 0{,}0183 lnC\_P_{t-3} + 0{,}9595 lnC\_P_{t-4} - 0{,}0032 R_t$$

$$\boldsymbol{lnI_t} = 3{,}9208 + 0{,}1070 lnI_{t-1} + 0{,}1415 lnI_{t-2} - 0{,}1907 lnI_{t-3} + 0{,}6323 lnI_{t-4} + 0{,}0432 R_t - 0{,}0363 R_{t-1} + 0{,}0592 R_{t-2} - 0{,}1031 R_{t-3}$$

$$\mathbf{lnEX_t} = 1{,}8118 + 0{,}3216\mathrm{lnEX}_{t-1} + 0{,}4293\mathrm{lnEX}_{t-2} - 0{,}3406\mathrm{lnEX}_{t-3} + 0{,}4535\mathrm{lnEX}_{t-4} + 0{,}0365\mathrm{R}_t - 0{,}0291\mathrm{R}_{t-1} + 0{,}0092\mathrm{R}_{t-2} - 0{,}0343\mathrm{R}_{t-3}$$