Assessing the Effect of the Riksbank Repo Rate on National Output and Price Level in Sweden:
Focusing on Employment and Housing Prices

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Abstract

There is no single commonly adapted model that explains the influence that various monetary policy instruments carry for the economy. During 2011-2017, the Swedish inflation rate has remained below the 2 percent target which has led the Riksbank to take measures aimed at stimulating the inflation. As of May 2018, the repo rate has experienced a number of decreases and is now at $-0.50\%$ which represents an unprecedentedly low level. With the inflation rate remaining below the target whilst the housing market has experienced substantial growth and recent decline, the question arises regarding what impact the repo rate exerts on various macroeconomic measures. In this paper, a statistical time series analysis is conducted using a Vector Autoregression model and the impulse responses are studied. A model of 7 economic variables is constructed to specifically study the effect of the repo rate on employment and housing prices. Results demonstrate that rational expectations exist in the economy. Furthermore, results show that the repo rate influences factors affected by inflation rapidly, exerting maximum influence during the first year after the shock. On the other hand, real variables based on quantitative measures that are adjusted for inflation experience the greatest influence of the repo rate after a delay of 6 to 7 quarters.

Employment experiences the greatest negative response to a repo rate shock after 7 quarters, with a magnitude of 0.317 standard deviations per standard deviation in the repo rate shock. Housing prices experience the greatest negative response to a repo rate shock after 4 quarters, with a magnitude of 0.209 standard deviations per standard deviation in the repo rate shock.

**Keywords:** Monetary Policy, Policy Rate, Inflation, Employment, Housing Prices, Vector Autoregression, Impulse Response Function
Sammanfattning


Sysselsättningen upplever störst negativ påverkan från en reporäntechock efter 7 kvartal motsvarande 0.317 standardavvikelser per standardavvikelse i chocken. Bostadspriser upplever störst negativ påverkan från en reporäntechock efter 4 kvartal motsvarande 0.209 standardavvikelser per standardavvikelse i chocken.

Svensk titel: En Undersökning av Reporäntans Effekt på Produktionen och Prisnivån i Sverige med Fokus på Sysselsättning och Bostadspriser

Nyckelord: Penningspolitik, Styrränta, Inflation, Sysselsättning, Bostadspriser, Vektorautoregression, Impuls-Responsfunktion
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Section 1: Introduction

1.1 Background

The major goals of economic policy are widely agreed upon and consist in general of high employment, stable prices and rapid growth. [1] According to Swedish law, the objective of the Swedish central bank (the Riksbank) is "to maintain price stability". Since the middle of the 1990s, this has been performed by the Riksbank through targeting a low and stable rate of inflation. The inflation is to be held at 2 percent annually according to the Riksbank and is currently measured by the Consumer Price Index with fixed interest rate (CPIF). [2]

Whilst there exists a wide consensus regarding the major goals of economic policy, the effects of monetary policy on macroeconomics does not bear the same characteristic. There is no single commonly adapted model that explains the impact that various policy instruments have in a country’s macroeconomic outcome and what role the different instruments should play in achieving the objectives. [3]

Due to the year-on-year inflation rate remaining below the 2 percent target during six consecutive years 2011-2017, the Riksbank has during this period taken measures aiming at stimulating the inflation rate. With the repo rate being one of the central bank’s most influential policy decisions, the policy rate committee has not increased the rate since the middle of 2011. Instead, the repo rate has experienced a number of decreases and is now, as of May 2018, at −0.50% which represents an unprecedentedly low level.

During 2011-2017, the Swedish housing market has experienced substantial price growth. The recent trend reversal during late 2017 in the Swedish housing market has sparked debate on the possible extent of the impact of the low interest rates on the overall economy.

1.2 Research Question

This paper seeks to explain, on the basis of historic Swedish macroeconomic development:

- What is the magnitude of the influence that the repo rate carries for the two macroeconomic parameters employment and housing prices?
- After what period of delay does the repo rate rate exert its maximum
influence on the two macroeconomic parameters employment and housing prices?

It is believed that the research question carries substantial significance, not least due to the fact that the current policy rate path of the Riksbank indicates one rate hike in late 2018 and more over the upcoming years. Due to the unprecedentedly low repo rate, rate hikes in a negative state have never been performed previously. Ability to include data from the last six years makes it interesting to investigate the outcome on a purely statistical basis. Furthermore, there exists a global trend of normalization of monetary policy. Several key central banks, such as the Federal Reserve (US), the European Central Bank, Bank of England and Bank of Japan are indicating rate hikes and wind-downs of asset purchases in the upcoming years. [4] This further illustrates the timeliness of the matter.

1.3 Limitations

The study is constrained to the Swedish economy and based on 25 years of quarterly data from the period 1993Q1 to 2017Q4. The details of the statistical model employed in this paper are presented in Section 3.2 Input Data. In general, the model consists of seven key macroeconomic variables, of which the repo rate is one and the other six are divided into three variables affected by inflation and three real economy variables adjusted for inflation. Although it is constructed based on macroeconomic theory, the statistical model is completely blind with respect to assumed relationships between the variables. What this means is that the results are strictly based on the observations in the input data. No assumptions or interpretations regarding economic theory are built into the mathematical modeling.

The impulse response function employed to assess the impact of the repo rate is not an interpretation of a realistic scenario. The conclusions drawn from the results of the impulse response function are solely statistical. An elaborate explanation for why this tool is still used in this study can be found in Section 2.2.2 Monetary Policy Shocks.

Although the mathematical tools employed in this report fully achieve their purposes, it should be noted that the VAR model remains one of the most basic tools with which this type of analysis can be performed. Another such tool, frequently used in the field of econometric, is the Bayesian VAR model. When employing the BVAR model, the model parameters have a prior probability assigned to them.
Section 2: Theoretical Framework

2.1 Mathematical Theory

Throughout this section, the presented theory is based on the content published by H. Lütkepohl in *New Introduction to Multiple Time Series Analysis*. [5]

2.1.1 Multiple Time Series Analysis in Forecasting

"In making choices between alternative courses of action, decision makers at all structural levels often need predictions of economic variables." - Lütkepohl, 2005

Time series analysis may be used to provide policy makers with basis for decisions through predicting future behavior of variables. Through analysis of the statistical relationships in historical observations, it is possible to create a model in which future development is estimated as a function of historical data points. Such a model provides an opportunity to both forecast future development and to estimate the influence of certain variables on the future development of others. Formally, this approach to forecasting may be expressed by starting with a single variable of interest $y_t$. Let $y_t$ denote the value of that variable in period $t$. Then, the model for the value of the variable in period $T + h$, constructed based on data points leading up to period $T$, has the form

$$\hat{y}_{T+h} = f(y_T, y_{T-1}, \ldots)$$

(1)

where $f(\cdot)$ denotes some suitable function of the past observations of $y_T$, $y_{T-1}, \ldots$. However, as is often the case in economics, the variable of interest does not only depend on predecessors in time of itself, but also on past values of other variables. Denoting related variables by $y_{1,t}, y_{2,t}, \ldots, y_{K,t}$, the forecast of the $k$:th variable $y_{k,T+h}$ at the end of period $T$ may be expressed as

$$\hat{y}_{k,T+h} = f_k(y_{1,T}, \ldots, y_{K,T}, y_{1,T-1}, \ldots, y_{K,T-1}, \ldots)$$

(2)

It is often interesting to analyze dynamic interrelationships between multiple variables. In a system consisting of several variables, one may want to learn about the effect of a change in one or more of the modeled variables. One mathematical model for such an analysis is Vector Autoregression which is
presented in the following sections.

2.1.2 Vector Autoregression (VAR)

VAR modeling is used to describe time series that depend on past behavior of a collection of variables. In the univariate example where $f(\cdot)$ in (1) is a linear function that models the proximate future value of $y$ (i.e. $h = 1$), the model becomes

$$\hat{y}_{T+h} = \nu + \alpha_1 y_T + \alpha_2 y_{T-1} + \cdots + \alpha_p y_{T-p+1} + u_{T+1},$$

assuming that a finite number $p$ observations of $y$ are used in the formula. Furthermore, the true value $y_{T+h}$ will usually not be equal to the modeled $\hat{y}_{T+h}$. The forecast error is denoted by $u_{T+1} := y_{T+h} - \hat{y}_{T+h}$. The general assumptions are made in that the observations are realizations of random variables and that the same data generation law prevails in each period $T$. Under these assumptions, the general form of a univariate VAR is obtained, also known as an autoregressive process (AR),

$$y_t = \nu + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + u_t,$$

where $y_t, y_{t-1}, \ldots, y_{t-p}$ and $u_t$ are random variables. Also, it is assumed that the forecast errors, $u_t$, are uncorrelated for different periods. Subsequently, an obvious general extension into the realm of multiple time series is given by

$$y_t = \nu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t,$$

where $y_t$’s are regarded as random vectors given by $y_t := (y_{1,t}, \ldots, y_{K,t})'$, $\nu := (\nu_1, \ldots, \nu_K)'$ and

$$A_t := \begin{bmatrix} \alpha_{11,t} & \cdots & \alpha_{1K,t} \\ \vdots & \ddots & \vdots \\ \alpha_{K1,t} & \cdots & \alpha_{KK,t} \end{bmatrix}.$$  

Also, $u_t := (u_{1,t}, \ldots, u_{K,t})'$ form a set of independently identically distributed random $K$-dimensional vectors with zero mean vector.
2.1.3 Stable VAR($p$) Processes

It has been established that the general VAR($p$), VAR model of order $p$, is given by

\[ y_t = \nu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t, \quad t = 0, \pm 1, \pm 2, \ldots \]  

where $y_t$ is a $(K \times 1)$ random vector, the $A_i$’s are fixed $(K \times K)$ coefficient matrices and $\nu$ is a fixed $(K \times 1)$ vector of intercept terms enabling for the possibility of a non-zero mean $E(y_t)$. Finally, $u_t$ is a $K$-dimensional white noise or innovation process, with properties $E(u_t) = 0$, $E(u_t u'_t) = \Sigma_u$ and $E(u_t u'_s) = 0$ for $s \neq t$. The covariance matrix $\Sigma_u$ is assumed to be nonsingular if not otherwise stated. A nonsingular covariance matrix means that the multivariate normal density is well-defined.

To give an intuitive sense of the behavior of VAR($p$) processes, consider the VAR(1) model

\[ y_t = \nu + A_1 y_{t-1} + u_t. \]  

Assuming the generation mechanism starts at some time, $t = 1$, (7) renders

\[ y_1 = \nu + A_1 y_0 + u_1, \]
\[ y_2 = \nu + A_1 y_1 + u_2 = \nu + A_1(\nu + A_1 y_0 + u_1) + u_2 = (I_K + A_1)\nu + A_1^2 y_0 + A_1 u_1 + u_2, \]
\[ \vdots \]
\[ y_t = (I_K + A_1 + \cdots + A_1^{t-1})\nu + A_1^t y_0 + \sum_{i=0}^{t-1} A_1^i u_{t-i} \]
\[ \vdots \]

The vectors $y_1, \ldots, y_t$ are uniquely determined by $y_0, u_1, \ldots, u_t$. Also, the joint distribution of $y_1, \ldots, y_t$ is determined by the joint distribution of $y_0, u_1, \ldots, u_t$. If all eigenvalues of $A_i$ have modulus less than 1, the sequence $A_1^i u_t, i = 0, 1, \ldots$ is absolutely summable. The infinite sum $\sum_{i=0}^{\infty} A_1^i u_{t-i}$ therefore exists in mean square. The proof is omitted in this report, but can be found in the referenced material [5]. By stating this fact, the VAR(1) process $y_t$ is the well-defined stochastic process

\[ y_t = \mu + \sum_{i=0}^{\infty} A_1^i u_{t-i}, \]  

10
where
\[ \mu := (I_K - A_1)^{-1}\nu. \]  
(9)

The distributions and joint distributions of the \( y_t \)'s are uniquely determined by the distributions of the \( u_t \) process and can be proven to be

\[ E(y_t) = \mu \quad \text{for all} \quad t. \]  
(10)

Furthermore, the autocovariances, i.e. the covariances of the values of the process at pairs of different time points, are

\[ \Gamma_y(h) := E((y_t - \mu)(y_{t-h} - \mu)') = \sum_{i=0}^{\infty} A_i^h + \Sigma_u A_i'. \]  
(11)

A VAR(1) process is stable if all eigenvalues of \( A_1 \) have modulus less than 1, which is equivalent to

\[ \det(I_K - A_1z) \neq 0 \quad \text{for} \quad |z| \leq 1. \]  
(12)

This concept is subsequently extended to VAR(\( p \)) processes with \( p > 1 \), because any VAR(p) process can be written in VAR(1) form. More precisely, if \( y_t \) is a VAR(p) process as defined in equation (6), a corresponding \( Kp \)-dimensional VAR(1) process can be defined as

\[ Y_t = \nu + AY_{t-1} + U_t, \]  
(13)

where

\[ Y_t := \begin{bmatrix} y_t \\ y_{t-1} \\ \vdots \\ y_{t-p+1} \end{bmatrix}_{(Kp \times 1)} \]

\[ \nu := \begin{bmatrix} \nu \\ 0 \\ \vdots \\ 0 \end{bmatrix}_{(Kp \times 1)} \]
\[ A := \begin{bmatrix}
A_1 & A_2 & \cdots & A_{p-1} & A_p \\
I_K & 0 & \cdots & 0 & 0 \\
0 & I_K & \cdots & 0 & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots \\
0 & 0 & \cdots & I_K & 0
\end{bmatrix}_{(Kp \times Kp)} \]

and

\[ U_t := \begin{bmatrix}
u_t \\
0 \\
\vdots \\
0
\end{bmatrix}_{(Kp \times 1)} \]

Similarly, following the foregoing discussion, \( Y_t \) is stable if

\[ \det(I_{Kp} - Az) \neq 0 \quad \text{for} \quad |z| \leq 1. \quad (14) \]

Its mean vector is

\[ \mu := E(Y_t) = (I_{Kp} - A)^{-1}\nu \quad (15) \]

and the autocovariances are

\[ \Gamma_Y(h) = \sum_{i=0}^{\infty} A^{h+i}\Sigma_U(A^i)' \quad (16) \]

where \( \Sigma_U := E(U_tU_t') \). Using the \( K \times Kp \) matrix

\[ J := [I_K : 0 : \cdots : 0], \quad (17) \]

the process \( y_t \) is obtained as \( y_t = JY_t \). Because \( Y_t \) is a well-defined stochastic process, the same holds true for \( y_t \). Its mean is \( E(y_t) = J\mu \) which is constant for all \( t \) and the autocovariances \( \Gamma_y(h) = J\Gamma_Y(h)J' \) are also time invariant. \( y_t \) is stable if

\[ \det(I_{Kp} - Az) = \det(I_{Kp} - A_1 z - \cdots - A_p z^p) \neq 0 \quad \text{for} \quad |z| \leq 1, \quad (18) \]

which is defined as the stability condition. In summary, a VAR(\( p \)) process is stable if (18) holds and

\[ y_t = JY_t = J\mu + \sum_{i=0}^{\infty} A^i U_{t-i}. \quad (19) \]

As defined above, it can be seen that the process \( y_t \) is determined by its white
noise or innovation process.

2.1.4 Stationary Processes

A stochastic process is stationary if its first and second moments are time invariant. In other words, a stochastic process \( y_t \) is stationary if

\[
E(y_t) = \mu \quad \text{for all} \quad t, \tag{20}
\]

and

\[
E[(y_t - \mu)(y_{t-h} - \mu)'] = \Gamma_y(h) = \Gamma_y(-h)' \quad \text{for all} \quad t \quad \text{and} \quad h = 0, 1, 2, \ldots \tag{21}
\]

Condition (20) means that the process \( y_t \) has a constant mean vector for all \( t \). Also, the autocovariances do not depend on \( t \) but just on the time difference \( h \) between the two vectors \( y_t \) and \( y_{t-h} \). All quantities are assumed to be finite. It follows neatly from the foregoing discussion that a stable process is in fact stationary. In other words, stability implies stationarity, but the converse does not necessarily hold.

2.1.5 Autocovariance of Stable VAR(\( p \)) Processes

As has been determined, one requirement for stationarity is that the values of the process at pairs of different time points only depend on the time difference between the two points. Considering a higher order VAR(\( p \)) process,

\[
y_t - \mu = A_1(y_{t-1} - \mu) + \cdots + A_p(y_{t-p} - \mu) + u_t, \tag{22}
\]

the autocovariance is denoted as \( \Gamma_y(h) \). For \( h = 0 \),

\[
\Gamma_y(0) = A_1 \Gamma_y(1)' + \cdots + A_p \Gamma_y(p)' + \Sigma_u, \tag{23}
\]

and for \( h > 0 \)

\[
\Gamma_y(h) = A_1 \Gamma_y(h - 1)' + \cdots + A_p \Gamma_y(h - p). \tag{24}
\]

These equations are commonly known as the Yule-Walker equations. These equations may be used to compute the \( \Gamma_y(h) \) recursively for \( h \leq p \), if \( A_1, \ldots, A_p \) and \( \Gamma_y(p-1), \ldots, \Gamma_y(0) \) are known.
2.1.6 Autocorrelation of Stable VAR(\(p\)) Processes

The autocorrelation is more commonly used to interpret the relationship between the variables than the autocovariance. That is because the autocovariances depend on the unit of measurement used for the system and are therefore more difficult to interpret. The autocorrelation, defined as

\[
R_y(h) = D^{-1} \Gamma_y(h) D^{-1}
\]

is more convenient to use as it is a scale invariant measure of linear dependencies among the variables of the system. \(D\) here is a diagonal matrix with the standard deviations of the components of \(y_t\) on the main diagonal, equal to the square roots of the diagonal elements of \(\Gamma_y(0)\).

2.1.7 Estimation of VAR Processes

Estimating the parameters in a VAR model is a matter of finding the least square estimator of \(\beta\) that minimizes some error term.

Definitions:

\[
Y := (y_1, ..., y_T)
\]

\((K \times T)\),

\[
B := (\nu, A_1, ..., A_p)
\]

\((K \times (Kp + 1))\),

\[
Z_t := \begin{bmatrix}
1 \\
y_t \\
\vdots \\
y_{t-p+1}
\end{bmatrix}
\]

\(((Kp + 1) \times 1)\),

\[
Z := (Z_0, ..., Z_{T-1})
\]

\(((Kp + 1) \times T)\),

\[
U := (u_1, ..., u_T)
\]

\((K \times T)\),

\[
u := \text{vec}(Y)
\]

\((KT \times 1)\),

\[
\beta := \text{vec}(B)
\]

\(((K^2p + K) \times 1)\),

\[
b := \text{vec}(B')
\]

\(((K^2p + K) \times 1)\),

\[
u := \text{vec}(U)
\]

\(((KT \times 1)\).

Here, vec is the column stacking operator which works in the following way: Let \(A = (a_1, ..., a_n)\) be an \((m \times n)\) matrix with \((m \times 1)\) columns \(a_i\). The vec operator transforms \(A\) into an \((mn \times 1)\) vector by stacking the columns, i.e. placing the columns \(a_i\) on top of each other.
Using this notation, for \( t = 1, \ldots, T \), the VAR(\( p \)) model can be rewritten compactly to

\[
Y = BZ + U.
\]  

(26)

The normal equation can be written as

\[
(ZZ' \otimes \Sigma_u^{-1})\hat{\beta} = (Z \otimes \Sigma_u^{-1})y.
\]  

(27)

Consequently the LS estimator is

\[
\hat{\beta} = ((ZZ')^{-1}Z \otimes I_K)y.
\]  

(28)

Here, \( \otimes \) is the Kronecker operator which should not be confused with regular matrix multiplication.

2.1.8 VAR Order Selection

When setting up a VAR(\( p \)) model, the problem of selecting the optimal number \( p \) of lags arises. In theory, if \( y_t \) is a VAR(\( p \)) process, then it is formally also a VAR(\( p + 1 \)) process. This holds under the previously stated assumption that the possibility of zero coefficient matrices is not excluded. However, it is convenient and practical to have a unique number that is called the order of the process. Therefore, \( y_t \) is henceforth called a VAR(\( p \)) process if \( A_p \neq 0 \) and \( A_i = 0 \) for \( i > p \) so that \( p \) is the smallest possible order.

If \( y_t \) is a VAR(\( p \)) process, it is useful to fit a VAR(\( p \)) model and not a VAR(\( p + i \)) model, because under a Mean Square Error measurement, forecasts of the latter will be inferior to those from the true order model. This follows from the fact that \( \Sigma_y(1) = \frac{T + Kp + 1}{T} \Sigma_u \) is an increasing function of the order of the fitted model. Practically, testing a model for optimal order is performed by comparing models with different number of lags on some choice of selection criteria. For small samples up to 60 observations, the Akaike Information Criterion and the Final Prediction Error have been shown to be superior in determining the correct lag length. In turn, with a larger sample of 120 or more observations, the Hannan–Quinn Information Criterion has been found to outdo other measurements in identifying the correct order. [6]

2.1.9 Test for Non-Normality of a VAR Process

Normality of the data generating process is needed for calculating intervals in order to determine the accuracy of forecasts and impulse responses. A
stationary VAR($p$) process is Gaussian (normally distributed) if and only if the white noise process $u_t$ is Gaussian. Therefore, the normality of the $y_t$’s may be checked via the $u_t$’s. In practice, the $u_t$’s consist of the residuals from the estimation.

2.1.10 Impulse Response Analysis

In applied work, it is often of interest to study the response of one variable to an impulse of another variable in a system. Given a VAR model with several macroeconomic variables, one may be inclined to study the impulse response relationship between two variables in this system of higher dimension. As this report looks to explain the ”trickle-down” effects on employment and house prices to a shock in the repo rate, such a mathematical framework must be implemented.

Consider the problem of isolating the effect of a shock to one of the variables, at time $t = 0$, in a higher dimensional system. Suppose that all variables assume their mean value prior to time $t = 0$, $y_t = \mu$ for $t < 0$, and one variable $s$ increases by one unit in period $t = 0$. That is, $u_{s,0} = 1$. Now, one can trace what happens to the system during periods $t = 1, 2, \ldots$ if no further shocks occur, that is $u_{i,k} = 0$ for all variables $i \neq s$ for all $k \geq 0$ and $u_{s,k} = 0$ for all $k \geq 1$. The mean of the system in such an event is of no interest, but rather the variations of the variables around their baseline. This is an important aspect of this report. The fact that the means of the variables carry no significance entails that the actual negative value of the repo rate is of no interest when studying the impulse response.

$y_i = (y_{k,i})'$ is the first column of $A_i^1$. Analogous arguments show that the elements of $A_i^1$ represent the effect of unit shocks in the variables of the system after $i$ periods. Because of this, impulse responses are sometimes referred to as forecast error impulse responses. Since the variables often have varying scales, this may also be extended to shocks of different sizes simply by rescaling the impulse responses. This usually gives a better visualization of the dynamic interrelationship between the variables. Impulse responses are generally presented with a corresponding confidence interval based on the normality of the VAR process. The exact details of the impulse response function may be found in the referenced literature [5] by H. Lütkepohl.
2.1.11 Response to Orthogonal Shocks

One problem in the basic assumption of impulse response analysis is that shocks occur only in isolation, i.e. in one variable at a time. Such an assumption may be sufficient if shocks in different variables are assumed to be independent, which is usually not the case in economics. Thus, one may argue that error terms in real applications consist of all the influences from any variable that may not directly included in the model. Therefore, forcing the innovations in the other variables to zero may in fact obscure the actual relationship between the variables. Therefore, orthogonalization of the components in the $y_t$ process is made by performing the impulse response analysis in terms of the moving average representation of the VAR process. That is

$$y_t = \sum_{i=0}^{\infty} \Theta_i w_{t-i},$$

where the components of $w_t = (w_{1t}, ..., w_{Kt})'$ are uncorrelated and have unit variance, $\Sigma_w = I_K$. The mean term is dropped because it is of no interest for the impulse response analysis. This representation is obtained from the Choleski decomposition of $\Sigma_u$ as $\Sigma_u = PP'$, where $P$ is a lower triangular matrix, and defining $\Theta_i = \Phi_i P$ and $w_t = P^{-1} u_t$. It is reasonable to assume that a change in one component of $w_t$ has no effect on the other components, because the components are orthogonal (uncorrelated). Moreover, the variances of the components are 1. Thus, the elements of $\Theta_i$ are interpreted as responses of the system to unit innovations (size one standard deviation). More precisely, the $jk$:th element of $\Theta_i$ is assumed to represent the effect on variable $j$ of a unit innovation in variable $k$ that occured $i$ time periods ago.

2.2 Economic Theory

2.2.1 Monetary Policy

Study of macroeconomics is often focused on policy, divided into fiscal policy and monetary policy. Fiscal policy is conducted by political entities managing overall spending by tax regulations and government spending. Monetary policy affects the overall spending through the central banks’ changes in the quantity of money and interest rates. In turn, the usage of monetary policy is divided into expansionary and contractionary policy. An expansionary policy aims to increase the quantity of money and lower interest rates, whilst a contractionary policy works in the opposite fashion.
By achieving an increased quantity of money and lower interest rates in the economic system, expansionary monetary policy seeks to stimulate the economy. Examples of such stimulus are investments, an appreciated exchange rate and an increased appetite for spending rather than saving. This is argued to result in higher employment, larger export volumes and an overall increased aggregated demand which increases the price level, i.e. stimulates inflation. [3]

2.2.1.1 Effect on Key Components of Macroeconomics

It does not exist a commonly adopted model of the effects of monetary policy and how different macroeconomic parameters interact as a result of policy changes. Some economists view monetary policy as capable of influencing the level of aggregate activity, while others claim that the relevant correlations can be reproduced in models where aggregate demand management and monetary policy have no important role. [7] Attempts to explain how key components of macroeconomics are impacted by shocks in monetary policy have been made. In 1995, one such attempt produced the following four facts through VAR modeling published by Bernanke et al. [8]

1. Although an unanticipated tightening in monetary policy typically has only transitory effects on interest rates, a monetary tightening is followed by sustained declines in real GDP and the price level.

2. Final demand absorbs the initial impact of a monetary tightening, falling relatively quickly after a change in policy. Production follows final demand downward, but only with a lag, implying that inventory stocks rise in the short run. Ultimately, however, inventories decline, and inventory disinvestment accounts for a large portion of the decline in GDP.

3. The earliest and sharpest declines in final demand occur in residential investment, with spending on consumer goods (including both durable and non-durable goods) close behind.

4. Fixed business investment eventually declines in response to a monetary tightening, but its fall lags behind those of housing and consumer durables and, indeed, behind much of the decline in production and interest rates.
2.2.1.2 Monetary Policy as a String

Another theory regarding the role of monetary policy, often attributed to economist John Maynard Keynes, explains that "monetary policy is a string". The expression aims to illustrate the limitations of monetary policy. This comes from the fact that although contractionary policy limits the quantity of money in the market, expansionary policy does not enforce, but rather encourages the banks in an economy to increase the supply of money. In times of economic downturn, banks are likely to be more restrained in issuing new loans due to the increased risk of borrowers defaulting. Furthermore, investment is likely to be inelastic with respect to the interest rate in times of deep depression. [9] Monetary policy with the objective to stimulate the economy in a deep depression will accordingly only result in a substitution on the banks’ balance sheets between government bonds and idle liquidity. This explains the metaphor of a string with the ability to pull for constraining the economy but inability to push for stimulating the same.

2.2.1.3 The Role of Monetary Policy

In 1968, Friedman published The Role of Monetary Policy [1] which would prove to reshape monetary policy significantly. He argues that monetary policy can only have temporary influence on the economy. The trade-off between unemployment and inflation is only temporary but returns to an equilibrium in the long-term perspective, he claims. With regards to monetary policy and employment in particular, it is widely held that monetary growth affects interest rates in a way that stimulates employment. Friedman states that while this is a commonly held view, the monetary authority can not adopt a target for employment due to the "immediate and delayed consequences of such a policy". A stimulative policy would initially make income and spending start to rise. However, as selling prices generally experience a faster increase as response to larger nominal demand than what prices of factors of production experience, real wages decline. As employees demand increased wages in times of excess demand for labor, real wages will rise and reverse the increase in unemployment. Friedman completes his reasoning by stating two key requirements for monetary policy.

1. Monetary policy should be conducted by magnitudes that it can control, not by ones that it can not control.
2. The governing agency should avoid sharp swings in conducting monetary
2.2.1.4 The Equation of Exchange

Forecasting the effect of an increase to monetary policy has previously been modeled by VAR. Such a model has provided results of a hump-shaped response in consumption, investment, profits, and productivity as well as a weak response of real wages. [10] The theoretical reasoning of hump-shaped responses is also encapsulated in a simplification of Fisher’s equation of exchange $M \cdot V = P \cdot Q$ that describes the quantity theory of money. This is the theoretical framework of the monetarism school of economics. [3] The equation explains that the price level $P$ is linearly dependent on the money supply $M$ in the presence of a constant velocity of money $V$ and a constant real output (real GDP). Based on this theory, money supply has a direct impact on inflation. In his paper, Friedman presents his personal judgment based on review of historical data of the US. He estimates that in “a couple of decades”, the effect on employment of an unexpected higher rate of inflation ceases and the new rate of inflation is adjusted to. He adds that for larger changes, the adjustment process is faster. [1]

2.2.1.5 Rational Expectations

The view of rational expectations reflects that market actors will make optimal decisions based on all information available. This significantly distinguishes the theory of rational expectations from other economic theories. It has been argued that adding rationality into economic theories leads to results inconsistent with observations. Whilst the theory of rational expectations fully acknowledges this argument, it explains this phenomena with the exact opposite claim, i.e. that economic models generally do not assume enough rationality. When introducing the concept of rational expectations, J. Muth stated that expectations in practice are the same as predictions of relevant economic theory since expectations are informed decisions of future events. In summary, Muth states that his model of rational expectations asserts three claims [11]:

1. Information is scarce, and the economic system generally does not waste it.
2. The way expectations are formed depends specifically on the structure of the relevant system describing the economy.
3. A "public prediction," in the sense of Grunberg and Modigliani [12], will have no substantial effect on the operation of the economic system (unless it is based on inside information).

Adopting this theory means that in estimates of future inflation, both past rates of inflation as well as available information regarding fiscal and monetary policy will be taken into account. Due to the fact that actors under rational expectations will understand the underlying intention of policy changes, expectations of the inflation will be adjusted immediately. Thus, market inventions will fail in both the short run and the long run. [3]

2.2.2 Monetary Policy Shocks

Since monetary policy is determined by a central bank targeting a pre-determined objective, movements in monetary policy are generally due to the systematic component of the policy. In other words, the economy can most often know what to expect in terms of monetary policy and movements are seldom due to deviations from that expectation. There are not many good interpretations of what a shock to monetary policy could realistically be explained and actualized as. Other than due to an unlikely coincidence, the most frequently discussed monetary policy shocks are due to sudden changes in how the central bank prioritizes inflation and employment, potentially caused by changes in the power of individuals making monetary policy decisions. [13]

Shocks to monetary policy are unlikely due to the nature of the way monetary policy is conducted. At the same time, there is much time and effort put into trying to identify the contribution of such shocks to macroeconomic outcomes. What is interesting is to investigate non-systematic movements in monetary policy to estimate causal effects of monetary policy on macroeconomic parameters. To identify the response of the economy, deviations from the systematics of monetary policy are therefore required. So while monetary policy may very well have great impact, the potential shocks that are simulated to estimate that impact are themselves very unlikely and represent no significant source of macroeconomic instability. [13]
2.2.3 The Riksbank Repo Rate

The premise for the repo rate is that only the Riksbank can create new money in the shape of banknotes, coins or intraday credit. The Swedish bank transaction system RIX has all major banks as participants and each participating agency has its own account in RIX. Whenever banks need to borrow money in Swedish currency, they may do so from each other through RIX. The core of the Riksbank’s interest rate management is the demand of the banks overnight. Before RIX closes, all accounts must be balanced. Therefore, banks with either a surplus or deficit have to balance their accounts through overnight loans or deposits, either at another participating bank or at the Riksbank. The difference between the Riksbank’s interest rates for overnight loans and deposits create incentives to make those loans and deposits with other banks at an interest rate between the Riksbank’s two interest rates. Accordingly, the Riksbank controls the overnight interest rate by the repo rate, which propagates and influences interest rates of all term lengths. [14]

2.2.4 Negative Interest Rate Policy

The current state of the repo rate at an unprecedentedly low \(-0.50\%\) makes for the question whether the influence of monetary policy is altered in relation to previous levels of the repo rate. What can not be dismissed is that conventional means of conducting expansionary monetary policy through lowering the repo rate are no longer as feasible and that a new era of implementing monetary policy has been entered as a result of very low and even sub-zero rates. [15] From a theoretical perspective, negative nominal interest rates in a cashless economy would be of no more concern than positive rates. Real interest rates would be what matters. However as cash is introduced into the analytical framework, negative nominal interest rates leads to that holding cash becomes attractive and several observers have expressed concern regarding that negative policy rates may jeopardize financial stability. This concern comes from the three claims that

1. Deposit rates can not follow policy rates into negative territory.

2. Bank margins will be squeezed if deposit rates hit a floor at zero but lending rates decrease further.

3. Banks will reduce lending to protect their capital ratios.
With some countries having adopted negative policy rates, consequences of these policies have been evaluated to test these concerns. The objectives for adopting negative policy rates fall into two categories, not mutually exclusive. Those are to raise inflation and to decrease appreciation pressures. The success of implementing negative policy rates to achieve the objectives have been mixed so far. The International Monetary Fund notes that for Sweden however, the outlook for inflation has markedly improved and that probably due to the negative repo rate. Furthermore, the case studies of countries with implemented negative policy rates show a strong resilience so far of the banks’ net interest margins and profits. It is suggested that so far, negative policy rates have contributed to loosening financial conditions with no major side effects on banks or market functioning. [16]

2.2.5 Housing Prices and Financial Stability

The housing market is widely considered a cornerstone of what constitutes financial stability and is therefore a prioritized focal point for policy makers. This is mainly because of its large contribution to the collective household balance sheet of the economy. However, it has also been one of the most prominent sources of vulnerability and crises in recent decades. The key theoretical interconnection of monetary policy to the housing market is through the mortgage market. Market rates for housing loans and mortgages are by construction closely linked to current short-term and medium-term key interest rates affected by monetary policy. [17] Empirical studies have consistently shown the relationship between the key repo rate and house prices to be negative. That is, real house prices tend to decline should the repo rate be increased. It is also reflected in key theoretical assumptions that when financing costs are increased, i.e. mortgage rates increase, real prices of leveraged assets go down. [18] Notably, when assessing credit risk the value of housing assets are subject to market pricing whereas loans and mortgages are valued in nominal terms.

Section 3: Methodology

3.1 Previous Similar Research

The methodology undertaken throughout this investigation is inspired by Working Paper 138: Macroeconomic Effects of a Decline in Housing Prices
in Sweden, published by the National Institute of Economic Research in March 2015. [19] The working paper presents a quantitative assessment of the macroeconomic effects of a drop in housing prices using a Bayesian VAR model. Seven domestic and foreign variables are included and modeled using 103 time series observations representing quarterly data from 1989Q1 to 2014Q3. The trends and seasonality of the data are adjusted for appropriately. The VAR model is established with a lag length of 4 quarters. The analysis is performed with orthogonal shocks in the impulse response functions of the model, setting conditions on each of the variables’ ability to impact each other in the system. The impulse responses are then presented over a 10-year-period, i.e. 40 quarters.

3.2 Input Data

3.2.1 Variable Selection

For convenience and relevance, a selection of variables must be performed. Using the four facts regarding repo rate influence by Bernanke et. al. [8] presented previously, a model of seven variables is employed to determine the effect of the repo rate on employment and housing prices. In this model, the repo rate is seen as the underlying variable that influences six other variables. In turn, these six variables also have influential powers to affect each other. Of these six variables, two are the variables of interest employment and housing prices. Furthermore, apart from the repo rate, three variables are adjusted (or unaffected by nature) for inflation while three variables are influenced by inflation. The reasoning behind this is that employment is in a short-term perspective primarily connected to the national output quantity, whilst housing prices are primarily affected by the inflation rate and expectations on the inflation rate. In total, the following seven variables are included in the model:

1. **The Riksbank Repo Rate**
   The Swedish central bank’s primary policy rate and the variable of which the influence is investigated.

2. **Fixed Gross Investments**
   The index of fixed gross investments in the Swedish economy with reference year 2016, adjusted for inflation. The model is designed on the assumption that the development in the real quantity of investments has an inverted relationship to changes of the repo rate
and in turn, affects the employment quantity.

3. *Swedish GDP*
   The total Swedish real GDP at market price with reference year 2016, adjusted for inflation. The model is designed on the assumption that the development of this measurement has an inverted relationship to changes of the repo rate and in turn, affects the employment quantity.

4. *Inflation Rate*
   The development of the Consumer Price Index with fixed interest rate (CPIF) which represents the Riksbank’s measure of inflation. In accordance with Friedman’s rule that monetary policy should be conducted by magnitudes that it can control, the model is designed on the assumption that the CPIF development has an inverted relationship to changes of the repo rate and in turn, affects housing prices.

5. *Mortgage Rate*
   The weighted average of all outstanding loans in Sweden to Swedish households. The model is designed on the assumption that the development of the weighted average mortgage rate has an elastic relationship to changes of the repo rate and in turn, affects housing prices.

6. *Employment*
   Employment numbers as defined by Statistics Sweden in their workforce survey. One of the variables of interest when determining the influence of the repo rate in this report.

7. *Housing Prices*
   The index of housing prices as defined by Statistics Sweden. The index is determined by the price level of Swedish permanent detached houses (Swe: permanenta småhus). One of the variables of interest when determining the influence of the repo rate in this report.

### 3.2.2 Data Collection

The datasets used in determining the autoregressive relationships have been gathered from public databases at the websites of Statistics Sweden and the Riksbank. To create a good statistical measure of the accuracy of the VAR model, as much relevant data as possible should be employed in the study. The most frequent interval for which all the above variables are available is
quarterly data. The working paper from the National Institute of Economic Research also employed quarterly data. Regarding the length of the time series, it has to be noted that the current economic situation is unique due to the unprecedentedly low repo rate. Thus, using data that is too old could be irrelevant for today’s economic era and thereby decrease the accuracy of the model. Finding the balance between collecting enough data and collecting relevant data is difficult although crucial for constructing the model. In this study, the autoregressive relationships are modeled by quarterly data from the 25 years 1993-2017 since this is the longest available time frame in which the current monetary policy with an inflation rate target has been the guiding principle for the Riksbank.

3.2.3 Data Transformations

In accordance with the mathematical framework, the time series used to determine the VAR model have to be stationary. Thus, before implementing the VAR model, the time series are checked for stationarity and transformed when necessary.

3.2.3.1 First-Order Differences

First-order differencing adjusts for a linear trend when the expectation is variant. Should the time series be following a model where $k$ is the constant trend, $\nu$ is the interception at $t = 0$ and $u$ is the white noise process such that

$$y_t = \nu + k \cdot t + u_t$$  \hspace{1cm} (30)

the expectation $E[y_t]$ is clearly dependant on $t$. First order differencing means constructing a new time series $y'_t$ by taking the differences of consecutive observations in $y$ such that

$$y'_t = y_t - y_{t-1}, \hspace{0.5cm} t = 1, 2, ...$$

$$y'_t = (\nu + k \cdot t + u_t) - (\nu + k \cdot (t - 1) + u_{t-1})$$

$$= k(t - (t - 1)) + u_t - u_{t-1}$$

$$= k + u_t - u_{t-1}$$  \hspace{1cm} (31)

where these differences have constant expectation given that the assumed linear model is true for the time series studied, i.e. $E[u_t] = 0$ for all $t$ and $E[y'_t] = k$. Note that the new time series carries one less value from the
nature of the calculations of the differences.

3.2.3.2 Seasonality Adjustment

A seasonal pattern has known length and occurs with similar magnitude during the same period each year. To minimize the impact of parameters outside the assumed model, seasonal adjustments are performed to delete the impact of such patterns on the variance of the time series. In practice, this is performed with the X-13ARIMA-SEATS Seasonal Adjustment Program which is a seasonal adjustment software developed by the United States Census Bureau. The concept of seasonal adjustments involves dividing a time series into a trend component, a cyclic component, a seasonal component and an error component. The software computes these components and deletes the seasonal component from the series. The output is a seasonally adjusted time series of the data.

3.2.3.3 Performed Transformations

Some of the original time series exhibit clear trends or seasonal patterns. Thus, appropriate transformations were performed on each time series in isolation. These transformations are presented below.

1. Employment, Investments and GDP
   All variables above were seasonally adjusted. To adjust for trend, first-order differencing was performed on the seasonally adjusted time series.

2. House prices
   First-order differencing was performed to adjust for trend.

Plots of the original and transformed time series are presented in the Appendix. Four of the variables are transformed using first-order differencing, leaving those transformed time series with one less value than the untransformed ones. Therefore, the final VAR model is constructed on 99 data points of each variable where a single value of an untransformed variable at a specific time point corresponds to the development of the transformed variable leading up to the same time point.
3.3 Implementing the VAR Model

Although the economic variables in the model are chosen on the basis of economic theory, the VAR model is completely blind with respect to assumed relationships between the variables. What this means is that the results of the VAR are strictly based on the observations in the input data. No assumptions or interpretations regarding economic theory are built into the mathematical modeling. Thus, the framework for evaluating the research question relies solely on pure statistical causality-relationships between the observed time series of the variables.

The lag length is determined through evaluation of the model based on several different criteria. The methodology from Working Paper 138: Macroeconomic Effects of a Decline in Housing Prices in Sweden is also taken into consideration. Finally, the order of the VAR model is set to \( p = 4 \). The impulse responses will also be evaluated on a 40-quarter-horizon.

3.3.1 R

Estimating the VAR model has been performed with the statistical software R in R Studio version 1.1.442. The packages used in building the model for this study are:

- VAR Estimation package: VARS [20]
  The package is a tool in R to estimate, test and perform analysis on VAR models. It has also built-in functionality for the impulse response function.

- Seasonal adjustments: Seasonal [21]
  Package used to detect and adjust time series for seasonality. Functionality is explained in Section 3.2.3.2 Seasonality Adjustment.

3.3.2 Testing the Model Adequacy

The model is primarily tested for stability, which is fundamental for the adequacy of the model. Following the line of argument in Section 2.1.3 Stable VAR(p) Processes, a VAR(p) process is stable if all eigenvalues of the companion matrix \( A \) have modulus less than 1. The function for this test is built into the \textit{vars}-package and the output confirms stability, see the Appendix.
3.3.3 Scenario Analysis

When applied to this particular model and underlying theoretical research question, the impulse response analysis is an analysis of a predefined scenario. Fully in accordance with the impulse response function’s characteristics, this report aims to directly observe the magnitude and delay of the effect which a change in the repo rate implies.

Section 4: Results

4.1 The Final VAR(4) Model

The best fitted model of order 4 is presented in Tables 1-4 below. The coefficients are rounded to three significant figures for the presentation, however the full extent of available information is obviously utilized in the analysis. The headers \((k)\ lag\ p\) denote the coefficient of variable with index \(k\) to lag \(p\), i.e. the coefficient \(\alpha_{ik,p}\) to \(y_{k,t-p}\) where \(i\) represents the index of the predicted variable. Variable indices are as follows:

1. The Riksbank Repo Rate
2. Fixed Gross Investments
3. Swedish GDP
4. Inflation Rate
5. Mortgage Rate
6. Employment
7. Housing Prices
### Table 1: Coefficients: Intercept and Lags of (1) The Riksbank Repo Rate

<table>
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<th>(2) ( lag ) 3</th>
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### Table 2: Coefficients: Lags of (2) Fixed Gross Investments and (3) Swedish GDP

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### Table 3: Coefficients: Lags of (4) Inflation Rate and (5) Mortgage Rate

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<td>-3.78e - 03</td>
<td>-2.75e - 03</td>
</tr>
<tr>
<td>( t = 6 )</td>
<td>-2.05e - 01</td>
<td>-1.79e - 02</td>
<td>-1.31e - 02</td>
<td>+6.86e - 02</td>
<td>+6.51e - 01</td>
<td>-3.39e - 02</td>
<td>+6.75e - 01</td>
<td>-8.77e - 02</td>
</tr>
<tr>
<td>( t = 7 )</td>
<td>+4.84e - 02</td>
<td>+1.91e - 02</td>
<td>-4.91e - 02</td>
<td>+1.14e - 02</td>
<td>+6.04e - 01</td>
<td>+3.24e - 01</td>
<td>+3.39e - 01</td>
<td>+3.44e - 01</td>
</tr>
</tbody>
</table>

### Table 4: Coefficients: Lags of (6) Employment and (7) Housing Prices
4.2 Impulse Response Functions

Figure 1: Impulse Responses to Shocks of 1 Standard Deviation in the Riksbank Repo Rate With 95% Bootstrap Confidence Intervals

Note that the magnitudes in several of the figures represent transformations of the original data. Furthermore, the original data points are indices for the housing price time series.
Table 5: Standard Deviations of Transformed Data

<table>
<thead>
<tr>
<th>Standard Deviation</th>
<th>Investments</th>
<th>GDP</th>
<th>CPIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dev. Magnitude</td>
<td>0.278</td>
<td>0.334</td>
<td>0.264</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Deviation</th>
<th>Mortgage Rate</th>
<th>Employment</th>
<th>House Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dev. Magnitude</td>
<td>0.145</td>
<td>0.317</td>
<td>0.209</td>
</tr>
</tbody>
</table>

Table 6: Magnitudes of Greatest Deviations in Terms of Standard Deviations

A positive shock to the repo rate exerts immediate positive responses in all variables except housing prices for which the immediate response is negative. The development in investments and GDP follow a similar pattern of an initial hike followed by a significant downturn. Note that both investments and GDP are expressed as first-order differences. Hence, investments decrease for a period of nine quarters starting one quarter after the initial shock. Both measures prove to be impacted the greatest 6 quarters after the initial shock, demonstrating alternating movements during the first 5 quarters.

The mortgage rate increases over a period of 8 quarters before a small reversal is shown. Notably, a shock to the repo rate is followed by the inflation rate edging higher for an extended period of 14 quarters before demonstrating a small reversal. Whilst the inflation rate demonstrates the greatest response after 2 quarters, the mortgage rate lags behind and the greatest deviation is shown after 3 quarters.

Employment initially turns higher for a period of 3 quarters following a shock to the repo rate and subsequently turns significantly lower for a period of 9 quarters. A shock to the repo rate lowers housing prices for 8 quarters before turning moderately higher. The greatest influence of the repo rate is exerted on employment after 7 quarters whilst the housing price variable demonstrates a more rapid response as well as a more rapid reversal to baseline.

4.3 Research Question

- The greatest positive magnitude of the impact of the repo rate to the transformed employment variable is 0.162 standard deviations per standard deviation in the repo rate shock. This response is demonstrated in the quarter immediately following the shock.
- The greatest negative magnitude of the impact of the repo rate to the
transformed employment variable is 0.317 standard deviations per standard deviation in the repo rate shock. This response is demonstrated 7 quarters after the shock.

- The greatest positive magnitude of the impact of the repo rate to the transformed housing price variable is 0.0881 standard deviations per standard deviation in the repo rate shock. This response is demonstrated 11 quarters after the shock.

- The greatest negative magnitude of the impact of the repo rate to the transformed housing price variable is 0.209 standard deviations per standard deviation in the repo rate shock. This response is demonstrated 4 quarters after the shock, however the response after 2 and 5 quarters is approximately of equal magnitude.

Section 5: Discussion

5.1 Policy Rate Target

The safeguarding of financial stability is one of the Riksbank’s objectives, second to maintaining price stability. This means ensuring that no external factors constitute an overwhelming and possibly uncontainable risk to the financial system. Today’s well-adopted regime of inflation targeting is commonly seen as the most efficient method to achieve such a goal since price stability in the short-term and medium-term implies a lowered risk of shocks to the financial system. However, the development since the financial crisis in 2008 tells a slightly different story. Despite prolonged expansionary activities from the Riksbank, inflation pressure is only now slowly starting to show in CPIF data.

The recent decline in the housing market constitutes an instance of instability that is an unwanted consequence of the monetary policy conducted in the last 10 years. The results of this report suggest that the housing prices are very sensitive to shocks in the repo rate and that the housing market would experience an immediate downturn following a rate hike. This contrasts all the other observed variables, since housing prices do not experience any significant positive response to a repo rate shock. This highlights the possibility that the impact of the recent monetary policy has placed the housing market in a position where a significant correction is unavoidable should the rate environment edge higher. As previously noted,
this is in line with the forward guidance of the Riksbank. Furthermore, this future development is also in line with the economic theory that higher rates imply a devaluation of leveraged assets. With regards to Keynes’ theory presented in Section 2.2.1.2 Monetary Policy as a String, the question arises whether the string will be able to withstand the dynamics of the housing market or whether it will break.

In this context, it is interesting to also return to one of Friedman’s principles regarding monetary policy presented in Section 2.2.1.3 The Role of Monetary Policy. Friedman states that "Monetary policy should be conducted by magnitudes that it can control, not by ones that it can not control." [1] On the basis of the development of the Swedish housing market coupled with the development of the repo rate, the question arises whether monetary policy not only should be controlled by what the policy rate itself can control. The natural extension of Friedman’s reasoning on this basis is whether the repo rate should be controlled by all measurements that it can control. In other words, since the target measurement CPIF does not include housing prices, does it still provide the optimal guiding principle for the Riksbank when the effect of the repo rate on the housing market is overlooked?

5.2 Presence of Rational Expectations

The impulse responses suggest that rational expectations exist to some degree in the Swedish economy. The real variables investments, GDP and employment demonstrate immediate positive impulse responses in the proximate quarter following the deviation of the repo rate. The largest deviations of those variables are however not positive, but negative in line with the theory of contractionary monetary policy. Furthermore, the greatest influence of the repo rate is thus also delayed beyond the immediate quarter following the impulse. In general, the classic relationship between inflation and employment, i.e. the Phillips Curve, exhibits a weaker legitimacy of the classical perspective that as job markets tighten, wage growth eventually drives inflation. These results suggest that rationality should matter in economic theory and that the tools of contractionary monetary policy initially has an expansionary effect.

Two perhaps even more eye-opening impulse responses are those of the inflation and mortgage rates. The figures demonstrate significant hikes with only minor reversing movements after 10 to 15 quarters following the repo
rate shock. The largest deviations from baseline, which as noted are positive, are found already after 2 to 3 quarters. This result is shocking given that monetary policy makers act in the very opposite fashion when attempting to stimulate the inflation rate. Should this calculated reaction of the inflation rate be materialized, one logical explanation would be that the response is due to rational expectations. The psychological aspect of the signal value in a repo rate increase is with this result suggested to outweigh the actual economic effect on the dynamics of the economic system. However, although the results should not be disregarded, this conclusion should certainly not be regarded as the only truth. The relationships between the variables in this 7-variable-model are based on historic observations where the repo rate structurally has experienced negative development. During 2011-2017 this has been coupled with a declining inflation rate. Thus, effects to the inflation of a positive repo rate development are not as present in the data constituting the model. Consequently, the basis for drawing conclusions about rational expectations in the presence of a repo rate hike is limited.

5.3 The Effect of Monetary Policy on Output and Price Level

Dividing the employed model in this study into one group of real economy variables and one group of variables that are affected by inflation, more general conclusions can be drawn. When studying the impulse responses of the repo rate on these elements, it is clear that the variables affected by inflation experience a far more rapid response than the real variables. Whilst the group affected by inflation experiences the largest influence after 2 to 4 quarters, the real variables do not reach the greatest deviation from the baseline until after 6 to 7 quarters. This result demonstrates a reactive effect in the Swedish economy, i.e. that national output follows an increase in economic resources. Based on the Riksbank’s objective to maintain price stability, these results could therefore argue that the Riksbank should take measures to regulate output more proactively in connection to alterations in the repo rate than has been performed historically. In general, the Swedish Riksbank is considered to be one of the world’s most reactive central banks as opposed to central banks such as the Federal Reserve (US) taking proactive policy measures.

The magnitudes of the responses indicate that the repo rate exerts greater influence on all real variables compared to the variables affected by inflation.
Whilst being well-aware that such a conclusion is based solely on a single time period for each variable, it certainly provides an understanding of the scale of the impulse responses. Along with the results regarding the delay of the maximum influence, the results of this study suggests that the repo rate has short-term impact on the price level of the Swedish economy. However, in a longer perspective the repo rate has a delayed but greater impact on the national output of the Swedish economy.

5.4 Further Study

As noted throughout this report, the model employed is relatively simple and constrained to only 7 aspects of the Swedish macroeconomy. When producing predictions and analysis of economic variables at the monetary policy department of the Riksbank, the much more advanced and comprehensive model Ramses II is used. This is a dynamic stochastic general equilibrium (DSGE) model which includes economic theory in the calculations. [22] As previously noted, one common aspect of econometric models is Bayesian estimation and subsequently to employ a BVAR model which has not been performed in this investigation. In order to increase the legitimacy of the results presented in this paper it is encouraged to expand and refine the extent of the implemented model.

The model employed in this study was constructed based on the four facts published by Bernanke et. al. in Inside the Black Box: The Credit Channel of Monetary Policy presented in Section 2.2.1.1 Effect on Key Components of Macroeconomics. We encourage further studies regarding the legitimacy of Fact 2 and the full extent of Facts 1, 3 and 4. However the results of this report produce similar results as Bernanke et. al. regarding Facts 1, 3 and 4 as follows:

1. A monetary tightening is followed by sustained declines in real GDP and short-lived transitory effects on interest rates. However no sustained decline in the price level has been observed.

3. The earliest and sharpest decline in final demand does indeed occur in residential investment.

4. Investments eventually decline in response to monetary tightening (following an initial hike) and its fall lags behind that of housing. However the decline of investments does not fall behind that of interest rates.
Appendix A: Original Data

Figure 2: Original Datasets Without Transformations
Appendix B: Transformed Data

Figure 3: Datasets After Transformations
Appendix C: Model Diagnostics

Figure 4: Diagrams of Fit and Residuals for Variables
Figure 5: OLS-CUSUM Stability Test for Variables
References


