Stockholm School of Economics
Department of Economics
Master of Science Thesis 2011

Monetary Policy and Rules: The Case of Sweden

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Abstract
The debate about how monetary policy should be conducted is almost as old as the science of economics itself. During different periods of time, different policy regimes have prevailed. Some have focused on the flexibility that discretionary decisions allow. Others have been more concerned with the stability and time consistency of rule based policies. This paper compares the monetary policy decisions taken by the Riksbank to those recommended by a number of monetary policy rules. The use of real-time data, and construction of such series, is also emphasized.

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Acknowledgements
I am indebted to everyone who has contributed to this thesis. More specifically, this includes my tutor, Kelly Ragan, and those of my fellow students who have participated in thesis seminars with me. Without them, this thesis would have been significantly worse. Any remaining flaws are, of course, my own responsibility.

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1. Introduction

During the 1970's and 1980's, many industrial countries had periods of sustained high inflation. Some of them even suffered from high inflation combined with high unemployment, i.e. stagflation, two states of the economy previously thought to be mutually exclusive due to the mechanics of the Philips curve. This empirical experience sparked a trend towards more independent central banks (Arnone, Laurens & Segalotto 2006), building on research showing that inflation was negatively correlated to the degree of central bank independence (Cukierman 1992, Cukierman et al. 1992, Eijffinger & De Haan 1996).

At the same time, there was an increasing consensus that the bulk of stabilization policy was to be conducted by these independent monetary authorities. The heydays of Keynesianism, and aggressive discretionary fiscal policy, seemed to be long gone. As is often the case, however, the revolution seems to have been followed by a counterrevolution. With the financial crisis that hit the world in 2008, and the economic downturn that followed with it, came a stabilization policy regime that was more heavily dependent on discretionary decisions. Also, as central banks have hit the nominal interest rate floor, fiscal policy has had to step in.

This paper aims to evaluate the performance of the Riksbank, the Swedish central bank, during the last decade. To do this, the Riksbank's policy actions are compared to the counterfactual performance of policies recommended by simple rules, such as the Taylor rule. The importance of using real-time data is also emphasized. To summarize, the aim of this paper is to:

> *Compare the Riksbank's actual policy actions to those recommended by a number of monetary policy rules, and investigate how policy recommendations are affected by the use of real-time data.*

The rest of the paper is structured as follows. In chapter two the method that is to be used, and the restrictions that are to be made, will be discussed. In chapter three the theoretical framework is outlined, and previous research discussed. In chapter four the data is described, while in chapter five the econometric models are defined and their results presented. Finally, in chapter six, a discussion about the results can be found.

2. Method

This paper is restricted by limitations in both time and space. Given that the Riksbank is the world's oldest central bank (Wetterberg 2009) one could, hypothetically, study long time series. Also, there are an infinite amount of potential monetary policy rules to which the Riksbank's actual policies could be compared. Here, we will focus on the period between the first quarter of 2000 and the first quarter of 2011. And we will restrict our attention to three policy rules: The taylor rule, a rule based on inflation expectations and a rule targeting nominal GDP growth. More on the specifics of these models later.

The Riksbank's price stability target, interpreted as containing the inflation level between one and three percent (Riksbank 1993), was formulated explicitly in 1993 (Wetterberg 2009). And it was not before 1999 that the Riksbank became fully independent. Before this, Sweden had a number of other monetary regimes (see, for example, Tson Söderström 2008 for a historic summary). This makes evaluations of longer time periods less interesting, given that the monetary policy was conducted with different goals in mind, and within a different administrative structure.

As far as the choice of policy rules to be used goes, it is rather arbitrary. The three rules, however, originate from three of the most widely discussed types of rules: Taylor rules, inflation expectations based rules and rules targeting the growth of nominal GDP. Combined, thus, they should provide an interesting benchmark to which the Riksbank's actual policy can be compared.

3. Theoretical Framework

3.1 General Review of Historic Developments

The debate about how stabilization policy should be conducted is as old as the fundamental question of whether or not one should try to counter swings in the business cycle at all. One of the primary differences of opinion has, at least during the last century, originated mainly from a conflict between those who endorse a fiscal and monetary regime in which discretionary actions are allowed – and encouraged! – and those who, instead, want policies to be guided by fixed rules (Orphanides 2007, Blinder 2006).

It is, obviously, impossible to make a fair representation of all the arguments that have been made in support of one side or the other. It should also be noted that the arguments used, and the majority's view on the matter, has shifted over time (Romer & Romer 2002, Taylor 2000, Tson Söderström 2008). In the decades leading up to the most recent financial crisis, however, monetary authorities became increasingly independent and seemed to be guided by policy rules to a greater extent than before (Arnone, Laurens & Segalotto 2006).

3.2 Monetary Policy Rules

There are an infinite number of possible rules that could guide monetary authorities. For long periods of time, monetary policy has strived to maintain a metal standard of some sort (Tson Söderström 2008, Wetterberg 2009). One of the first versions of a monetary policy rule that is also applicable to a system based on fiat money was formulated by Knut Wicksell (Wicksell 1936, Jonung 1990). According to Wicksell, "the problem of keeping the value of money steady, the average level of money prices at a constant height … evidently is to be regarded as the fundamental problem of monetary science …" (Graboyes & Humphrey 1990, p. 3). In order to achieve this goal, Wicksell argued that the banks' lending rates need to equal the natural interest rate, i.e. the expected rate of return on investment. Thus, Wicksell argued, monetary authorities should try to increase (decrease) interest rates whenever the price level rises (falls).[1]

The most famous of monetary policy rules, however, is probably the Taylor rule (Taylor 1993), which states that the short nominal interest rate should be a function of the rate of inflation in the current period, the equilibrium interest rate, the output gap and the difference between current inflation and the target inflation:

$$i_t = \pi_t + r_t^* + \alpha_\pi(\pi_t - \pi_t^*) + \alpha_y(y_t - \bar{y}_t) \qquad (1)$$

Here, i is the short nominal interest rate, r* is the equilibrium real interest rate, α_π is a constant, π is inflation, π^* is the targeted inflation level, α_y is a constant, y is the logarithm of

[1] There is a number of ways to interpret Wicksell, and to translate his prose into explicit equations, but a full discussion of those problems are not within the scope of this paper.

real GDP and $\bar{y}$ is the logarithm of potential output. This is the first policy rule that we will use as a benchmark and compare the Riksbank's policies to.

The Taylor rule was one of the rules the Riksbank (2002) itself used to describe and evaluate its policies. Another rule that the Riksbank (2002) used in this comparison, and which it states is a good rule-of-thumb to understand its reasoning, says that interest rate is a function of forecasts of the inflation rate (see, for example, Bernanke & Woodford 1997 for a description of problems associated with targeting inflation forecasts):

$$i_t = \alpha + bi_{t-1} + c(\pi^F_{t+1} - \pi^*) + d(\pi^F_{t+2} - \pi^*) + e_t \qquad (2)$$

In this expression, i is the short nominal interest rate, π^F_{t+1} is the forecasted inflation rate one year from the current period, π^F_{t+2} is the forecasted inflation rate two years ahead and e is a measure of how much the Riksbank deviated from the rule in the previous period. This forms the base for the second rule that we will use to evaluate the Riksbank's policies.

Another famous monetary policy rule, that came to form the basis of what is now known as the monetarist tradition, was formulated by Friedman (1960) and Snyder (1935). Friedman's skepticism of the monetary authorities' ability to adjust the monetary supply in a countercyclical manner made him propose that the money supply should expand at a fixed rate. Even though this "k-percent rule" is no longer as influential as it once was, there are still a number of rules advocated by influential scholars that give the growth rate of the money supply a prominent role. One such example is found in McCallum (2000). He formulates a rule in which the growth in the monetary base should respond to deviations in the growth of nominal GDP from a certain goal:

$$\Delta b_t = \Delta x^* - \Delta v^a_t + 0.5(\Delta x^* - \Delta x_{t-1}) \qquad (3)$$

Here, Δb is the change in the log of the adjusted monetary base, i.e. the growth rate of the base. The term Δx^* is a target growth rate for nominal GDP. This target value Δx^* is specified as $\pi^* + \Delta y^*$, where Δy^* is the long-run average rate of growth of real GDP and π^* is an inflation target of some sort. The term Δv^a is the average growth of base velocity over the previous 16 quarters and reflects a structural change in the demand for money. This is the third and final rule that we will use in our evaluation.

3.3 Methodological Challenges

Taylor (1993, 1998) not only defined the Taylor rule, but also argued that following such a rule would be beneficial for central banks pursuing a flexible inflation target (see Svensson 2008 for a discussion about different types of inflation targets). Specifically, Taylor (1998) used historical data to show how the FED would have acted, had they followed the Taylor rule. Taylor's conclusion is that deviations from the Taylor rule was "associated with either high and prolonged inflation or drawn out periods of low capacity utilization" (Taylor 1998, p. 40). Others (Woodford 2001) have echoed the same results based on more theoretical reasoning.

The Taylor rule, and the policy response it recommends, however, has not been spared of criticism (see for example McCallum 1993). Most notably, its practical use has been questioned. Specifically, Orphanides (2003, 2007) notes that historical evaluations often recommend a Taylor rule that reacts strongly to deviations from potential output. These types of analyses, however, often fail to take into account the fact that real-time estimates of the output gap tend to deviate substantially from the actual output gap (Kamada 2005). Thus, policy recommendations from a Taylor rule are sensitive to whether or not one uses real-time estimates of the output gap (Gerberding, Worms & Seitz 2004, Herrmann, Orphanides & Siklos 2005) and to the econometric technique employed in the process of estimating this gap (Bernhardsen et al. 2004).

Even though the difference between ex post and ex ante estimates of the output gap has received most of the attention in the literature, the same type of concerns can be raised when it comes to the use of ex post data on inflation. Even though inflation can be measured, rather than estimated, to a larger degree than the output gap, some challenges remain. First, it takes time to collect data on inflation, and since monetary policy has effects far into the future (Batini & Nelson 2002, Culbertson 1960, Friedman 1960, 1961, 1968, 1972, Gordon 1965, Hendershott 1966), one still need to make calculated guesses about the inflation level in the future. Guesses that can deviate quite substantially from actual inflation. Second, there are examples of how measurement errors have skewed the real time estimates of the inflation level substantially (Statistics Sweden 2008).

Even if one was able to accurately estimate the output gap, the inflation level, the natural rate of interest and so on, there is another aspect of monetary policy that causes problems for most policy rules. The aspect that we have in mind is the fact that monetary transmission mechanisms often are assumed to lead to lags between the implementation of a certain policy and the effects of the policy in question (Orphanides 2007). The policies of today, thus, might need to be designed to counter the output gap and inflation of tomorrow. And those forecasts are even more uncertain. When these types of uncertainties in the relationship between monetary policy and the real effects are modeled, recommendations might change substantially (Kilponen & Leitemo 2008).

By definition, the only option available to the monetary authorities is to use real-time estimates and forecasts of the variables that they are interested in. Any evaluation of the performance of different policy rules, thus, should use such real-time estimates when exploring the counterfactual performance that would have been achieved if another policy than the one actually used would have been implemented. That is exactly what we will do here. However, as was mentioned above, the fact that there are a number of possible techniques that can be used when on tries to construct series of real-time estimates means that there is no such thing as *the* estimated real-time output gap etcetera (Bernhardsen et al. 2004, Cayen & van Norden 2004). More on this issue later.

4. Data

Ex post data is limited by the fact that the Riksbank did not start to use the repo rate as its instrumental interest rate until the second quarter of 1994. All ex post data, therefore, stretches between the second quarter of 1994 and the first quarter of 2011. The real-time data is constrained by the fact that we do not have real-time estimates of the output gap from earlier than the first quarter of 2000. All real-time data, thus, is contained in series between the first quarter of 2000 and the first quarter of 2011.

However, when one wants to investigate the effects of using real-time data instead of ex post data, it seems reasonable to use the same time period for all estimations. Otherwise, differences in outcomes might not solely be attributed to the use of real-time data instead of ex post estimates, but might also be a consequence of one looking at different time periods. Thus, all estimations will only make use of data between 2000:1 and 2011:1.

4.1 The Real-Time Output Gap

To get a point estimate of the output gap in real time and combine these points into a time series is not easy. Mainly, this is due to the fact that, in every given point in time, there are several estimates of the output gap. This, in turn, is a result of the fact there are a number of different econometric processes by which an output gap can be estimated, and that these techniques are all affected by the GDP data that one uses (Bernhardsen et al. 2004, McCallum 2000). The choice of time periods included also has an effect on the resulting estimates.

The main source for data on an output gap estimated in real time that will be used is the one presented by Öberg (2010), a series containing quarterly data from 2000 to 2010. There have been a number of other authors who have tried to create similar time series (Heller Sahlgren 2006, Henriksson 2008), but they have based their estimates on other data sources than the ones used by the Riksbank, and they don't include the more recent observations found in Öberg (2010). This makes them slightly less relevant for our purposes.

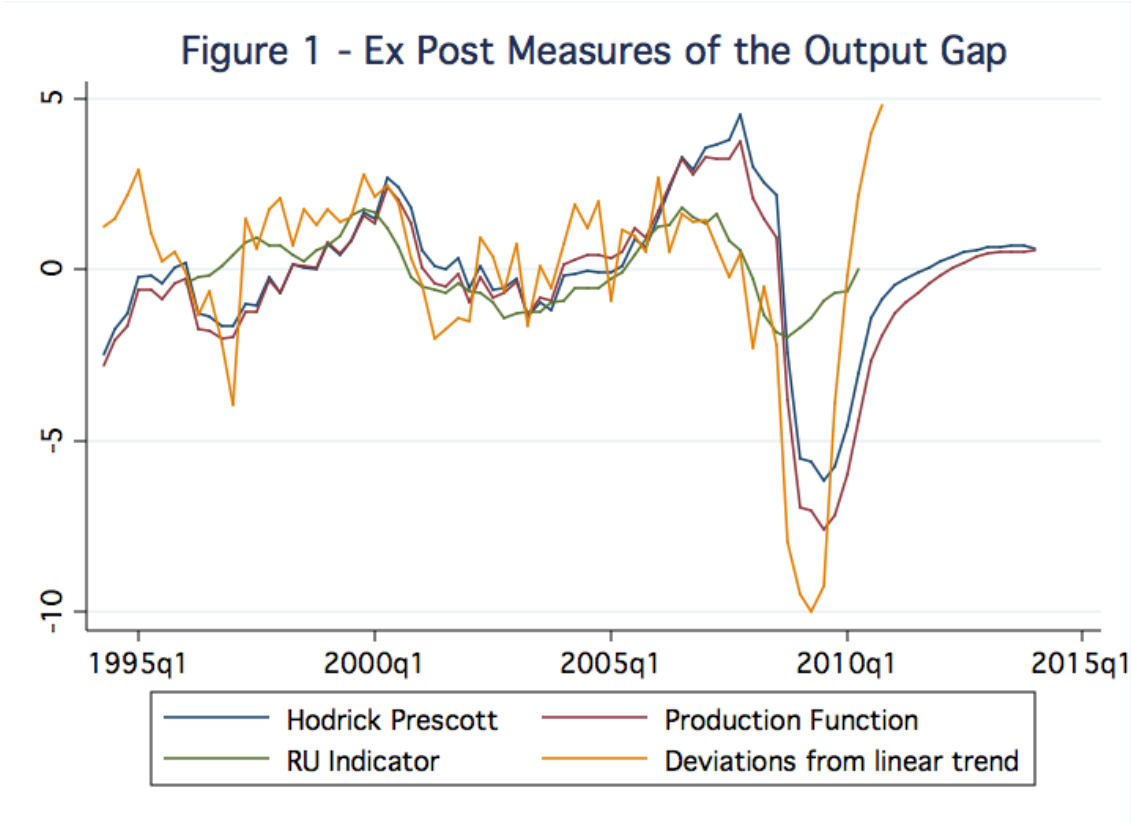
More recently, the Riksbank itself has also published real-time estimates of the output gap in its Monetary Policy Reports, which make for a nice benchmark. In order to get a series with as much data as possible, the Riksbank estimates from time periods not included in Öberg (2010) will be joined with Öberg's series. The result is a series with data between the first quarter of 2000 and the first quarter of 2011.

As expected, there are differences between different estimates, but the series used by Öberg (2010) does not seem to be biased in a manner which would lead us to question its validity. However, one should note that the Riksbank (2000), in real-time, estimated that the output gap in the beginning of year 2000 was slightly above zero. Öberg (2010), on the other hand, claims that the Riksbank thought that output level was two and a half percentage points above trend. This goes to show that these types of estimations are uncertain, and this is something that the reader should keep in mind as she continues to read the rest of this paper.

4.2 The Ex Post Output Gap

After the fact, estimating actual values of the output gap is relatively easy. Even though there are a number of different techniques that could be used, we will use the estimates of the output gap found in Riksbank (2011), derived using a Hodrick-Prescott filter.

To further illustrate the potentially large effects that the choice of econometric technique has, the figure below compares the resulting output gap found using four different estimation techniques, based on the Hodrick-Prescott filter, using a production function, based on the RU indicator (see Nyman 2010 for a description) and as estimated by deviations from a linear trend of log GDP. The first three measures are taken from Riksbank (2011a), while the deviations from a linear trend of log GDP have been estimated using data from Statistics Sweden (2011d), corresponding to growth levels between 1994:2 and 2010:4.



4.3 The Long-Run Average Growth Rate of Real GDP

What long-term growth rate in GDP could be combined with non-accelerating inflation? This is a question without a definitive answer. Öberg (2010) claims that the Riksbank estimates that GDP can grow at a rate slightly above two percent per year without giving rise to an increasing rate of inflation. Since the beginning of the 1990's, the Swedish economy grew by slightly more than two and a half percent per year on average (Statistics Sweden 2010). Between 1960 and 2005, the average growth rate was 2.3 percent per year (Riksbank 2010). The proposition that potential GDP growth is somewhere between two and three percent does not seem unrealistic. More specifically, some models will be estimated assuming that the potential growth rate is either two percent or two and a half percent.

4.4 Real-Time estimates of the Inflation Rate

The source for real-time estimates of the inflation level is the Riksbank's Monetary Policy Reports, and Monetary Policy Updates. In these reports, which are published three to six times every year, the Riksbank presents time series of a number of different measures of the inflation rate, as well as forecasts of these measures. The Riksbank uses CPI as its goal variable, and given the fact that the other measures relation to the CPI is not constant, we will use the CPI as one of our main measure of inflation. There are obvious drawbacks with this strategy, the most notable being that the CPI is affected in a non-representative way by the Riksbanks policies.

Although the measure is not perfect, the fact that it is the Riksbank's goal variable, that data is available, that the Riksbank (2002) itself has used CPI in similar policy evaluations and that there is such high correlation between the CPI and, for example, the GDP deflator makes it a suitable variable to use.

The series has been constructed is as follows. Estimations of the inflation rate, and forecasts of the inflation one and two years into the future, have been taken from the most recent Monetary Policy Report or Monetary Policy Update that was available at the time. It has been assumed that if a report is published on, or before, the 15th of a certain month, the estimates in that report of the inflation rate during that particular month was available to the Riksbank. Combined, these observations should make for a good approximation of actual real-time estimates. In the reports, estimates are reported as monthly values, so they have been converted into quarterly averages, using the arithmetic mean of the values from the months contained in a specific quarter.

The problems relating to the CPI being affected by the Riksbank's policies call for a measure of underlying inflation to be used as a benchmark. The Riksbank, for a long period of time, used the UND1X/CPIX measure, but in 2008 it decided to phase out this measure and replace it with the CPIF (Riksbank 2008a, 2008b). A series of real-time estimates of the underlying inflation, and expectations of the underlying inflation in the future, has been constructed in the same way as the series with CPI estimates. From January of 2000 until June of 2008, UND1X/CPIX has been used as the sole measure of underlying inflation. From July of 2008 until January of 2009, the period in which the UND1X/CPIX was phased out and CPIF was phased in, the average value of the UND1X/CPIX and CPIF measures has been used. And from February of 2009, only the values of the CPIF have been used. See Hansson, Johansson & Palmqvist (2008) for a more extensive discussion of how the Riksbank views different measures and their relative merits.

4.5 Actual Inflation

Values of ex post inflation, as measured by the CPI, are taken from Statistics Sweden (2011a). The data contains monthly observations on the rate of change in the CPI, compared to the same month last year, and these have been converted into quarterly averages.

Ex post data on the underlying inflation, as measured by the CPIX and CPIF, is taken from Statistics Sweden (2011b, 2011c). The same type of merging of the series containing CPIX and CPIF that was undertaken when constructing the real-time series is done to construct the ex post series, with the exception that CPIX has been used as the sole measure of underlying inflation from April of 2004, rather than from January of 2000, in order to make it fit the rest of the ex post series.

4.6 Interest Rates

The short-term nominal interest rate that will be used is this analysis is the so called repo rate. The Riksbank (2011b) has published a time series with historic values of the repo rate, and it is this data that will be used.

The analysis, however, also require that the long-run average rate of interest is estimated. This is not an easy task, given that changes in the potential growth rate of GDP changes the long-run average real interest rate as well. The Riksbank (2010) estimates that a "normal" value of the repo rate, i.e. the nominal rate, is somewhere between 3.5 and 4.5 percent. Using the Fisher equation, and subtracting the average inflation rate of two percent, we notice that the real interest rate should be somewhere between 1.5 and 2.5 percent on average. To assume that the long-run average real interest rate is two percent does not seem unrealistic and, thus, this is what we will do.

4.7 Real-Time Estimates of the Growth Rate of Nominal GDP

Unfortunatley, the Riksbank does not publish estimates of the nominal interest GDP in regular publications, which make it impossible to construct a series of real-time estimates of the growth of nominal GDP. Statistics Sweden (1999:4-2011:1), on the other hand, publishes quarterly estimations of the nominal GDP, in their Gross domestic product/Quarterly series. However, these estimates are not done in real-time, as we have interpreted the term previously. Instead, the value of nominal GDP in certain quarter is published about three months later.

The published estimates are nonetheless uncertain, and subject to continuous revision. Thus, published estimates, even though they are probably more accurate than true real-time estimates, differ from the actual values that are available even further into the future. Following McCallum (2000), we will assume that the growth rate in period t pertains to the actual growth rate in period t-1, which is published in period t. This is because the growth rate of nominal GDP in period t is not known until period t+1, and a rule demanding that monetary authorities base their policy on variables that are not known is not operational.

4.8 Ex Post Estimates of the Growth Rate of Nominal GDP

Ex post estimates of the growth in nominal GDP is taken from Statistics Sweden (2011d).

4.9 Monetary Base

Measures of the monetary base are taken from Statistics Sweden (2011e). The question of what to include in such a measure is highly debatable, but we will use the measure as it is defined by Statistics Sweden. The definition of the monetary base was changed in 2009 (Riksbank 2009), but this series are in accordance with the new definition. Values are reported monthly, and have therefore been converted into quarterly averages. The value used for the first quarter of 2011 corresponds only to the value from January, since this is the only available data.

4.10 Average Growth in Base Velocity

The velocity of the monetary base is defined as the ratio of nominal GDP to the monetary base. The sources for these variables were stated above. In order to capture structural changes in the demand for money, the arithmetic average growth of base velocity during the last 16 quarters will be used.

4.11 Comparison Between Real-Time and Ex Post Estimates

Below are three figures comparing the real-time and ex post series of the output gap, inflation, underlying inflation and the growth of nominal GDP. There seem to be a fairly large discrepancy between the two series of the output gap, whereas the inflation and GDP growth estimates are less affected by whether one uses real-time or ex post data.

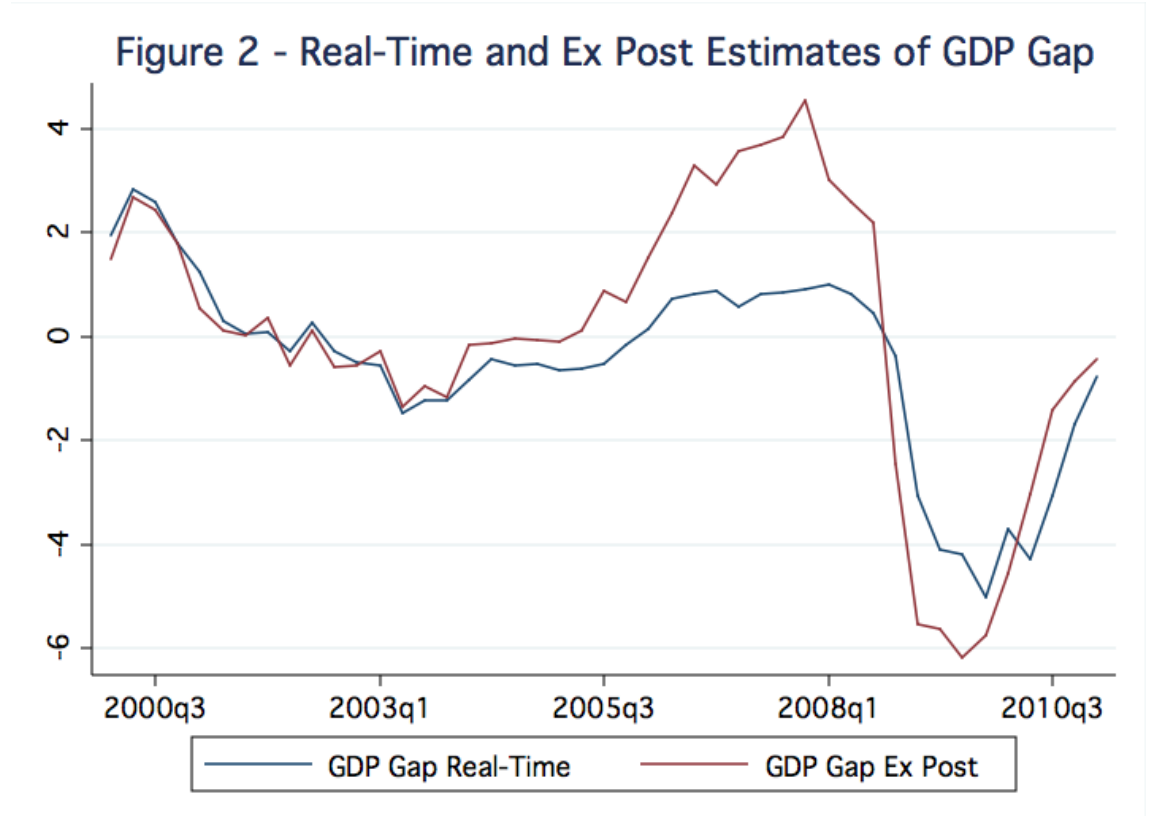


Figure 3 - Real-Time and Ex Post Estimates of CPI

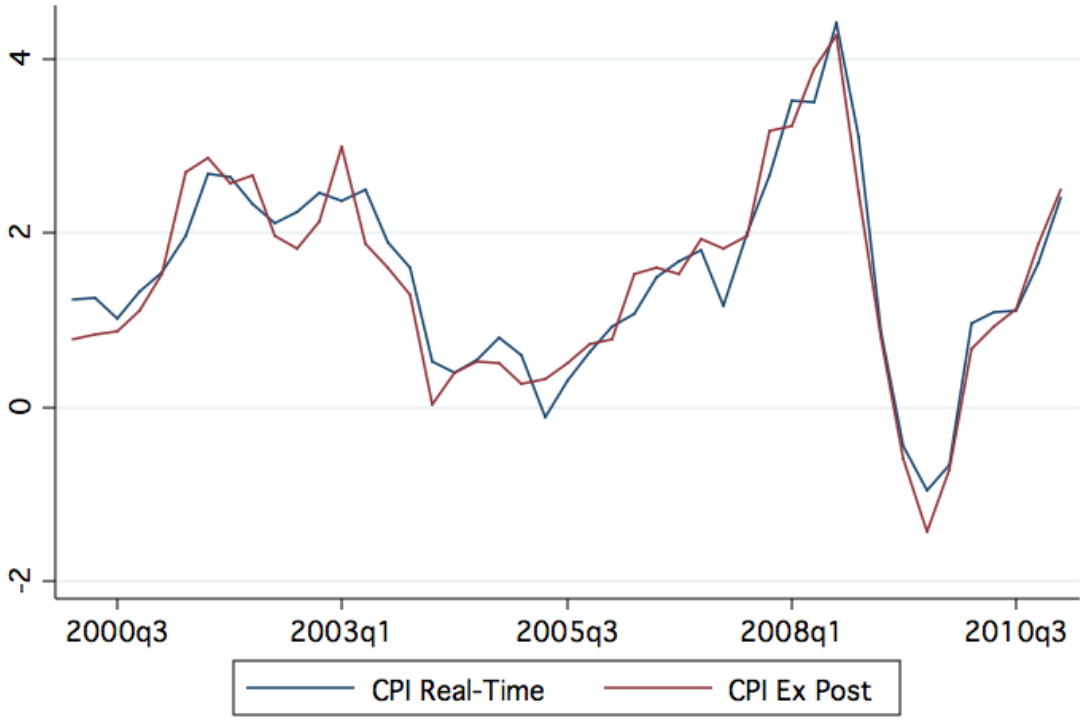
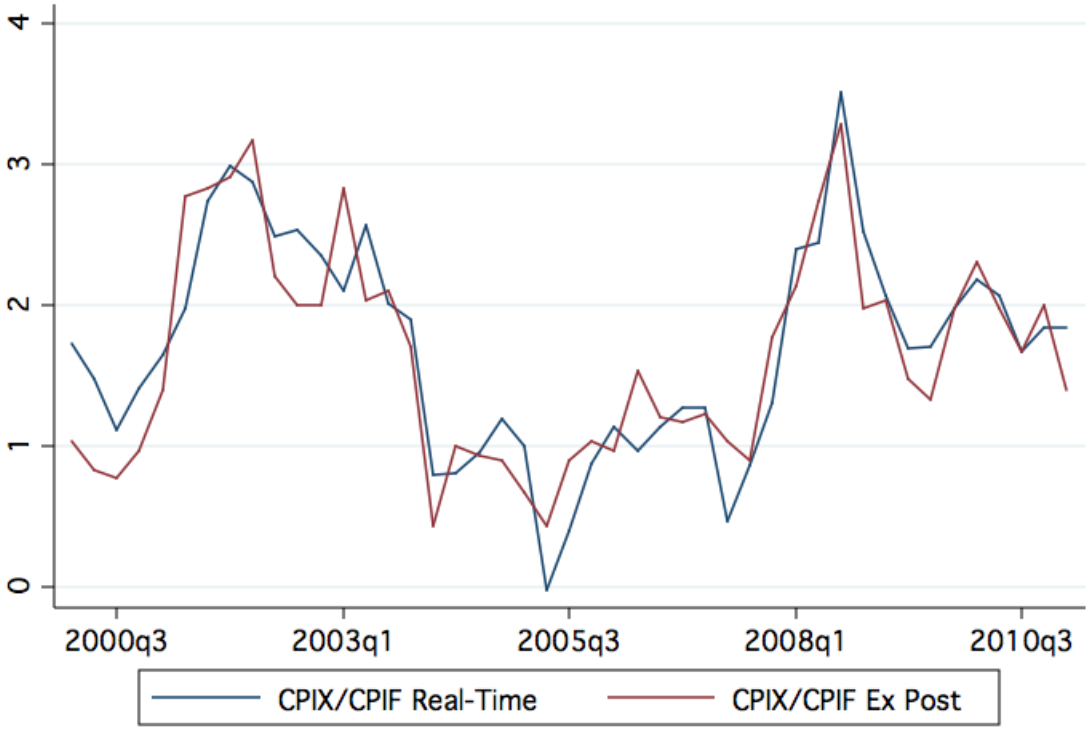


Figure 4 - Real-Time and Ex Post Estimates of Underlying Inflation



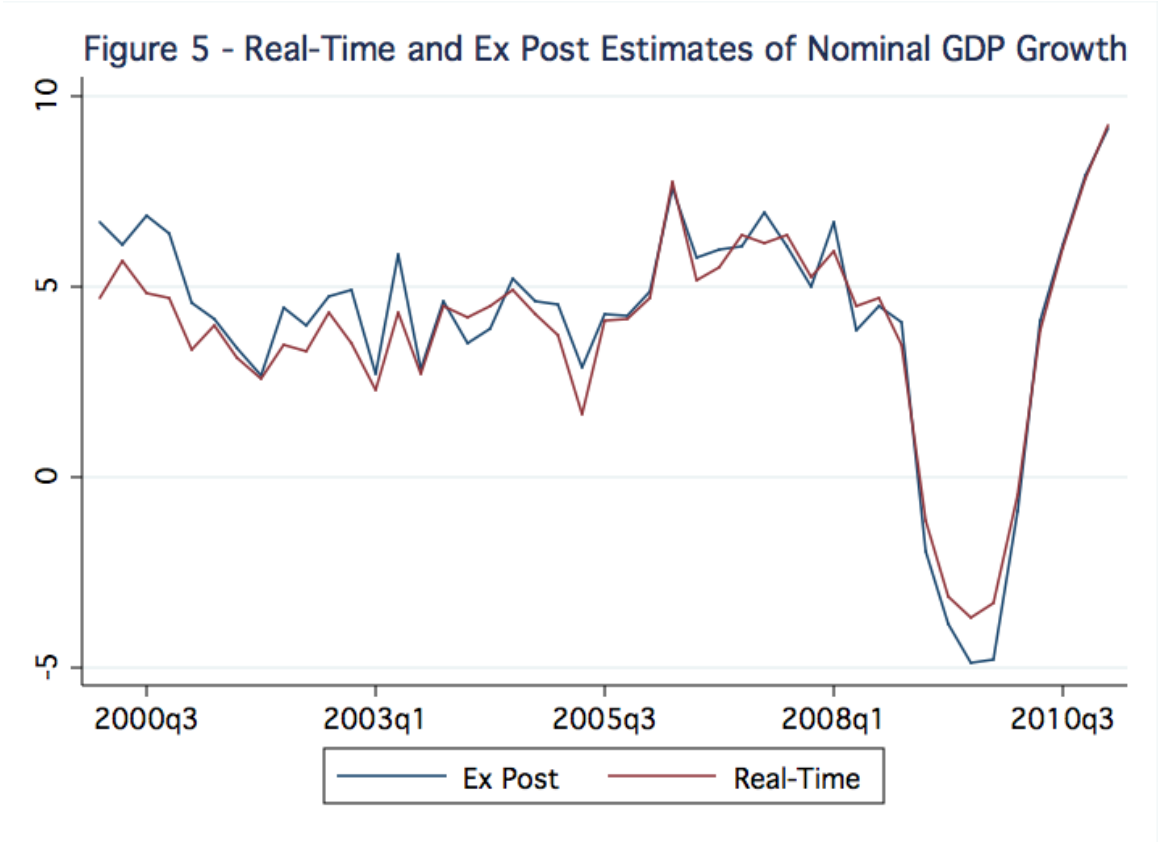


Figure 5 - Real-Time and Ex Post Estimates of Nominal GDP Growth
10
5
0
-5
2000q3
2003q1
2005q3
2008q1
2010q3
Ex Post
Real-Time

5. Model Specification and Econometric Estimates

There are two main approaches one can take, when evaluating a central bank's policies and how they would differ, had the central bank followed a specific policy rule. *Primo*, one can create a model economy in which the central bank is instructed to follow such a rule, and then simulate different scenarios. Examples of such an approach are found in Batini & Haldane (1998), Fuhrer & Moore (1995), McCallum (1990) and many other papers.

Secundo, one can use historic data and construct counterfactual reactions by the central bank, based on the same type of policy rules. Examples of this approach are found in Friedman (1960), McCallum (1988, 2000) and Taylor (1998).

There are pros and cons with both approaches. Here, we will focus on the latter. The Riksbank's actions will be compared to that recommended by three specific monetary policy rules. In all specified models, all independent variables have been regressed on quarterly dummies, in order to test whether there is a need for seasonal adjustment.

5.1 The Taylor Rule

As was briefly mentioned in chapter two, we will estimate a standard Taylor rule of the form

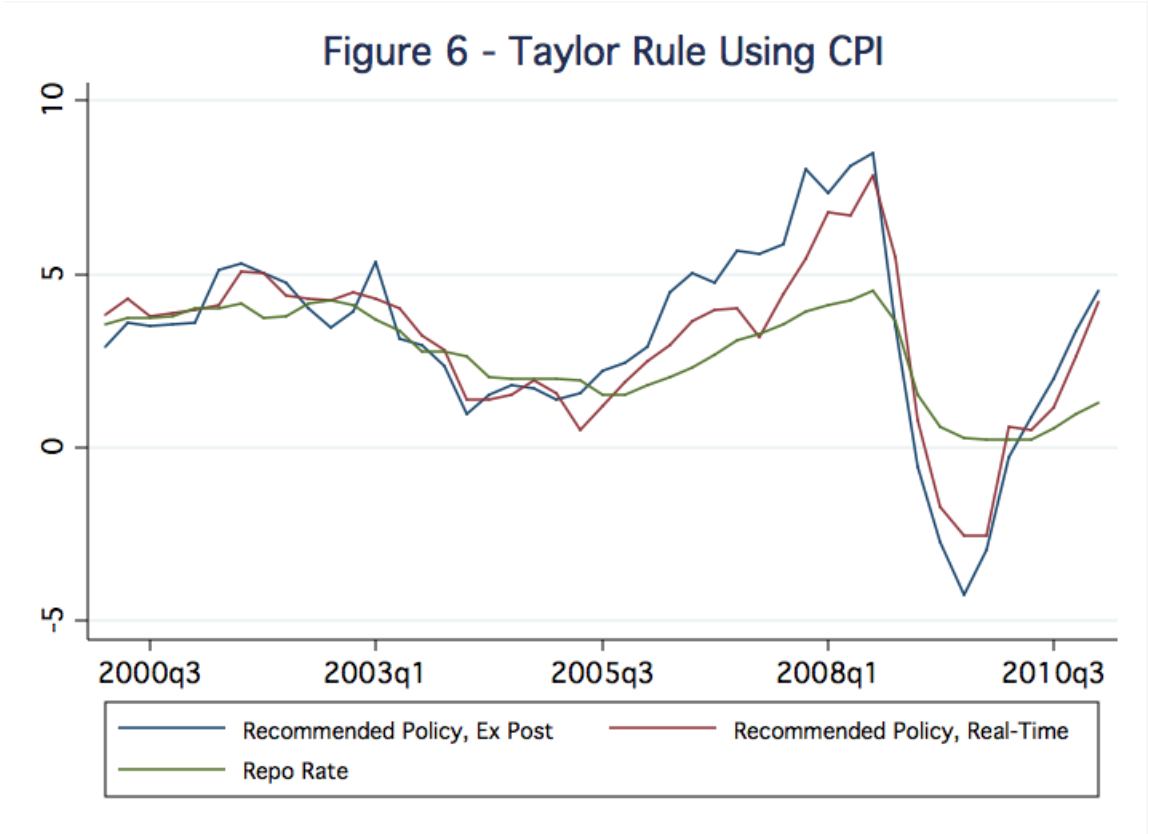
$$i_t = \pi_t + r_t^* + \alpha_\pi(\pi_t - \pi_t^*) + \alpha_y(y_t - \bar{y}_t)$$

using real-time and ex post data, and both the CPI and a measure of underlying inflation.

Taylor (1998), emphasized the so called taylor principle, stating that nominal interest should react stronger to changes in inflation than a simple tit-for-tat strategy would imply. This is due to the fact that if the nominal interest rate does not react to changes in inflation by more than a factor of one, the real interest rate would fall (rise) if inflation increased (decreased).

Thus, one way to judge the success of a central bank's work is to see whether or not α_π is significantly different from zero. Taylor (1993) himself proposed that a value of 0.5 for both α_π and α_π would be suitable.

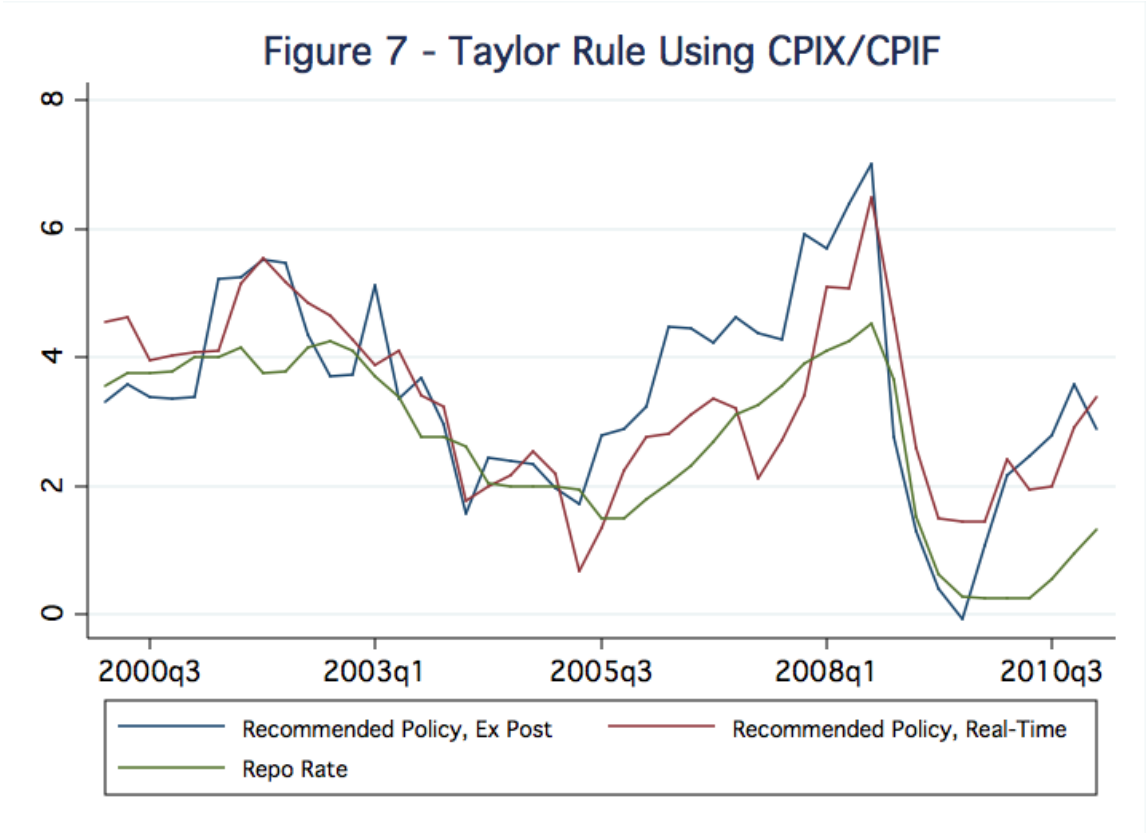
First, let us plot the recommended and actual policy using both real-time and ex post data. This will illustrate any differences between the Riksbank's actions and those recommended by the Taylor rule.



As one can see, the repo rate followed the path recommended by a Taylor rule pretty closely until 2005. From then on, the repo rate was constantly lower than the recommended rate until the crisis hit. During 2009, the Taylor rule dictated that the repo rate should be negative. As the repo rate hit the zero percent boundary, the discrepancy between actual and recommended policy grew.

One interesting observation is that from 2006 the repo rate has been closer to following the Taylor rule if one uses real-time data. Thus, one potential explanation for part of the ex post discrepancy between actual and recommended policy is that the Riksbank based its decisions on data that would later prove to need revision.

One reason why the difference between recommended and actual policy was so large during the crisis is that the CPI is negatively affected by the lowering of interest rates, which calls for even lower interest rates and so on. This is a problem that measures of underlying inflation try to control for. Thus, let us look at actual and recommended policy as implied by a Taylor rule using CPIX/CPIF as our measure of inflation.



Now, the pattern is not so obvious. The repo rate actually follows the recommended policy fairly closely. Particularly if one looks at the real-time data available to the Riksbank, it seems not to deviate from the Taylor rule in any systematic way until late 2008. From then on, the repo rate has actually been lower than what the Taylor rule recommends. This result is contrary to that found when using the CPI, and is an effect of the CPIX/CPIF not being affected by interest rate adjustments. One way to interpret it is that the Riksbank actually follows a Taylor rule pretty closely, but that the fairly large estimation errors contained in the output gap make it look as though they do not.

The eyeball econometrics conducted above is no doubt relevant and interesting. However, a more formal analysis would help to shed light on the explicit reaction function that the Riksbank seems to have followed. Thus, the four versions of the Taylor rule defined above – using CPI, CPIX/CPIF, real-time and ex post data – have been estimated using standard OLS. The results are presented in Table 1, with p-values below the parameter estimates.

	(**1**)	(**2**)	(**3**)	(**4**)
CPI Gap Ex Post	.0193126			
	0.907			
CPIX Ex Post		.3750659		
		0.129***		
GDP Gap Ex Post	.0614308	.3765298		
	0.453	0.000***		
CPI Real-Time			-.1615934	
			0.273	
CPIX Real-Time				.2160955
				0.206**
GDP Gap Real-Time			.4365487	.7333571
			0.000***	0.000
R^2	0.0193	0.3632	0.3461	0.6967
No. Obs.	45	45	45	45

Table 1 – Taylor rule

* Can't reject the null hypothesis that the coefficient is equal to 0.5 on a 1 percent level
** Can't reject the null hypothesis that the coefficient is equal to 0.5 on a 5 percent level
*** Can't reject the null hypothesis that the coefficient is equal to 0.5 on a 10 percent level

One can note that for all significant estimates, the Riksbank seems to have reacted in the way that one would suspect, increasing (decreasing) interest rates if inflation or the output gap increases (decreases). Also, for both estimates using CPIX/CPIF as the measure for inflation, i.e. model (2) and (4), the estimated response parameter pertaining to changes in inflation is not significantly different from 0.5. In model (2), using ex post data, both parameters are not significantly different from 0.5. This is interesting, because in real-time the Riksbank seems to overreact to changes in the output gap, but after the fact it seems as its policies end up following a Taylor rule rather closely.

There are two main things one should keep in mind when studying the table. First, the Taylor rule is both a recommendation and an approximation of actual behavior by the central bank. It is, however, not an attempt to fully understand all things that go into monetary policy decisions. Thus, the normal attempts one would make to make sure that functional form, included variables and estimation techniques are all optimal are redundant.

Second, we do not know whether the Taylor rule describes an optimal policy. This includes its functional form and the specific parameter values recommended by Taylor (1993). The most fundamental reason being that there is no one goal that monetary policy should try to achieve (McCallum 2000). Instead, the Riksbank, for example, strive both to maintain price stability and promote sustainable growth and high employment (Ingves 2011). The balance between the different goals is not explicitly formulated in a loss function, but is instead

subject to debate. Thus, the optimal policy is dependent on what goal one wants monetary policy to strive towards.

However, one could argue that to have interest rates of seven percent just months before the crisis hit seems suboptimal, given the lags present in the transmission mechanism (Orphanides 2007). That is one of the reasons that one might want to consider rules that take forecasts of future developments into account. That will be the subject of the next segment.

5.2 Inflation Forecasts and Monetary Policy Rules

When it comes to targeting inflation forecasts, there is no rule of thumb for how strong a central bank should react if forecasts deviate from target as widely accepted as the Taylor rule. The specific choice of model used, thus, naturally becomes somewhat arbitrary. We will use the model described in Riksbank (2002), and thus estimate:

$$i_t = \alpha + bi_{t-1} + c(\pi^F_{t+1} - \pi^*) + d(\pi^F_{t+2} - \pi^*)$$

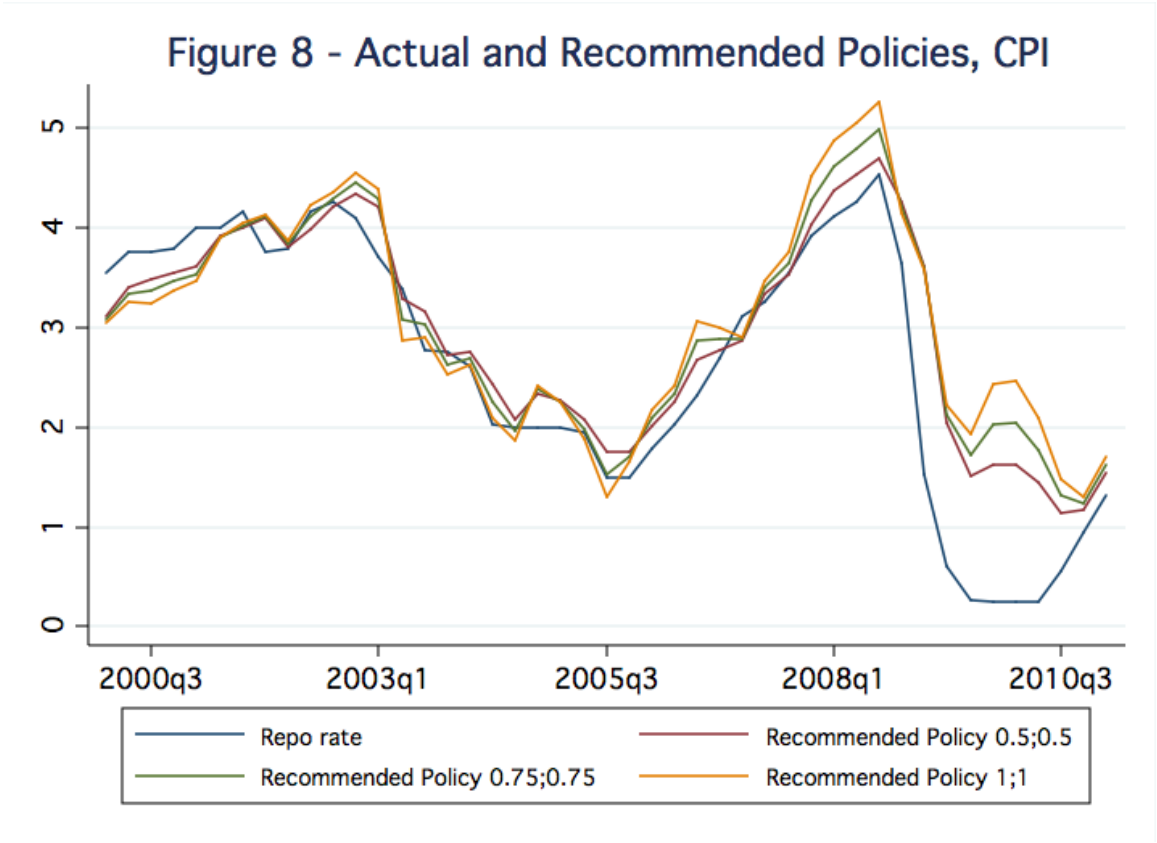
What policy that is to be regarded as recommended by the model above is not obvious. However, the parameters c and d should probably be positive. When one estimates the model, the following results are obtained, where the p-values are found below the parameter estimates:

	(1)	(2)
Lagged Repo Rate	.8347622	.8733165
	0.000	0.000
CPI Gap One Year Ahead	.5989208	
	0.000	
CPI Gap Two Years Ahead	-.3753857	
	0.034	
CPIX/CPIF Gap One Year Ahead		.1452499
		0.607
CPIX/CPIF Gap Two Years Ahead		1.25686
		0.021
Constant	.5965697	.5154732
	0.007	0.034
R^2	0.9224	0.9083
No. Obs.	45	45

Table 2 – Inflation Forecasts

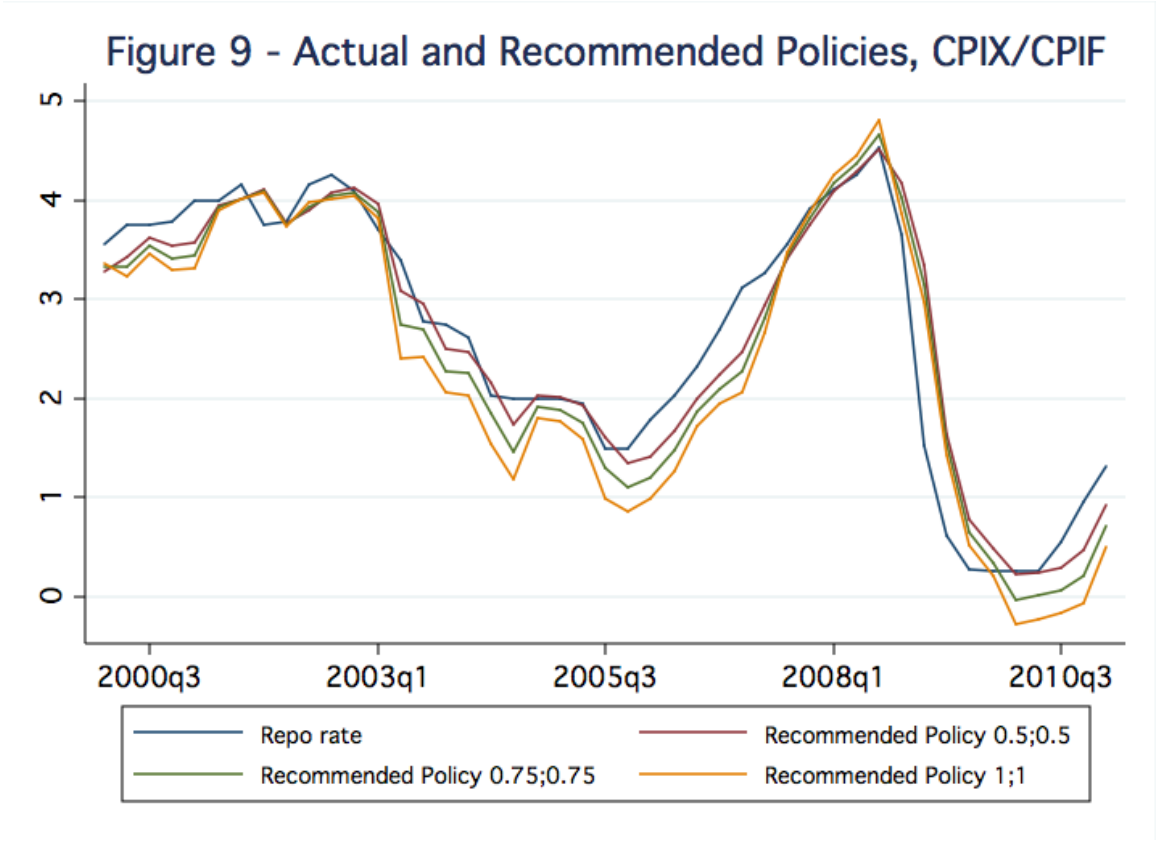
When using the CPI as our measure for inflation, the results indicate that the Riksbank follow a rather peculiar rule, as they seem to increase interest rates as inflation forecasts one year ahead go up, but lowers interest rates as inflation forecasts two years ahead go up. However, when one instead uses a measure of underlying inflation, the Riksbank seem to raise (lower) the real interest rate when inflation forecasts go up.

It is, as was mentioned earlier, hard to tell if the Riksbank's response has been optimal or not. In order to get something to compare its policies to, Figure 8 shows the actual repo rate and the interest rate recommended by the rule for three specific choices of parameter values. The first series is based on the assumption that the parameters for the inflation gaps should equal a half. This is probably too low to be optimal, since that would mean that a one percentage point deviation from target both one and two years ahead would induce the Riksbank to keep the real interest rate constant. The second series is based on the assumption that they should 0.75, and the third series is based on the assumption that they should equal one.



The repo rate tracked the three different versions of the rule pretty closely until the crisis. Thereafter the repo rate has been significantly lower than what the rules recommend. The main reason being that inflation expectations were not affected dramatically by the crisis, which is why the recommended interest rate is significantly higher than the actual repo rate. The discrepancy, thus, could potentially be attributed to the Riksbank trying to help stimulate the economic recovery and not only focusing on inflation expectations.

Figure 9 is equivalent to Figure 8, but instead of looking at the deviation of the CPI from its target, we now use our measure of underlying inflation.



Using the CPIX/CPIF, we see that the repo rate followed the recommendations from the rules even more closely. I was slightly higher than what the rules recommend during 2006-2008, but one does not need to assume that the Riksbank tried to stimulate aggregate demand to understand why they set interest rates so low during the crisis. As Figure 9 demonstrates, the policy response can be understood as the Riksbank simply managing inflation expectations.

5.3 McCallum's Monetary Rule

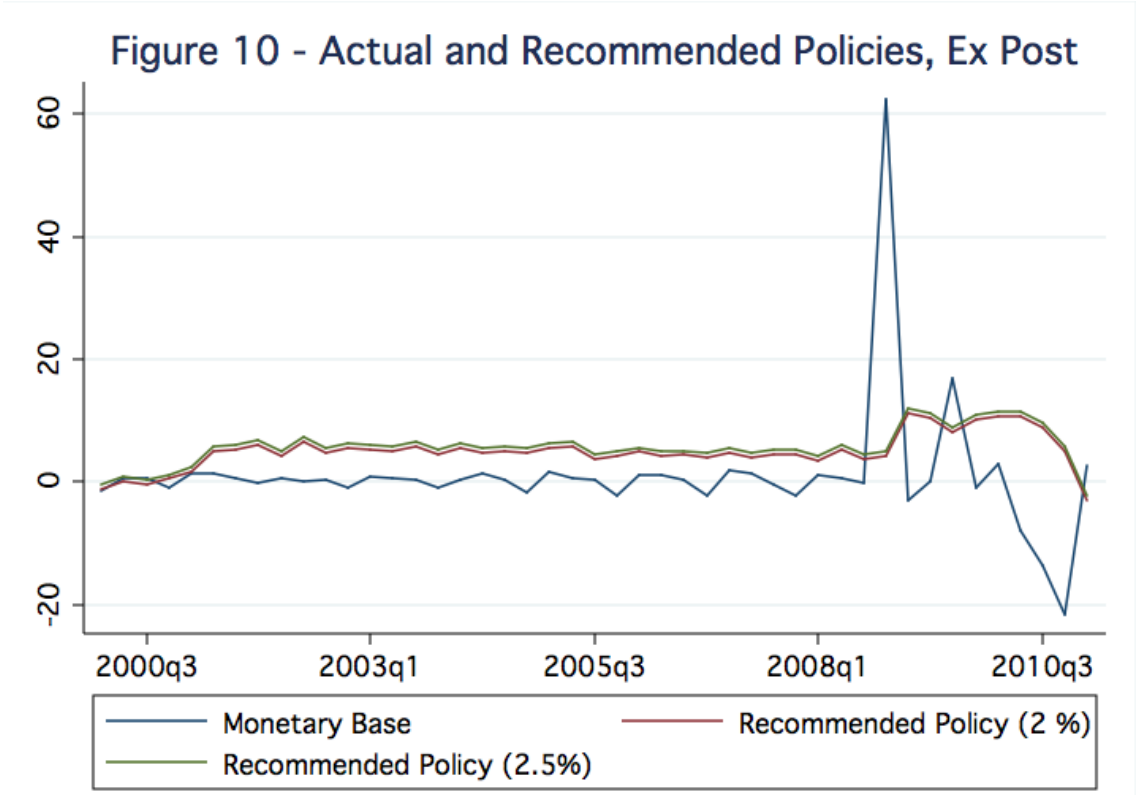
McCallum (2000) argues that the biggest difference between real-time and ex post data of the output gap does not come from data revisions, but from a changed belief of what the potential level of GDP is. Thus, McCallum argues, a rule based on a variable which potential is not subject to as much revision would let a central bank act on real-time information with greater confidence. One such variable could be the potential growth rate of nominal GDP (Orphanides 2007 seems to be thinking along the same lines, while Cayen & van Norden 2004 disagrees).

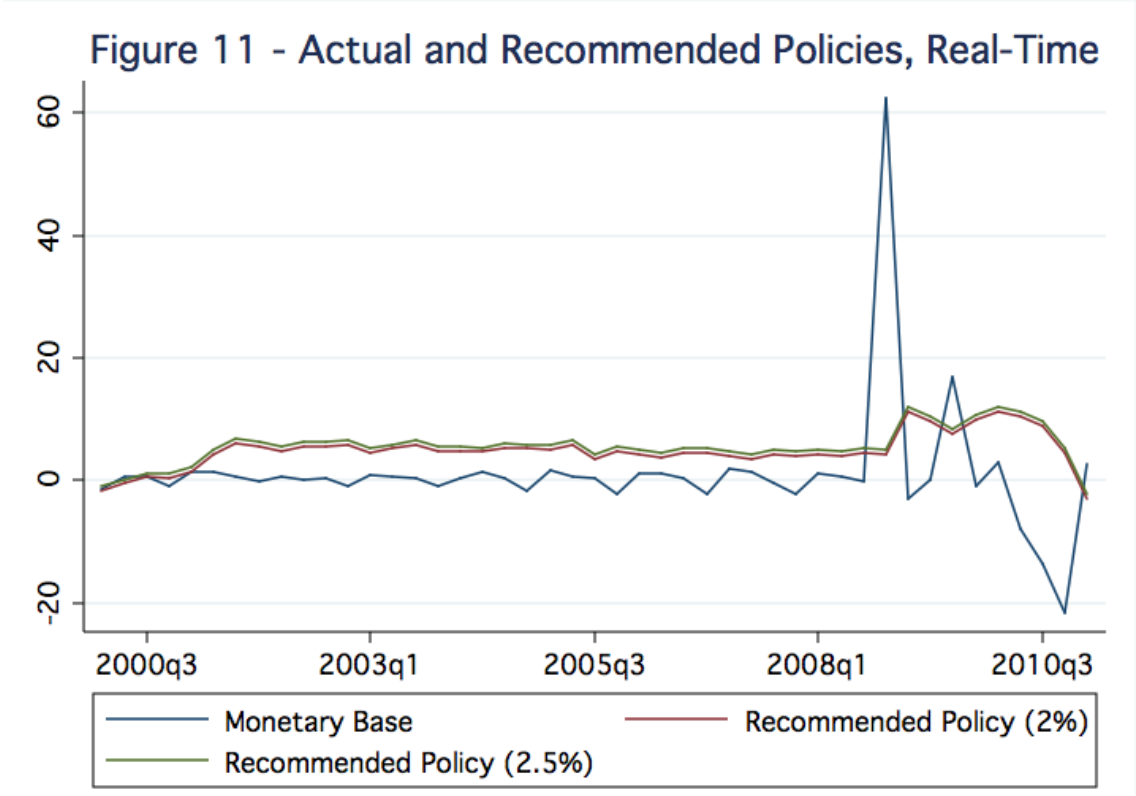
Here we will compare the Riksbank's policies to those recommended by the rule suggested by McCallum (2000):

$$\Delta b_t = \Delta x^* - \Delta v_t^a + 0.5(\Delta x^* - \Delta x_{t-1})$$

All growth variables refer to growth between quarters and all series, except that of long-run growth in base velocity, have thus been seasonally adjusted. The rule will be estimated using

real-time and ex post data on nominal GDP growth, and under the assumption that the long-run equilibrium growth rate of real GDP is either two, or two and a half percent. First, let us compare the actual path for the repo rate to those suggested by the rule. The results are shown in Figure 10 and 11.





Given the similarity between real-time and ex post estimates of the growth in nominal GDP, the two figures are almost identical. Compared to the relatively good fit between actual and recommended policies for the Taylor rule and the rule based on inflation expectations, one must conclude that the Riksbank does not seem to have adjusted the monetary base according to the rule recommended by McCallum (2000).

This can be tested more formally, by regressing the monetary base on the independent variables and test if the parameter corresponding to the gap between the goal for nominal GDP growth and actual growth is significantly different from 0.5. The result of such regressions are found below, in Table 3.

	(**1** – 2%)	(**2** – 2.5%)	(**3** – 2%)	(**4** – 2.5%)
Nom. GDP Growth Gap, Ex Post	-.7134941	-.8105199		
	0.186	0.087		
Nom. GDP Growth Gap, Real-Time			-.7086691	-.8257019
			0.224*	0.104
R^2	0.0395	0.0649	0.0335	0.0589
No. Obs.	45	45	45	45

Table 3 – McCallum's Rule

* Can't reject the null hypothesis that the coefficient is equal to 0.5 on a 1 percent level

As can be seen, all four estimations yield very low values of R^2. Furthermore, the estimated coefficient is of the opposite sign compared to that recommended by McCallum. This further strengthens the claim that the Riksbank seems to be operating according to a different rule.

6. Analysis

We have seen that estimates of the output gap seem to be rather sensitive to both the choice of econometric method used to estimate it, and to whether or not one uses real-time or ex post data. This, in turn, would indicate that there is somewhat of a risk involved in basing monetary policy on these types of estimates. One might end up with policies constructed for significantly different circumstances than the ones that actually prevail. This might be one of the reasons why the Riksbank's policies mimic a Taylor rule more closely when one uses real-time data. It is possible that they try to follow a Taylor rule, but that the measurement errors contained in the output gap make it look as though they do not.

Among the different Taylor rules tested, the one using CPIX/CPIF and real-time data clearly had the highest explanatory power. However, the hypothesis that the Riksbank's reactions to changes in underlying inflation followed a Taylor even after data revisions could not be rejected. No structural and/or major deviations from the recommendations from the rules, except for the period just before the crisis, could be found. During that period, however, all four versions of the Taylor rule indicated that the repo rate should have been slightly higher.

This prediction, however, is not confirmed when one instead looks at rules based on inflation expectations. Out of all models tested, the ones based on inflation expectations give rise to the highest values of R^2. Also, which was shown in Figure 9, it is interesting to note that the massive interest rate cuts that followed in the wake of the financial crisis need not be understood as attempts to stimulate aggregate demand, but could also be explained as inflation expectations management.

However, and this is an important reminder, this does not mean that the Riksbank's policies have been good, in any sort of objective manner. The repo rate rather closely tracks the path of a rule that the nominal interest rate should increase by a half percentage point for every percentage point increase in inflation expectations one or two years ahead. But such a policy yields a rather weak response to increases in inflation expectations, compared to other rules.

The lowest explanatory power, and statistically most insignificant results, are found when comparing the repo rate's path to that recommended by McCallum's rule. Most notably, the expansion of the monetary base during the crisis seemed to have been motivated by other factors than to restore the growth of nominal GDP to its equilibrium level.

The monetary policy rules here tested show no sign of the Riksbank pursuing a structurally different policy than what the rules prescribe. Sometimes the repo rate is above the level recommended by a rule, and sometimes it is below. But conclusive evidence of the Riksbank deviating fundamentally from what could be viewed as a sound policy does not exist. On the contrary, the Riksbank's policies can be fairly well understood in the context of policy rules. And in one of the cases in which the Riksbank has deviated, e.g. when it kept interest rates lower than some of the rules recommended just before the financial crisis hit, one could rather easily argue that this was for the better.

Finally, one needs to remember that the types of results presented in this paper suffer from a number of weaknesses. First, as the Riksbank (2006) have noted, there is no reason to believe that parameter values should be constant over time. Second, the monetary transmission mechanism not only suffers from lags, but *variable* lags. Thus, an identical response from the Riksbank might yield different results in different time periods. Third, as has been mentioned earlier, there is no optimal monetary policy, since there is no single goal for monetary authorities to strive towards.

7. References

Arnone, Marco, Laurens, Bernard J. & Segalotto, Jean-François (2006), *Measures of Central Bank Autonomy: Empirical Evidence for OECD, Developing, and Emerging Market Economies*, WP/06/228, IMF Working Paper

Batini, Nicoletta & Haldane, Andrew G. (1998), *Forward-looking Rules for Monetary Policy*, Working Paper, No. 91, Bank of England

Batini, Nicoletta & Nelson, Edward (2002), *The Lag From Monetary Policy Actions to Inflation: Friedman Revisited*, External MPC Unit Discussion Paper No. 6, Bank of England

Bernanke, Ben S. & Woodford, Michael (1997), *Inflation Forecasts and Monetary Policy*, Journal of Money, Credit and Banking, Vol. 29, No.4, pp. 653-684

Bernhardsen, Tom, Eitrheim, Øyvind, Jore, Anne Sofie & Røisland, Øistein (2004), *Real-time Data for Norway: Challenges for Monetary Policy*, No. 26/2004, Discussion Paper Series 1: Studies of the Economic Research Centre, Deutsche Bundesbank

Blinder, Alan S. (2006), *The Case Against the Case Against Discretionary Fiscal Policy*, in Kopcke, Richard W., Tootell, Geoffrey M. B. & Triest, Robert K., ed. (2006), *The Macroeconomics of Fiscal Policy*, MIT Press, Massachusetts

Cayen, Jean-Philippe & van Norden, Simon (2004), *The Reliability of Canadian Output Gap Estimates*, No. 29/2004, Discussion Paper Series 1: Studies of the Economic Research Centre, Deutsche Bundesbank

Cukierman, Alex (1992), *Central Bank Strategy, Credibility, and Independence: Theory and Evidence*, MIT Press, Cambridge

Cukierman, Alex, Webb, Steven B. & Neyapti, Bilin (1992), *Measuring the Independence of Central Banks and its Effect on Policy Outcomes*, The World Bank Economic Review, Vol. 6, No. 3, pp. 353-398

Culbertson, John M. (1960), *Friedman on the Lag in Effect of Monetary Policy*, The Journal of Political Economy, Vol. 68, No. 6

Eijffinger, Sylvester C.W. & De Haan, Jakob (1996), *The Political Economy of Central-Bank Independence*, No. 19, Special Papers in International Economics, Princeton University

Friedman, Milton (1972), *Have monetary policies failed?*, The American Economic Review, Vol. 62, No. 1/2 (Mar. 1, 1972), pp. 11-18

Friedman, Milton (1968), *The Role of Monetary Policy*, The American Economic Review, Vol. 58, No. 1

Friedman, Milton (1961), *The Lag in Effect of Monetary Policy*, The Journal of Political Economy, Vol 69, No. 5, pp. 447-466

Friedman, Milton (1960), *A Program For Monetary Stability*, The Millar Lectures, Number Three, Fordham University Press, New York City

Fuhrer, Jeffrey C & Moore, George R (1995), *Forward-looking Behavior and the Stability of a Conventional Monetary Policy Rule*, Journal of Money, Credit and Banking, Vol. 27, pp. 1060-1070

Gerberding, Christina, Worms, Andreas & Seitz, Franz (2004), *How the Bundesbank really conducted monetary policy: An analysis based on real-time data*, Discussion paper 2004:25, Series 1: Studies of the Economic Research Centre, Deutsche Bundesbank

Gordon, Robert A. (1965), *Review: [untitled]*, The American Economic Review, Vol. 55, No. 1/2, pp. 236-238

Graboyes, Robert F. & Humphrey, Thomas M. (1990), *Wicksell's Monetary Framework and Dynamic Stability*, Working Paper 90-7, Federal Reserve Bank of Richmond

Hansson, Jesper, Johansson, Jesper & Palmqvist, Stefan (2008), *Varför behöver vi mått på underliggande inflation?*, Penning- och valutapolitik, Nr. 2/2008

Hendershott, Patric H. (1966), *The Inside Lag in Monetary Policy: A Comment*, The Journal of Political Economy, Vol. 74, No. 5, pp. 519-523

Herrmann, Heinz, Orphanides, Athanasios & Siklos, Pierre L. (2005), *Real-Time Data and Monetary Policy*, The North American Journal of Economics and Finance, Vol. 16, Issue 3, pp. 271-276

Ingves, Stefan (2011), *Flexible Inflation Targeting in Theory and Practice*, speech available via < http://www.riksbank.com/templates/Page.aspx?id=47023> [2011-05-12]

Jonung, Lars (1990), *Knut Wicksell*, in Jonung, Christina (ed.) & Ståhlberg, Ann-Charlotte (ed.) (1990), *Ekonomporträtt. Svenska ekonomer under 300 år.*, SNS Förlag, Stockholm

Kamada, Koichiro (2005), *Real-Time Estimation of the Output Gap in Japan and its Usefulness for Inflation Forecasting and Policymaking*, The North American Journal of Economics and Finance, Vol. 16, Issue 3, pp. 309-322

Kilponen, Juha & Leitemo, Kai (2008), *Model Uncertainty and Delegation: A Case for Friedman's k-Percent Money Growth Rule?*, Journal of Money, Credit and Banking, Vol. 40, Issue 2-3, pp. 547-556

McCallum, Bennett T. (2000), *Alternative Monetary Policy Rules: A Comparison with Historical Settings for the United States, the United Kingdom and Japan*, Working Paper 7725, National Bureau of Economic Research

McCallum, Bennett T. (1993), *Discretion Versus Policy Rules in Practice: Two critical points – A Comment*, Carneige-Rochester Conference Series on Public Policy, Vol. 39, pp. 215-220

McCallum, Bennett T. (1990), *Could a Monetary Base Rule Have Prevented the Great Depression*, Journal of Monetary Economics, Vol. 26, No. 1, pp. 3-26

McCallum, Bennett T. (1988), *Robustness Properties of a Rule for Monetary Policy*, Carnegie-Rochester Conferences Series on Public Policy, Vol. 29, pp. 173-203

Nyman, Christina (2010), *An Indicator of Resource Utilisation*, Economic Commentaries, No. 4 2010, The Riksbank

Orphanides, Athanasios (2007), *Taylor Rules*, FEDS 2007-18, Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C.

Orphanides, Athanasios (2003), *Historical Monetary Policy Analysis and the Taylor Rule*, Journal of Monetary Economics, Vol. 50, No. 3, pp. 605-631

Riksbank (2011a), *Monetary Policy Report: February 2011*

Riksbank (2011b), *Repo rate, deposit and lendign rate*, database available at the Riksbank's website <http://www.riksbank.com/templates/stat.aspx?id=17184>, [2011-02-20]

Riksbank (2010), *Monetary Policy Report: February 2010*

Riksbank (2009), *The Monetary Base – The Riksbank Changes Statistical Definition*, PM, 2009-04-16, available at <http://www.riksbank.se/templates/Page.aspx?id=31305> [2011-02-22]

Riksbank (2008a), *Monetary Policy Report 2008:2*

Riksbank (2008b), *The Riksbank to Phase Out the CPIX Inflation Measure*, No. 24/2008, Press Release

Riksbank (2006), *Inflationsrapport 2006:2*

Riksbank (2002), *Inflationsrapport 2002:1*

Riksbank (2000), *Inflationsrapport 2000:2*

Riksbank (1993), *The Riksbank's Target for Monetary Policy*, Press release, No. 5 1993

Romer, Christina & Romer, David (2002), *The Evolution of Economic Understanding and Postwar Stabilization Policy*, Federal Reserve Bank of Kansas City

Snyder, Carl (1935), *The Problem of Monetary and Economic Stability*, Quarterly Journal of Economics, Vol. 49, No. 2, pp. 173-205

Statistics Sweden (2011a), *Inflation Rate According to CPI*, data available via <http://www.scb.se/Pages/TableAndChart____284158.aspx> [2011-02-26]

Statistics Sweden (2011b), *CPIX, annual changes*, data available via <http://www.scb.se/Pages/ProductTables____33793.aspx> [2011-03-02]

Statistics Sweden (2011c), *CPIF, annual changes*, data available via <http://www.scb.se/Pages/ProductTables____33793.aspx> [2011-03-02]

Statistics Sweden (2011d), *GDP Quarterly 1993-2010:4*, available via <http://www.scb.se/Pages/ProductTables____22932.aspx> [2011-03-02]

Statistics Sweden (2011e), *Financial Market Statistics, December 2010*, available at <http://www.scb.se/Pages/ProductTables____37284.aspx> [2011-02-22]

Statistics Sweden (2010), *Nationalräkenskaper, kvartals- och årsberäkningar*, available at <http://www.scb.se/Pages/TableAndChart____219331.aspx> [2011-02-22]

Statistics Sweden (2008), *Consumer Price Index (CPI) August 2008: Higher Inflation but July Adjusted Downwards*, Press release, No. 2008:234

Statistics Sweden (1999:4-2011:1), *Gross domestic product/Quarterly YYYY:Q*

Svensson, Lars E O (2008), *Transparency under Flexible Inflation Targeting: Experiences and Challenges*, Sveriges Riksbank Economic Review, 1/2009, pp. 5-44

Taylor, John B. (2000), *Reassessing Discretionary Fiscal Policy*, Journal of Economic Perspectives, Vol. 14, No. 3, pp. 21-36

Taylor, John B. (1998), *A Historical Analysis of Monetary Policy Rules*, Working Paper 6768, National Bureau of Economic Research

Taylor, John B. (1993), *Discretion versus Policy Rules in Practice*, Carnegie-Rochester Conference Series on Public Policy, 39, pp. 195-214

Tson Söderström, Hans (2008), *Stabiliseringspolitik*, Pocketbiblioteket Nr. 31, SNS Förlag, Stockholm

Wetterberg, Gunnar (2009), *Pengarna & makten: Riksbankens historia*, Atlantis, Stockholm

Wicksell, Knut (1936), *Interest and Prices: A Study of the Causes Regulating the Value of Money*, Macmillan, London

Woodford, Michael (2001), *The Taylor Rule and Optimal Monetary Policy*, The American Economic Review, Vol. 91, No. 2, pp. 232-237

Öberg, Svante (2010), *Potentiell BNP, resursutnyttjande och penningpolitik*, speach available at < http://www.riksbank.se/templates/Page.aspx?id=45066> [2011-01-24]