Authors: Arvid Eriksson, 21560 *
Lisa Wimmerstedt, 21479 **

Stockholm School of Economics
Department of Economics

THE OPTIMAL INFLATION TARGET WITH RESPECT TO SWEDISH UNEMPLOYMENT

Abstract:
The rise in unemployment experienced by Sweden in recent decades is assumed to be uncorrelated with the low rate of inflation. The generally accepted theory of a long-run vertical Phillips curve has lately been questioned by studies that show that a long-run trade-off between inflation and unemployment may exist at low levels of inflation. This is due to the fact that people choose to ignore, or not to fully take into account, inflation at low levels. The concept is called 'near-rationality'. Our thesis examines whether a long-run effect exists and what the optimal inflation target for Sweden is, taking into account the welfare costs of inflation and unemployment. We find that there is evidence of a long-run trade-off between inflation and unemployment and that, on this basis, it would be beneficial to increase the target inflation rate to between 2.5 and 2.8 percent from the 2 percent target being pursued today.

Course 659. Degree Project in Economics
Bachelor's Thesis
Spring 2011

Supervisor: Kelly Ragan
Examiner: Örjan Sjöberg

* 21560@student.hhs.se
** 21479@student.hhs.se

Table of Contents

1. Introduction

In 1993, the Central Bank of Sweden, Sveriges Riksbank, decided that its main purpose was to "maintain price stability" (Sveriges Riksbank, 2010a). The result was that, since 1995, Sveriges Riksbank has set an inflation target of 2 percent.

> "It should be so low that no one takes it into account, but it should be sufficiently high to provide buffer against deflation, that is a decrease of the general price level, since this might cause problems." (Sveriges Riksbank, 2010b)

While monetary policy has been focused on keeping prices stable, unemployment has risen dramatically in Sweden. In the 1970s, the average unemployment rate was around 2 percent. In the 1980s it rose to approximately 2.5 percent. At the beginning of the 1990s, unemployment started rising dramatically and averaged over 6 percent for the decade. Today (March 2011), Sweden has an unemployment rate of 8.1 percent (Statistics Sweden, 2011).

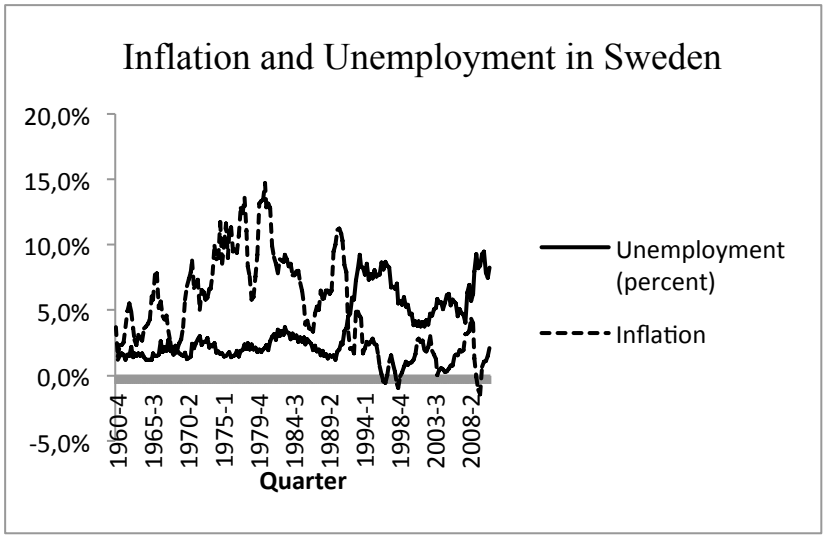

Figure 1. (Statistics Sweden)

Many economists believe that the relationship between inflation and unemployment is temporary and that inflation has no long-term effect on unemployment. However, some recent studies question this. If there is in fact a long-run relationship, this means that the inflation target might have an impact on unemployment. While 2 percent may be an appropriate inflation target in terms of GDP and growth, this might not be the optimal level for minimizing unemployment.

In our opinion, unemployment is one of today's biggest economic problems – not just in Sweden, but in many of the world's other major economies. The inflation target now being pursued in Sweden relies on the assumption that there is no long-term relationship between unemployment and inflation. However, if there were long-term effects, the current inflation target would have to be reevaluated.

1.1. Purpose

Based on these concerns about unemployment and inflation, the purpose of this thesis is to investigate what the optimal inflation target in Sweden would be when taking unemployment into account.

2. Background

2.1 Low Inflation and Low Unemployment

Few would argue that society should strive for a high level of unemployment, given the large costs it imposes on society. It is not quite so clear, however, why we should aim for a low level of inflation. A general mistake is that people think they are worse off when inflation is high since prices are increasing. But just as prices increase, wages increase as well. The truth is that there are both costs and benefits of inflation. The costs are usually divided into the costs of expected inflation and the costs of unexpected inflation. Since our main interest is in whether the inflation target has been set at the right level, we will not explore the details of the costs of unexpected inflation. Worth mentioning, though, is that a higher inflation target would probably lead to higher variability in actual inflation and hence a greater risk of unexpected inflation.

One cost of expected inflation is caused by frequent withdrawals from the bank due to inflation. When inflation is high, there is a cost associated with holding cash. This will lead to more frequent withdrawals from the bank. The increased amount of transactions will impose a cost on individuals as well as banks. Another cost of inflation is called *menu costs* (Mankiw, 2009). This means that, with high inflation, companies will have to change their prices more often. There is a cost attached to setting new prices, printing new catalogues and informing customers about those new prices. Furthermore, it is impossible to change prices continuously. Most companies cannot set new prices daily and some firms reevaluate their prices only once a year. This means that it is impossible to keep the relative prices constant throughout the year. An additional cost of high inflation is taxes. Individuals have to pay tax on, for instance, capital gains, where inflation is not taken into account. This means paying taxes on money that does not increase the individual's relative wealth. Another

significant inconvenience with inflation is that financial measures have to be regularly recalculated for accurate comparison. This creates difficulties in areas such as financial planning.

One of the main arguments for the benefit of inflation is the rigidity of nominal wages. While increased demand for workers leads to higher wages, an excess in the supply of workers might not result in wage cuts. Inflation gives employers the possibility to cut relative wages while keeping nominal wages constant. This leads to an increased flexibility in the labor market, since the equilibrium wage can be reached without having to lower the nominal wages. See, for example, Akerlof, Dickens and Perry (1996).

Some inflation is also important in stimulating the market. Inflation makes it more attractive to spend money rather than to hold cash.

Detailed research on the welfare costs of inflation is beyond the scope of this thesis. However, we will briefly go through the main ideas. The welfare cost of inflation can be seen as the loss to society due to inflation. Several models have been developed. Bailey (1956) and Friedman (1969) see inflation as a tax on money balance and calculate the deadweight loss due to inflation. In more recent papers, Lucas (2000), Lagos and Wright (2005) and Chiu and Molico (2010) develop models which explore the issue of how much consumption individuals would be willing to sacrifice in order to have price stability. Their idea is that liquidity is affected by inflation due to the decreased willingness to hold cash and that this disturbs consumption decisions.

The findings differ across time and models. Fisher (1981) finds that the cost of 10 percent inflation compared to price stability is around 0.3 percent of GDP. Lucas (1981) argues that the same cost is 0.45 percent of GDP. Cooley and Hansen (1989) find that the cost is 0.4 percent of GNP. Lagos and Wright (2005) are less conservative and approximate the cost to 3-4 percent of total consumption. Chiu and Molico (2010) calculate a cost of 0.62 percent of total consumption.

2.2 Phillips Curve – A Trade-off Between Inflation and Unemployment?

The theoretical relationship between inflation and unemployment is a large field of research. The constant flow of new theories has been reflected in monetary policy throughout the world's largest economies. Behind many of these theories are the elite of macroeconomics, many of them Nobel laureates.

The first step towards developing the now well-known Phillips curve was taken in 1958. Phillips (1958) found an empirical relationship between the rate of change of money wage and unemployment. The framework for his hypothesis was that, faced with a low rate of unemployment, employers would bid wages up to compete for the best workers. Conversely, in a setting where unemployment is high, employers would have no incentive to increase wages. This would imply that there is a relationship between the rate of change of money wage and unemployment. Phillips finds empirical evidence from the U.K. for the period 1861-1957 of the existence of a non-linear negative relationship between unemployment and the rate of change of money wage. This is the origin of what would later be called the Phillips curve.

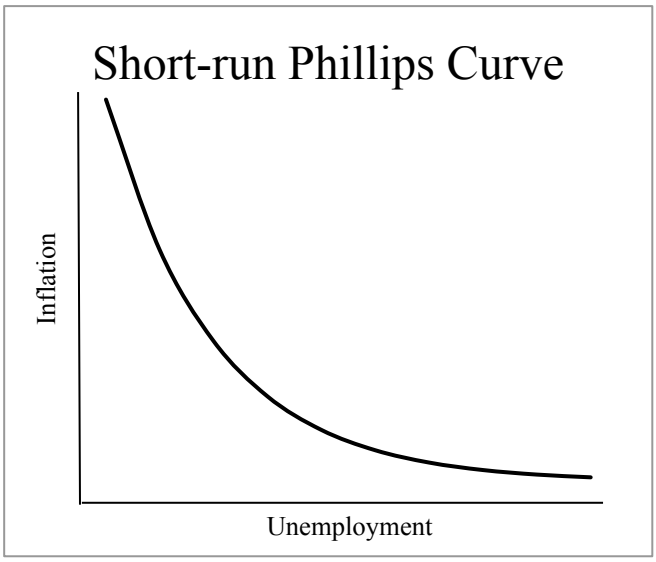

Figure 2. (Mankiw 2009 p. 394)

Two years' later, Samuelson and Solow (1960) find similar results for the United States. However, based on their data, they are of the opinion that the relationship is linear. Their conclusion is that there is also a trade-off between rising prices and unemployment in America. This would mean that it is not possible to have wage stability and a low rate of unemployment at the same time.

At the end of the 1960s, Friedman (1968) states that the relationship between inflation and unemployment is temporary and that there is no permanent trade-off. This implies that monetary policy cannot control the long-run rate of unemployment. Intuitively, Friedman explained that when money grows and this has not been expected, interest rates fall. This leads to increased income and spending, which will result in both higher output and employment. However, nominal prices tend to rise faster than wages, which will mean that real wages are actually declining. Workers

are more likely to see their nominal wage increase as a real increase. This will lead to excess employment and, as soon as workers realize that their real wage is actually falling, unemployment will return to the same rate as before.

Parallel to Friedman's work, Phelps (1967, 1968) also argues for a temporary trade-off. One of his main findings is that inflation expectations matter. Inflation is related to both expectations about inflation and to unemployment. The importance of inflation expectations can be explained by the fact that prices are not regularly adjusted. This means that wages have to be set based on expectations about inflation. The implications are that unemployment is in fact related to the difference between current inflation and expected inflation. Since it is not possible to keep this difference constant, the relationship between inflation and unemployment has to be a temporary one.

These findings would imply that the Phillips curve is negatively sloping in the short-run, but vertical in the long-run. This has been the belief for many years. Although Phelps is one of the founders of the vertical Phillips curve, he discussed the possibility that, at low rates of inflation, it could in fact be negatively sloped. The reason is that the expected wage increase would not have a one-to-one relationship with the current wage increase at low levels.

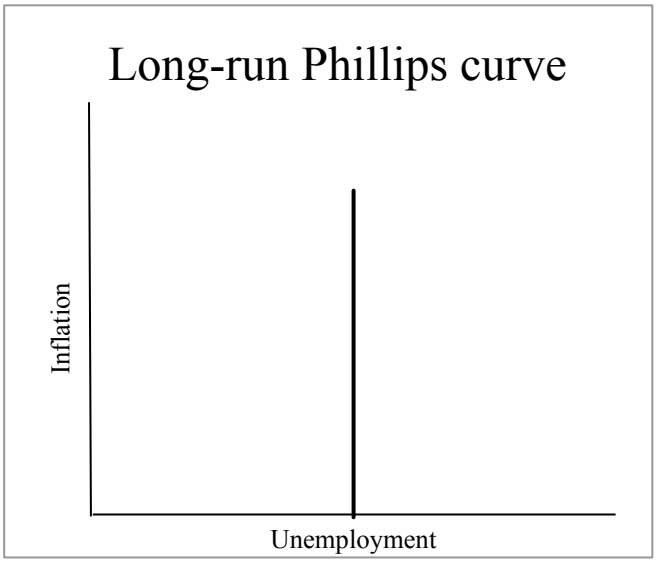

Figure 3. (Friedman 1968, Phelphs 1967,1968)

At the start of the 1970s, Lucas (1972) strengthened the evidence for the vertical Phillips curve. Friedman and Phelps used the theory of adaptive expectations when testing for the vertical Phillips curve. Lucas found that this would lead to a systematical error in the regressions that could result in a false long-run effect of unemployment on inflation. Lucas developed the theory of rational expectations. Behind the concept is the belief that people form their expectations based on all available information and not just on previous expectations. With this approach, Lucas was able to support and provide evidence for the long-run vertical Phillips curve.

Later studies have shown different results regarding the long-run effects of inflation on unemployment. An investigation of post-war data by King and Watson

(1994) found significant long-term trade-offs between inflation and unemployment. This discovery suggests a non-vertical long-term Phillips curve.

Further evidence against the theory of a long-run vertical Phillips curve was provided by Fair (2000). In his paper, he attempts to test the dynamics implied by NAIRU (Non-Accelerating Inflation Rate of Unemployment). This theory suggests that there is a natural rate of unemployment under which inflation will forever accelerate and over which inflation will decelerate. This is in line with the theory that no long-term change in unemployment can be achieved with a new level of inflation. The conclusion he draws is that the NAIRU dynamics are inaccurate. He argues that lowering the unemployment rate only has a modest effect on long-term price levels.

2.3 The Theory of Near-Rationality

We will now explain the mechanisms on which we build our paper. The theory of near-rationality relies on the assumption that people are not always fully rational. This concept was first introduced by Akerlof and Yellen (1985). People sometimes choose to simplify their decision-making by not taking every detail into account. This means that, in this case, individuals may ignore inflation at low levels of inflation. Akerlof, Dickens and Perry (2000), the authors are henceforth referred to as ADP, show in their paper that firms put different weights on inflation depending on the rate of inflation. When inflation is high, virtually all companies take it into account when determining prices and wages. But at low or moderate levels of inflation, some firms will either ignore inflation or take it into account only partially. This can be explained by the fact that people do not act rationally towards inflation, possibly because the decision-making is not one in which every aspect of a problem is weighed and dealt with equally, and that workers perceive inflation in a way that differs from what economists expect.

The first issue of why inflation is not always dealt with rationally can be explained by a behavior called *editing* and is investigated by Kahneman and Tversky (1979). They show that decision makers keep a small number of variables in their mind and disregard those that are not as important for the decision. This behavior implies that, when making a decision, not everything that matters for that decision is included on the basis that it may be too time consuming and costly to do so. There is no real data available on how many wage and/or price setters disregard inflation, but

one of the main goals for the Swedish central bank is for companies and citizens to edit away inflation:

> "The Riksbank has chosen an inflation target of 2 per cent. There is no exact science that says what is the right level for an inflation target. It should be so low that no one takes it into account but it should be sufficiently high to provide buffer against deflation, that is a decrease of the general price level, since this might cause problems. This is why the Riksbank and other central banks have chosen a target of 2 per cent." (Sveriges Riksbank, 2010b)

This statement, taken from the goals of the Swedish central bank, clearly indicates that the bank does not want companies or citizens to feel the need to include inflation in their forecasts. An average inflation rate of 1.2 percent between 1995 and 2007 (the time the inflation target has been in effect) is also an indication of the priority the central bank places on maintaining a stable price level. According to ADP, this will in turn lead to some firms disregarding inflation up to the point when it becomes too costly for them to ignore it.

In terms of the second issue of how workers perceive inflation, it has been shown through previous studies that there are large differences in the way economic scientists expect people to act or react to inflation, and what people actually do in practice. Shiller (1996) published a paper based on surveys about inflation conducted among random samples of people and compared their answers to those given by economists. The results show that the average salary taker has a much more pessimistic view of how inflation affects his or her salary than economists. This can have a positive effect on workers' productivity: A company can offer wage increases that do not match inflation and this will still increase job satisfaction and, therefore, productivity. Further evidence that workers' perceptions are different from the fully rational is presented in a paper by Shafir, *et al.* (1997). Their paper examines the underlying psychological reasoning behind the term *Money Illusion*. This is where people think of money in nominal rather than real terms. They find that even if people understand the real consequences of inflation, they often think about economic transactions in nominal terms as well. The *Money Illusion* arises from the fact that there is a slight bias towards evaluating economic transactions in nominal rather than real terms.

Akerlof and Yellen (1985) show that not taking all the relevant factors into account for decision-making can create small losses for individuals, but can have large effects on social welfare. In this context, not taking inflation expectations fully into account will matter for the level of unemployment. At very low levels of inflation, a large proportion of people might choose to ignore inflation. Nevertheless, inflation at these levels is not high enough to impact unemployment. At higher levels of inflation, some actors may still ignore or not fully consider its effects, even though these levels might actually matter for the level of unemployment. So we are at a level where there are real economic implications in ignoring inflation, and yet the cost for some people of ignoring it is still negligible. At even higher levels of inflation, however, it will be too costly for actors to continue disregarding its impact. This implies that unemployment will be unaffected when everyone take inflation fully into account.

The implications for this theory are that there are levels of inflation where it is possible to maintain a level of unemployment which is below what the vertical Phillips curve would predict. This is a level where inflation is low enough for a proportion of the population to ignore it, but high enough to matter in an economic sense. This would produce a hump-shaped long-run Phillips curve, as shown in figure 4.

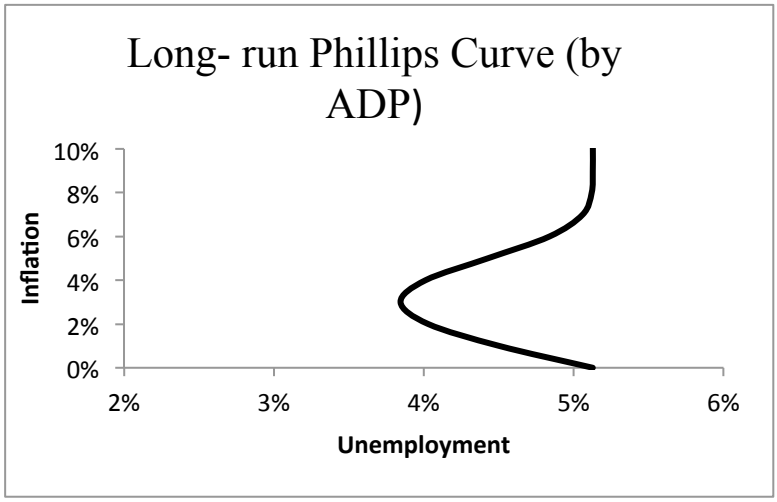

Figure 4. (Akerlof, Dickens and Perry 2000)

In 2000, ADP found evidence of the hump-shaped Phillips curve in the U.S. They used over 125 different specifications on the long-run Phillips curve, and found that the level of inflation that would minimize unemployment is between 1.5 and 4.0 percent.

Lundborg and Sacklén (2006) carried out the same analysis as ADP, but for Swedish data between 1960 and 2000. Their results are similar. Their conclusion is that Sweden would benefit from a higher inflation target. Their results are based on 24 different specifications on the long-run Phillips curve and they find that

unemployment would decrease by several percentage points if the inflation were set to 4 percent (in contrast to today's 2 percent).

Bryan and Palmqvist (2005) have tested the theory of near-rationality with detailed survey data from both the U.S. and Sweden. They find that for the U.S. there is no proof of near–rationality, on the contrary, rather there is evidence against it. As discussed above, if inflation is high all actors should take it into account and expectations should be very close to actual inflation. When inflation then decreases there should be an increasing number of respondents that under-predict or disregard inflation. For the U.S. the data show characteristics that run counter to this theory, but for Sweden the theory holds true in a broad sense. However, Bryan and Palmqvist argue that the increasing proportion of households that under-predict or disregard inflation in Sweden when it decreases is due not to near–rationality, but to the clear views and messages coming from the central bank. The point they make is that when confidence is high in a central bank whose views have proven reliable in previous years, a low and stable inflation rates leads people to expect zero inflation.

There are differences in Swedish and U.S. data that may be relevant here. For example, certain differences exist between how wages are set in America compared to Sweden. ADP uses a wage-efficiency framework which is not totally applicable to the Swedish labor market, where collective bargaining is more widespread. Even so, all labor markets contain both unilateral wage setting and wage bargaining. Studies by Agell and Lundborg (1995, 2003) suggest that efficiency wages have some relevance when it comes to wage setting in Sweden.

3. Delimitations

Given the purpose of this thesis, and based on current knowledge within the area, it is worth investigating the implications of the theory of near-rationality on the Phillips curve, as first proposed by ADP, in order to see what this means for the inflation target. Lundborg and Sacklén (2006) find that the Phillips curve is non-vertical in Sweden, and their research suggests it would be optimal to change the inflation target in order to minimize unemployment. This investigation can be taken a step further by looking at the trade-off between lower unemployment and higher inflation since, like unemployment, inflation also has social costs.

The main question and sub-questions are:

- Based on the theory of near-rational behavior, what is the optimal inflation target in Sweden when considering the cost of inflation relative to the cost of unemployment?
    - Is there evidence of near-rational behavior in Sweden? (Sub-question 1)
    - What would be the optimal level of inflation to minimize unemployment? (2)
    - What is the GDP cost of inflation? (3)
    - What is the GDP cost of unemployment? (4)
    - What is the optimal inflation target when taking these costs into account? (5)

4. Empirical Method

4.1 Method

We will run a regression of unemployment on inflation to test for the long-run Phillips curve. We will use the same method as first proposed by ADP. The main difference between this regression and the linear Phillips curve is that the coefficient on inflation expectations is allowed to vary with the level of inflation. The long-run Phillips curve is derived mathematically in the ADP approach and is left to the interested reader. The regression to be estimated is as follows:

$$\pi = d + a * u + \phi\left(D + E\pi_{L,t}^{2}\right) * \pi_e + k_i X_i + \varepsilon \qquad \text{(a)}$$

The coefficients to be estimated are d, a, D and E. X represents a number of dummies and are not important for our further analysis – although they do matter for avoiding bias in the estimated coefficients. $\phi(\,)$ is the standard normal cumulative distribution (with mean 0 and standard deviation 1). The coefficient on inflation expectations may at first look slightly intimidating. However, what we are seeking to capture is that a fraction of the population takes inflation expectations into account at certain levels of

inflation. A fraction would have to be between zero and one. When using the cumulative normal distribution we guarantee that the coefficient on inflation expectations will be between zero and one. In this cumulative normal function we will have a constant and a coefficient on past inflation. Past inflation $\pi_{L,t}$ represents previous levels of inflation. For high levels of inflation, the coefficient $\phi\left(\mathrm{D} + \mathrm{E}\pi_{\mathrm{L,t}}^{2}\right)$ will become one, that is, everyone take inflation fully into account. For lower levels of inflation, however, the coefficient might be less than one and support near-rational behavior. If the coefficient on past inflation (E) is significant, we will find evidence of near-rational behavior and the level of inflation will be a factor in how people form their expectations. This will give us the answer to sub-question 1. The coefficients will be estimated using non-linear least squares.

We will use three different methods for constructing the value $\pi_{L,t}$, which represents the past inflation taken into account when estimating inflation expectations. The first method (i) uses a moving average. The parameter λ will be estimated in the regression. This allows recent levels of inflation to have greater importance than older ones.

$$\pi_{\mathrm{L,t}} = \frac{\sum_{\mathrm{i=1}}^{\mathrm{I}}(1\text{-}\mathrm{i}\lambda)\pi_{\mathrm{t\text{-}i}}}{\sum_{\mathrm{i=1}}^{\mathrm{I}}(1\text{-}\mathrm{i}\lambda)} \qquad \text{(i)}$$

The second measurement for past inflation that we will use is an equal weighted average of previous levels of inflation (ii).

$$\pi_{\mathrm{L,t}} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \frac{1}{\mathrm{n}} \pi_{\mathrm{t\text{-}i}} \qquad \text{(ii)}$$

The third specification (iii) is a geometrically declining average. We have simplified the analysis by assuming that each year carries the same weight and that the next year has half the importance of the previous year.

$$\pi_{L,t} = \sum_{i=1}^{n} g_i \pi_{t-i} \qquad \text{(iii)}$$

$$\sum_{i=1}^{n} g_i = 1 \qquad 0 \leq g_i \leq 1$$

All three specifications will be calculated with 16 periods (n=16).

With the coefficients estimated in the regression, we are able to calculate the Phillips curve. To find the long-run unemployment rate in the model, we set past inflation, present inflation and inflation expectations to the same level ($\pi_{L,t} = \pi = \pi^e$). From that we can calculate the unemployment rate that is related to different levels of inflation. We can also determine the level of inflation that minimizes unemployment and find an answer to sub-question 2.

The next step is to calculate the cost of inflation and the cost of unemployment. From previous research we can conclude that the major cost of inflation is a lower level of GDP. We will therefore approximate the costs of inflation by regressing GDP on inflation. The cost of unemployment is rather more difficult to approximate. The most common way of measuring the social cost of unemployment is to see what effect it has on GDP. This may not be the most precise way of measuring the cost of unemployment, because it can be argued that the effects of unemployment on GDP are larger than the lost production. This loss in productivity comes from, among other things, situations where unemployed workers take jobs that they are overqualified for and the gap between getting fired and finding a new job. The money provided under social security arrangements for these individuals is only a small part of the cost of high unemployment. Arguments have been made by Feldstein (1978) that using the drop in GDP can both over- and understate the cost of unemployment, depending on the current situation on the labor market, but this drop does at least give a general idea of the costs associated with unemployment. By collecting quarterly data on GDP, workforce growth, technological advances in productivity, exchange rates, market rates, unemployment and inflation, we regress GDP on these variables. We also control for the shocks to the economy mentioned below. Other factors may be relevant when trying to determine the development of GDP, but these are assumed to have such small effects that we have chosen not to include them. Our aim is to use a simplified model that provides a more general idea of how unemployment affects GDP growth. Estimates that are not significant can then be excluded to simplify the relationship. The variables that are not expressed as percentages (such as GDP) will be used in logarithmic form.

$$\ln GDP = \beta_0 + \beta_1 * inflation + \beta_2 * inflation_{t-1} + \beta_3 * unemployment + \beta_4 * unemployment_{t-1} + \beta_5 * (inflation)^2 + \beta_6 * (unemployment)^2 + \beta_7 * \ln GDP_{t-1} + \alpha_i Z_i + \gamma_i Z_i Z_j + k_i X_i + \quad \text{(b)}$$

Where α, β, k, γ are coefficients to be estimated, Z is other variables to be controlled for, and X is dummies for demand shocks. The coefficients on inflation $\beta_1, \beta_2, \beta_5$ will give us the cost of inflation in terms of GDP – in other words, the answer to sub-question 3. In the same way, the coefficients on unemployment $\beta_3, \beta_4, \beta_6$ will give us the cost of unemployment and the answer to sub-question 4.

By using the corresponding rates of unemployment and inflation we get from the long-run Phillips curve, we can minimize the cost of inflation and unemployment. This will give us the optimal inflation target with respect to a long-term relationship between inflation and unemployment. By extension this gives us a socially optimal level of inflation with respect to GDP and the answer to sub-question 5.

In both of the regressions, we will use a Hodrick-Prescott filter as proposed by Hodrick and Prescott (1997). They propose a way of dividing time series into two parts, a smoothly varying trend component and a cyclical component, often referred to as business cycles. The regression can then become less sensitive to short-term fluctuations and, in this way, capture the long-run variations.

4.2 Empirics

In the first regression (a), the following variables will be used: Unemployment, inflation and expected inflation. All data were gathered on a quarterly basis ranging between 1979:1 and 2007:4.

In regression (b), in addition to unemployment and inflation, the following variables are included: GDP, productivity, size of labor force, exchange rates and Swedish market rates. All data were gathered on a quarterly basis ranging between 1987:1 and 2007:4.

In both regressions we will have to use dummies to control for different supply shocks as well as for the quarters. The dummies are mainly related to price shocks in oil. All specifications for the data and the dummies are listed in the appendix.

The sources can be assumed to be reliable, but errors can still appear. Further, inflation expectation is a problematic variable to capture and should be treated with caution. However, we feel that this measure is a more appropriate one than adaptive expectations, which impose greater assumptions. Moreover, Lucas (1972) found that, in contrast to rational expectations, using adaptive expectations could give a false long-term effect due to systematic errors.

5. Analysis and Results

5.1 Analysis Regression (a)

The results from regression (a) are shown in table 1. The coefficient on unemployment, a, is negative – as we would expect. The size of the other coefficients does not give us any direct economic interpretation. The first important question is whether our coefficient E is significant and shows evidence of near-rational behavior, that is, that the coefficient on inflation expectations depends on the past levels of inflation. We find that it is significant in all three specifications at a 1 percent significance level. The inference from this is that the long-run Phillips curve might depend on the level of inflation.

Regression (a)

Specification of past inflation	(i)	(ii)	(iii)
d	0.00915	0.00911	0.00898
p-value	0.00	0.00	0.00
a	-0.15810	-0.14930	-0.14537
p-value	0.00	0.00	0.00
D	0.68306	0.59847	0.67561
p-value	0.00	0.00	0.00
E	209.14	230.58	231.00
p-value	0.00	0.00	0.00

Table 1. Regression (a)

Conclusion (1): There is evidence of near-rational behavior in Sweden since the coefficient E in the regression is significant.

By assuming constant inflation ($\pi_{L,t} = \pi = \pi^e$) at an equilibrium level of unemployment, we can calculate the long-run Phillips curve by changing the level of inflation and, from the equation, calculate the level of unemployment. We find three different Phillips curves depending on our specification of past inflation.

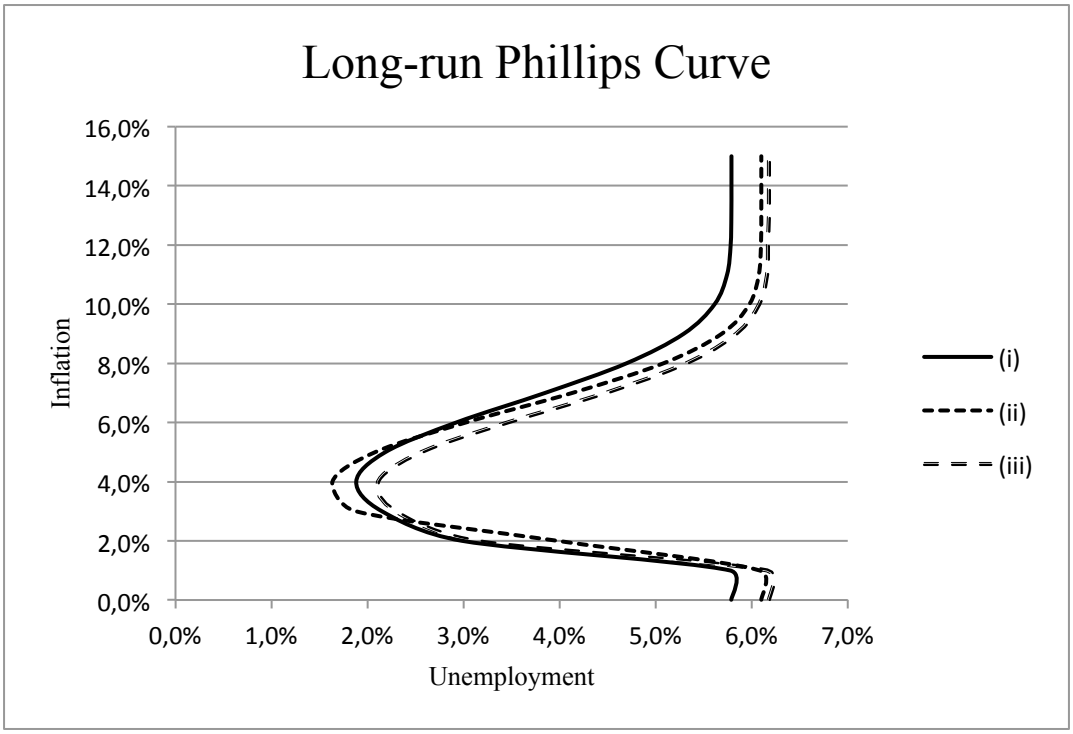

Figure 5

	(i)	(ii)	(iii)
Minimized unemployment	1.881%	1.624%	2.088%
Inflation at min. unemployment	3.950%	3.834%	3.764%

Table 2. Minimized level of unemployment

In all of the three specifications, we find a hump-shaped long-run Phillips curve. The minimizing levels of unemployment can be approximated from the Phillips curves and are shown in table 2. All of the three specifications show that the optimal level of inflation with respect to unemployment is between 3.5 and 4 percent.

Conclusion (2): The optimal inflation target with respect to unemployment would be between 3.5 and 4 percent in Sweden. This level of inflation would minimize unemployment.

5.1.1 Discussion (a)

Possible errors in this part of the analysis could be the assumption of normal distribution. Our results might change if we were to use a log-normal distribution instead. The log-normal distribution would still allow the coefficient on inflation expectations to vary between zero and one, but would not give a symmetric distribution of the coefficient. Furthermore, like ADP, we could have tried more specifications, that is, we could have used several lags of unemployment. We could have varied the number of periods used to construct the measure of past inflation, and we could have used several different measures. The analysis is highly dependent on how we specify past inflation. However, we were fortunate to get similar results in all of our three specifications, which would imply that the results are robust for the specification of past inflation.

5.2 Analysis Regression (b)

The second regression (b) estimates the effect that unemployment and inflation have on GDP. The regression contains the variables unemployment and inflation, both in their natural form, with lags and squared. Additional variables that are controlled for are size of labor force, productivity, exchange rates and market rate. Two lags for GDP are also added. The significant and relevant coefficients (that is, the ones regarding inflation and unemployment) at a 1 percent significance level are unemployment, with two lags and squared. Inflation is found to be significant together with a lag and squared inflation. The relevant results are shown in table 3.

Regression (b)

ln(GDP)	**Coefficient**	**P-value**
unemployment	-1.3147	0.000
inflation	-0.0794	0.000
unemployment (t-1)	2.6357	0.000
unemployment (t-2)	-1.3586	0.001
inflation (t-2)	0.0499	0.001
unemployment squared	0.1420	0.000
inflation squared	0.0839	0.002

Table 3. Regression (b)

In the model where unemployment and inflation are two of the variables to explain GDP, we find the cost of inflation and unemployment in terms of GDP. The percentage cost of unemployment and inflation, to the percentage of GDP, can be explained by the formula (from the regression with opposite signs, lags are added up together):

$$Cost\ to\ GDP = 0.0295 * inflation + 0.0376 * unemployment - 0.0839 * inflation^2 - 0.1420 * unemployment^2 \ (*)$$

The cost of inflation can be calculated with formula (*). The cost function is not linear and the marginal cost of inflation is decreasing. The cost of 1 percent inflation would be 0.03 percent of GDP. According to this model, the cost of 10 percent is 0.21 percent compared to price stability.

Conclusion (3): The cost of 10 percent inflation is estimated to be 0.21 percent of GDP.

The cost of unemployment is also non-linear and the marginal cost of unemployment is also decreasing. The cost of 1 percent unemployment in this context is 0.036 percent of GDP, and the cost of 10 percent unemployment is 0.23 percent.

Conclusion (4): The cost of 10 percent unemployment is estimated to be 0.23 percent of GDP.

With the costs and the Phillips curve in place, we are able to plot the long-run Phillips curve in a cost-inflation diagram. That is, we calculate the unemployment for different levels of inflation and use the corresponding values of inflation and unemployment in the function that describes cost to GDP. This allows us to see if the relationship between unemployment and inflation tells us something about the optimal inflation target. The results are shown below in figure 6.

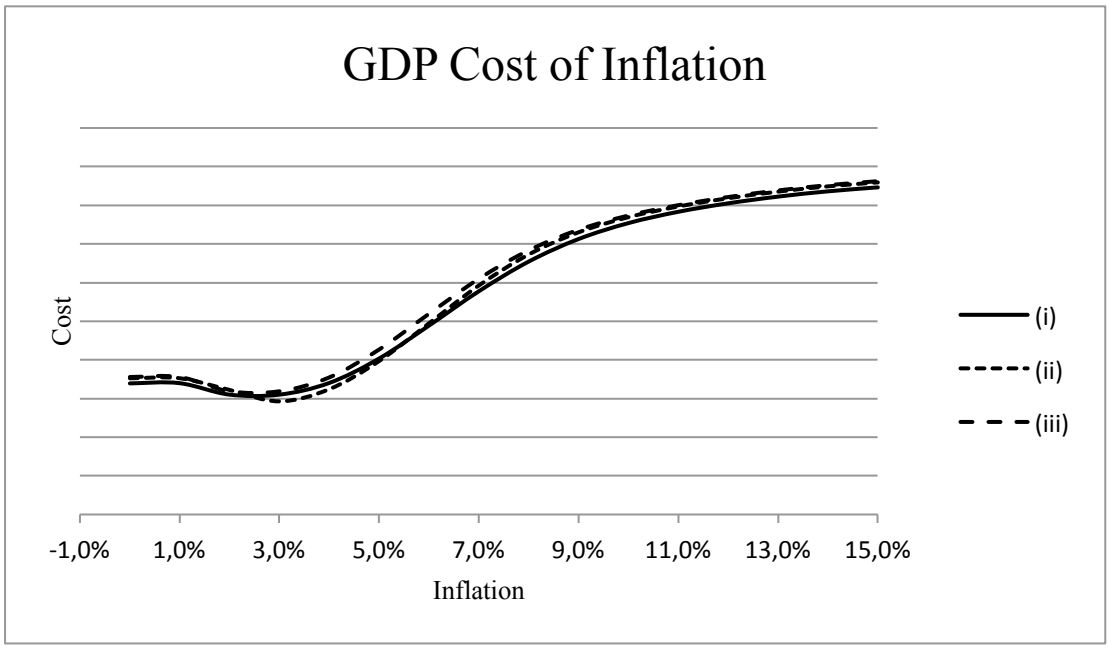

Figure 6

	(i)	(ii)	(iii)
Inflation at min. costs to GDP	2.53%	2.75%	2.52%

Table 4. Level of inflation that minimizes costs to GDP

We get a local minimum in all three specifications. The analysis shows that the optimal inflation target would be between 2.5 and 2.8 percent. This is higher than today's inflation target. However, it is not at the minimizing level of unemployment between 3.5 and 4 percent of inflation. This is due to the costs of inflation relative to the costs of unemployment.

At these optimal levels of inflation, the unemployment rate would be between 0.5 and 0.8 percent lower than at 2 percent inflation. However, the average inflation rate since the inflation target was implemented has been 1.2 percent. Allowing inflation to increase from 1.2 percent to between 2.5 and 3 percent would lead to an unemployment rate that is reduced by between 1.5 and 2.0 percentage points.

Conclusion (5): The optimal inflation target when taking unemployment into account would be between 2.5 and 2.8 percent. Changing the inflation target from 2 percent to close to 3 percent would decrease the rate of unemployment. However, it would not minimize the level of unemployment. The level found is the optimal level for GDP. This means that the benefits derived from increasing the inflation rate from 2 percent would be higher than the costs up to this optimal level.

5.2.1 Discussion (b)

The most critical part of this analysis is the risk of a biased coefficient on unemployment. Many factors that affect GDP are likely to be correlated with unemployment. We have tried to control for major variables such as market rate, size of labor force and exchange rates. The business cycle components are dealt with through the Hodrick-Prescott filter. However, it is not possible to control for all possible variables. All omitted variables that might have an effect on both GDP and unemployment are likely to reduce the coefficient on unemployment. That is, we see no variable that would decrease both GDP and unemployment, since decreased GDP is the result of lower production, which is in turn associated with higher unemployment. For our regression, this means that unemployment may not be as costly as predicted. The implications for our further analysis in this case is that

inflation is more expensive than unemployment and that the optimal inflation target we stated above is higher than the true optimal level of inflation.

However, another aspect to be considered is that the social costs of unemployment might be higher than the loss in GDP. Firstly, the money provided by the government to support the unemployed can, if unemployment is reduced, be invested instead in projects that have a larger positive effect on GDP than the amount invested. Secondly, there is a risk that unemployed workers suffer from loss of self-confidence that prevents them from reentering the work force. Finally, another situation in which the unemployed may find themselves is the one where they are left with no choice but to take a job that they are overqualified for. All of these cases would lead to a higher social cost of unemployment than estimated from the regression. This would mean that the optimal level of inflation we stated above would be lower than the true optimal level of inflation.

We acknowledge that there are many uncertainties involved in calculating the cost of unemployment. Nevertheless, we believe that our estimation is a plausible representation of the true cost of unemployment.

6. Conclusion

We find that the optimal inflation target in Sweden when seeking a balance between inflation and unemployment is between 2.5 and 2.8 percent. This finding is based on the observation that there is a long-term trade-off between inflation and unemployment as described in the theory of near-rational behavior. We also find, like Lundborg and Sacklén (2006), that the optimal inflation target to minimize unemployment would be just below 4 percent. However, there are social costs of both unemployment and inflation. We can conclude that the costs of inflation are non-linear and that the cost of 10 % inflation is around 0.21 percent of GDP. This is a low estimation in comparison with previous research, but not at all unreasonable. The cost of unemployment is also found to be non-linear. The cost of 10 % unemployment is estimated to 0.23 percent of GDP.

By calculating the costs to GDP at different levels of inflation and the corresponding level of unemployment, we can calculate the optimal level of inflation.

The results are instructive in the sense that they support previous research that claims that a higher inflation target would lower the long-run rate of unemployment. Whether this is due to the theory of near-rationality or the theory presented by Bryan and Palmqvist is not obvious, but the fact that actors disregard inflation at certain levels and that this has an effect on long-run unemployment is clear. However, this level of inflation is not optimal in a GDP context because of the costs of unemployment relative to the costs of inflation. Instead, the results indicate that the optimal inflation target would be somewhere between the 4 percent previously estimated and the current inflation target of 2 percent. This is important in several respects. One is that we find that the optimal inflation target with regard to the costs of inflation and unemployment differs from that pursued today. The Riksbank clearly states that there is no exact science behind the inflation target and that its main goal is to maintain price stability. Our results indicate that society could benefit from taking unemployment into account when setting the inflation target. Our findings also raise an interesting issue from the results of previous studies by ADP and Lundborg Sacklén: Our initial results are in line with theirs but, when we add the costs associated with their results, we arrive at an inflation target that is significantly lower.

We believe this topic is worth investigating further. A deeper analysis of what the costs and benefits would be in a monetary sense from changing the inflation target would generate an outcome that gives more tangible results. These results would then enable the discussion of whether the inflation target should be changed to be approached in a more concrete way. If it is possible to reduce Swedish unemployment with a modest rise in inflation that in the end reduces social costs, we see no reason why the inflation target should remain at the current level of 2 percent.

7. Reference List

Agell, J. & Lundborg, P. 2003, "Survey Evidence on Wage Rigidity and Unemployment: Sweden in the 1990s," *Scandinavian Journal of Economics,* vol. 105, no. 1, pp. 15-29.

Agell, J. & Lundborg, P. 1995, "Theories of Pay and Unemployment: Survey Evidence from Swedish Manufacturing Firms," *Scandinavian Journal of Economics,* vol. 97, no. 2, pp. 295-307.

Akerlof, G.A., Dickens, W.T. & Perry, G.L. 2000, "Near-Rational Wage and Price Setting and the Long-Run Phillips Curve," *Brookings Papers on Economic Activity,* , no. 1, pp. 1-44.

Akerlof, G.A., Dickens, W.T. & Perry, G.L. 1996, "The Macroeconomics of Low Inflation," *Brookings Papers on Economic Activity,* , no. 1, pp. 1-59.

Akerlof, G.A. & Yellen, J.L. 1985, "A Near-rational Model of the Business Cycle, with Wage and Price Intertia," *Quarterly Journal of Economics,* vol. 100, no. 5, pp. 823-838.

Bailey, M.J. 1956, "The Welfare Cost of Inflationary Finance," *The Journal of Political Economy,* vol. 64, no. 2, pp. pp. 93-110.

Bryan, M.F. & Palmqvist, S. 2005, *Testing near-rationality using detailed survey data*, Federal Reserve Bank of Cleveland, Working Paper: 0502.

Chiu, J. & Molico, M. 2010, "Liquidity, Redistribution, and the Welfare Cost of Inflation," *Journal of Monetary Economics,* vol. 57, no. 4, pp. 428-438.

Cooley, T.F. & Hansen, G.D. 1989, "The Inflation Tax in a Real Business Cycle Model," *American Economic Review,* vol. 79, no. 4, pp. 733-748.

Fair, R.C. 2000, "Testing the NAIRU Model for the United States," *Review of Economics and Statistics,* vol. 82, no. 1, pp. 64-71.

Feldstein, M.S. 1978, "The Private and Social Costs of Unemployment," *American Economic Review,* vol. 68, no. 2, pp. 155-158.

Fischer, S. 1981, "Towards an Understanding of the Costs of Inflation: II," *Carnegie-Rochester Conference Series on Public Policy,* vol. 15, pp. 5-41.

Friedman, M. 1969, *The optimum quantity of money and other essays,* MacMillan, Chicago.

Friedman, M. 1968, "The Role of Monetary Policy," *The American Economic Review,* vol. 58, no. 1, pp. pp. 1-17.

Hodrick, R.J. & Prescott, E.C. 2002, "Postwar U.S. Business Cycles: An Empirical Investigation" in *Long term trends and business cycles. Volume 2*, ed. T.C. Mills, Elgar Reference Collection. International Library of Critical Writings in Economics, vol. 149, Cheltenham, U.K. and Northampton, Mass.:, Elgar, distributed by American International Distribution Corporation, Williston, Vt, , pp. 390-405.

Kahneman, D. & Tversky, A. 1979, "Prospect Theory: An Analysis of Decision under Risk," *Econometrica,* vol. 47, no. 2, pp. 263-291.

King, R.G. & Watson, M.W. 1994, "The Post-war U.S. Phillips Curve: A Revisionist Econometric History," *Carnegie-Rochester Conference Series on Public Policy,* vol. 41, pp. 157-219.

Lagos, R. & Wright, R. 2005, "A Unified Framework for Monetary Theory and Policy Analysis," *Journal of Political Economy,* vol. 113, no. 3, pp. 463-484.

Lucas, R.E., Jr. 2000, "Inflation and Welfare," *Econometrica,* vol. 68, no. 2, pp. 247-274.

Lucas, R.E., Jr. 1981, "Discussion of: Stanley Fischer, 'Towards an Understanding of the Costs of Inflation: II.'," *Carnegie-Rochester Conference Series on Public Policy,* vol. 15, pp. 43-52.

Lucas, R.E., Jr. 1972, "Expectations and the Neutrality of Money," *Journal of Economic Theory,* vol. 4, no. 2, pp. 103-124.

Lundborg, P. & Sacklen, H. 2006, "Low-Inflation Targeting and Long-Run Unemployment," *Scandinavian Journal of Economics,* vol. 108, no. 3, pp. 397-418.

Mankiw, N.G. 2009, *Macroeconomics,* Worth, New York.

Phelps, E.S. 1968, "Money-Wage Dynamics and Labor-Market Equilibrium," *The Journal of Political Economy,* vol. 76, no. 4, Part 2: Issues in Monetary Research, 1967, pp. pp. 678-711.

Phelps, E.S. 1967, "Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time," *Economica,* vol. 34, no. 135, pp. pp. 254-281.

Phillips, A.W. 1958, "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957," *Economica,* vol. 25, no. 100, pp. pp. 283-299.

Samuelson, P.A. & Solow, R.M. 1960, "Analytical Aspects of Anti-Inflation Policy," *The American Economic Review,* vol. 50, no. 2, Papers and Proceedings of the Seventy-second Annual Meeting of the American Economic Association, pp. pp. 177-194.

Shafir, E., Diamond, P. & Tversky, A. 1997, "Money Illusion," *Quarterly Journal of Economics,* vol. 112, no. 2, pp. 341-374.

Shiller, R.J. 1996, *Why Do People Dislike Inflation?*, National Bureau of Economic Research, Inc, NBER Working Papers: 5539.

Statistics Sweden, 2011, *Labour Force Survey* [online] Available at: http://www.scb.se/Pages/Product____23276.aspx (Accessed 19 May 2011)

Sveriges Riksbank, 2010a, *Price Stability* [online] Available at: http://www.riksbank.com/templates/Page.aspx?id=10543 (Accessed 10 May 2011)

Sveriges Riksbank, 2010b, *What is inflation?* [online] Available at: http://www.riksbank.com/templates/Page.aspx?id=26609 (Accessed 10 May 2011)

Data:

Eurostat, *Labour productivity – Annual data* [online](Updated 4 May 2011) Available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/dataset?p_product_code=NAMA_AUX_LP (Accessed 15 Apr 2011)

National Institute of Economic Research, *Swedish Economy* [online](Updated 23 Jan 2008) Available at: http://www.konj.se/1499.html (Accessed 25 Feb 2011)

National Institute of Economic Research, *Meddelanden från Konjunkturinstitutet. Serie A, Konjunkturläget*. (1937-). Stockholm

Statistics Sweden**,** *Consumer Price Index (CPI), total, Fixed Index numbers, 1980=100. Month 1980M01-2005M12*, [online] (Updated 12 Jan 2006) Availible at: http://www.ssd.scb.se/databaser/makro/Produkt.asp?produktid=PR0101&lang=2 (Accessed 20 Feb 2011)

Statistics Sweden, *Consumer Price Index (CPI), total, Fixed Index numbers (two decimals), 1980=100. Month 2006M01-2011M03*, [online] (Updated 12 Apr 2011) Availible at: http://www.ssd.scb.se/databaser/makro/Produkt.asp?produktid=PR0101&lang=2 (Accessed 20 Feb 2011)

Statistics Sweden, *GDP quarterly 1993-2007:2* [online](Updated 29 Nov 2007) Available at: http://www.scb.se/Pages/ProductTables____38450.aspx (Accessed 7 Apr 2011)

Statistics Sweden, *GDP quarterly 1980-1992* [online](Updated 6 Mar 2008) Available at: http://www.scb.se/Pages/ProductTables____38450.aspx (Accessed 7 Apr 2011)

Statistics Sweden, *Labour Force Survey - Befolkningen 16-64 år (AKU) efter kön, ålder och arbetskraftstillhörighet. Kvartal 2005K2-2007K4* [online] (Updated 23 Jan 2008) Available at: http://www.ssd.scb.se/databaser/makro/produktAKU.asp?produktid=AM0401&lang=2&inl=AKU (Accessed 20 Feb 2011)

Statistics Sweden, *Labour Force Survey - Befolkningen 16-64 år (AKU) efter kön, ålder och arbetskraftstillhörighet. Kvartal 1976K1-2005K1* [online] (Updated 27 Apr 2005) Available at: http://www.ssd.scb.se/databaser/makro/produktAKU.asp?produktid=AM0401&lang=2&inl=AKU (Accessed 20 Feb 2011)

Sveriges Riksbank, *Swedish TWC index* [online](Updated daily) Available at: http://www.riksbank.com/templates/stat.aspx?id=25024 (Accessed 3 May 2011)

Sveriges Riksbank, *STIBOR fixing* [online](Updated daily) Available at: http://www.riksbank.com/templates/stat.aspx?id=17186 (Accessed 3 May 2011)

Appendix

The data used in the paper are as follows:

Regression (a)

Unemployment (Statistics Sweden, SCB)

Unemployment is defined as people actively seeking jobs that remain unemployed. It is expressed as a percentage of the entire workforce. The data are collected from labor markets surveys carried out by Statistics Sweden.

CPI (Statistics Sweden, SCB)

The CPI is an index of the price consumers pay for a representative basket of goods in actual money. It is the most common form of measuring inflation.

Expected inflation (National Institute of Economic Research, NIER)

The NIER produces a report in which it assesses the expected inflation for Sweden's macroeconomic indicators based on surveying companies and households. The survey is now published four times a year – more than in former years, although its frequency was never lower than two per year. This leads to some filling of gaps during earlier years in terms of quarterly data. In these instances of missing data, we used the average of the values for the previous and the next nearest periods.

All data for regression (a) were gathered on a quarterly basis ranging between 1979:1 and 2007:4

Regression (b) (in addition to unemployment and CPI)

GDP (Statistics Sweden, SCB)

The data collected are quarterly data on GDP at constant prices with reference year 2000. The GDP is calculated using the expenditure approach.

Productivity (Eurostat)

Productivity is defined as real labor productivity per hour worked expressed in national currency. To arrive at the correct time period, we used annual data and data on productivity per hour worked. We then make the assumption that labor productivity is constant for every quarter of that year (and, even with this assumption, we believe that it is a valid and important variable to include).

Size of labor force (Statistics Sweden, SCB)

The size of the labor force is defined as the people employed and people actively seeking jobs. The data are collected from labor markets surveys carried out by Statistics Sweden.

Exchange rates (The Swedish Central Bank, Riksbank)

The exchange rate is calculated using TCW (Total Competitiveness Weights) index that measures the Swedish krona against a basket of other currencies, enabling the Swedish krona to be measured on a global scale. The index is calculated by the IMF (International Monetary Fund).

Swedish market rates (The Swedish Central Bank, Riksbank)

A market rate is the rate people are prepared to pay for various types of credits. The data used were from the STIBOR 3M fixing due to the fact that it has the longest historical data.

All data for regression (b) were gathered on a quarterly basis ranging between 1987:1 to 2007:4.

Dummies

D1 – Equals 1 in 1979:1-1980:1 – oil price increase
D2 – Equals 1 in 1980:2-1981:3 – oil price increase
D3 – Equals 1 in 1981:4-1983:3 – oil price decrease
D4 – Equals 1 in 1986:1-1986:4 – oil price decrease
D5 – Equals 1 in 1990:1-1991:2 – tax reform in Sweden
D6 – Equals 1 in 1995:3-1996:2 – extreme wage increases

D7 – Equals 1 in 1999:2-2006:1 – oil price increase

D8 – Equals 1 in 2006:4-2007:4 – oil price increase

DQ1 – Equals 1 for X:1

DQ2 – Equals 1 for X:2

DQ3 – Equals 1 for X:3

The dummies take the value 0 for all other quarters.