Revised. Preliminary. Comments welcome.

The Possible Unemployment Cost of Average Inflation below a Credible Target [*]

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Abstract

The Riksbank in 1993 announced an official target for annual CPI inflation of 2 percent to apply from 1995. Over the last 15 years, 1997-2011, average CPI inflation has equaled 1.4 percent and has thus fallen short of the target by 0.6 percentage points. Has this undershooting of the inflation target had any costs in terms of higher average unemployment? This depends on whether the long-run Phillips curve in Sweden is vertical or not. During the last 15 years, inflation expectations in Sweden have become anchored to the inflation target in the sense that average inflation expectations have been close to the target. The inflation target has thus become credible. If inflation expectations are anchored to the target also when average inflation deviates from the target, the long-run Phillips curve is no longer vertical but downward-sloping. Then average inflation below the credible target means that average unemployment is higher than the rational-expectations steady-state (RESS) unemployment rate (the natural unemployment rate). The data indicate that the average unemployment rate has been about 0.8 percentage points higher than the RESS rate over the last 15 years. This is a large unemployment cost of undershooting the inflation target. Some simple robustness tests indicate that the estimate of the unemployment cost is rather robust, but the estimate remains preliminary and further scrutiny may be needed to assess its robustness.

JEL Classification: E24, E31, E52, E58

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The Riksbank in 1993 announced an official target for annual CPI inflation of 2 percent, to apply from 1995. By 1997, the new inflation-targeting regime had been established, in the sense that the inflation target was credible (inflation expectations were in line with the target), the repo rate (the Riksbank's policy rate) had been lowered to a normal level, and the Riksbank had had a few years to learn how to conduct inflation targeting. Over the last 15 years since then, 1997-2011, average CPI inflation has equaled 1.4 percent and has thus fallen short of the target by 0.6 percentage points (pp). Has this undershooting of the inflation target had any costs in terms of higher average unemployment? This depends on whether the long-run Phillips curve in Sweden is vertical or not. During the last 15 years, inflation expectations in Sweden have become anchored to the inflation target, in the sense that average inflation expectations have been close to the target. The inflation target has thus become credible. If inflation expectations are anchored to the target also when average inflation deviates from the target, the long-run Phillips curve is no longer vertical but downward-sloping. Then average inflation below the credible target means that average unemployment is higher than the rational-expectations steady-state unemployment rate (RESS) rate (also known as the natural rate unemployment rate, although sometimes less precisely defined, see Rogerson 1997). The data indicate that the average unemployment rate has been 0.8 pp higher than the RESS rate over the last 15 years. This is a large unemployment cost of undershooting the inflation target. Some simple robustness tests indicate that the estimate of the unemployment cost is rather robust, but the estimate is preliminary and further scrutiny is needed to assess its robustness.

Average inflation has fallen short of the target but inflation expectations have been anchored on the target

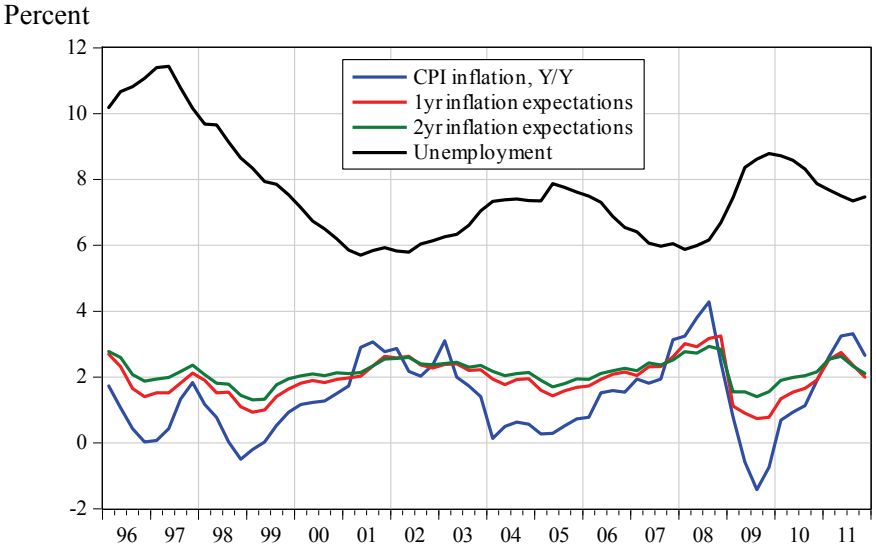
Figure 1 shows quarterly data from 1996 through 2011 of real-time annual CPI inflation, inflation expectations from the survey the Riksbank has commissioned from TNS Sifo Prospera of annual CPI inflation one and two years ahead, and the unemployment rate (15-74 age group). Throughout this paper I assume that the TNS Sifo Prospera survey is representative of private-sector inflation expectations in Sweden.[1]

Over the last 15 years, the period 1997-2011, average real-time CPI inflation has equaled 1.43 percent, thus undershooting the target of 2 percent by about 0.6 pp. Average revised CPI inflation was 1.31 percent during the same period. For the purposes of this paper, real-time inflation is more appropriate.[2]

[1] In 1995 the Riksbank commissioned Prospera Research (now TNS Sifo Prospera) to conduct a survey of the expectations of inflation and wage increases of a panel of labor market organizations, purchase managers, and money-market players. The first report was published in November, 1995. Initially the survey was to be published three times a year, but from 1996 the survey was conducted four times a year. Later the survey was expanded to include expectations of future GDP growth and repo rates and for money-market players also expectations of future 5-year government bond rates and USD and EUR exchange rates.

[2] As is explained in Sveriges Riksbank (2004), before 2005, CPI inflation was measured by Statistics Sweden not as the annual percentage increase in the CPI but with a method that excluded substitution effects on the composition of the basket, making measured inflation on average 0.2 pp higher. From 2005, CPI inflation is measured as the annual percentage change in the CPI.

Figure 1. Annual CPI inflation, CPI inflation expectations one and two years ahead (Prospera, all interviewees), and unemployment (15-74 age group).



Sources: Statistics Sweden and TNS Sifo Prospera.

As seen in figure 1, one- and two-year-ahead inflation expectations did not become close to 2 percent until the second half of 1996. A different series of inflation expectations, collected by Aragon Securities Fondkommission and referring to expectations of money-market participants only, is shown in figure 2, together with annual CPI inflation, unemployment, and the repo rate (the Riksbank's policy rate). The red curve shows expectations of average inflation for the next two years. The green curve shows expectations of average inflation during the next five years. We see that the credibility of the inflation target was quite low after its announcement in January 1993. The expected average inflation for the next five years was about 4 percent through the first half of 1995. Only toward the end of 1996 are the expected average inflation for the next two and the next five years both close to 2 percent.

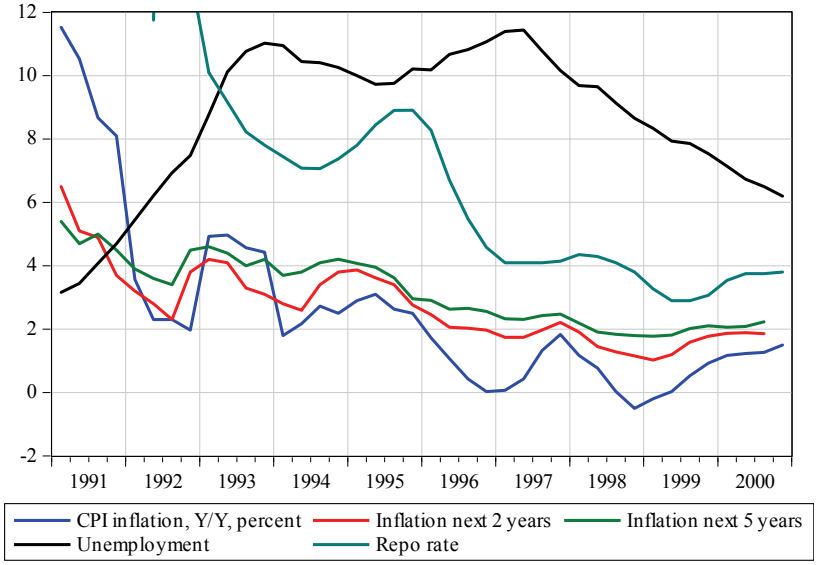
The high inflation expectations before 1997 mean that, everything else equal, tighter monetary policy and higher unemployment is needed to bring inflation close to the target. From 1997 onwards, inflation expectations are close to two percent, and this reason for tighter policy no longer applies. Furthermore, figure 2 shows that the repo rate by early 1997 had been lowered to a normal level, 4 percent. Also, by 1997, the Riksbank had had a few years to learn how to conduct monetary policy under inflation targeting.[3] By 1997, the new inflation-targeting regime had established itself. Therefore, it is relevant to scrutinize monetary policy from 1997 and onwards.[4]

[3] The paper Svensson (1997) about the principles of inflation targeting was written in 1996 when I was an advisor the Riksbank and was much stimulated by several meetings with Riksbank staff and management in which the principles of inflation targeting were being debated and developed. These principles were, as far as I can remember, gradually applied from 1997 and onwards.

[4] Andersson, Palmqvist, and Österholm (2012) discuss the inflation target attainment of the Riksbank for the period 1995-2011, note that average real-time CPI inflation was 1.5 percent during this period, but do not discuss the consequences for average unemployment of undershooting the target. In order to discuss the consequences for average unemployment, it would be misleading to include the period 1995-1997 in the sample, since inflation expectations exceeded the inflation target before 1997. For the sample 1995-2011, the long-run Phillips curve is flatter than the benchmark and the excess average unemployment is larger, even if the smaller undershooting of 0.5

Thus, both the Prospera and Aragon series indicate that inflation expectations were anchored to the inflation target from 1997, but not before, in the sense that average inflation expectations were close to the target. Figure 3 shows five-year moving averages of inflation expectations one and two years ahead and real-time CPI inflation.

Figure 2. Annual CPI inflation, expectations of average CPI inflation the next 2 and 5 years (Aragon), unemployment (15-74 age group), and the repo rate



Source: Statistics Sweden, Aragon Securities Fondkommission, Stockholm, and the Sveriges Riksbank

For the period 1997-2011, average inflation expectations one and two years ahead are 1.94 and 2.13 percent, respectively. My starting point is therefore that during the last 15 years inflation expectations have on average equaled the target of 2 percent and that average CPI inflation has fallen 0.6 pp below target.

Average inflation expectations are economically and statistically significantly above average inflation.[5] The inflation expectations are not rational, as shown in detail by Jonsson and Österholm (2012). Perhaps they are "near-rational" as in in Akerlof, Dickens, and Perry (2000) (ADP).

In ADP near-rational behavior means that, when inflation does not deviate too much from zero, a significant fraction of the private sector neglects inflation and behaves as if it would equal zero. When inflation becomes sufficiently above zero, an increasing fraction of the private sector becomes rational and has rational expectations. The result is a long-run Phillips curve that is vertical for high inflation rates, for which the long-run unemployment rate equals the rational-expectations steady-state (RESS) rate (what is often somewhat imprecisely called the "natural rate", see Rogerson 1997). For low positive inflation rates, the long-run Phillips curve has a hump to the left and the long-run unemployment rate is lower than the

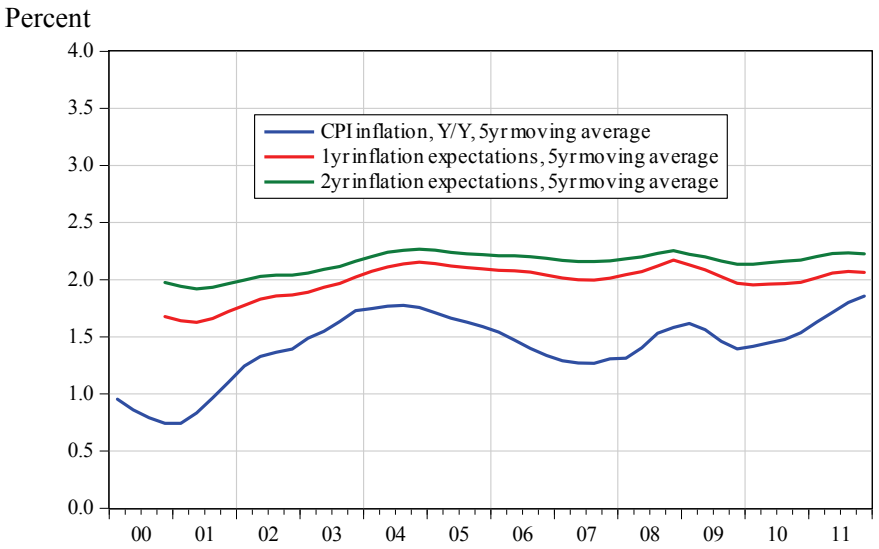
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percentage point is used. The average real-time CPI inflation is 1.4 percent for the both the samples 1996-2011 and 1997-2011.

[5] A regression 1997-2011 of one-year-ahead inflation expectations less CPI inflation on a constant results in the constant 0.51 and a Newey-West standard error (lag 4) of 0.16.

RESS rate. For zero inflation, the long-run unemployment rate is again equal to the RESS rate (ADP p. 18, figure 1).[6]

Figure 3. CPI inflation expectations one and two years ahead (all interviewees) and CPI inflation, five-year moving averages.



Sources: Statistics Sweden and TNS Sifo Prospera.

In the present context, near-rational behavior would mean that, when average inflation does not deviate too much from the inflation target of 2 percent, a significant fraction of the private sector neglects that deviation and behaves as if average inflation would equal the inflation target. A possible explanation is that this fraction of the private sector may have been more influenced by the Riksbank's communication of the inflation target of 2 percent than by actual average inflation. Thus, whereas near-rational behavior in ADP is with reference to zero inflation, here it would be with reference to the inflation target of 2 percent.

In particular, central wage negations in Sweden start from an assumption that the Riksbank will attain its inflation target and that CPI inflation will be 2 percent, regardless of what actual inflation is or has been. This is can be seen in documents about the principles of wage negotiations from the Swedish Trade Union Confederation (Morin 2009) and the Industrial Trade Unions (Facken inom industrin 2011):

> During the years 1995-2008 the CPI has on average increased by 1.4 percent… That the price increase has fallen short of the inflation target should not be the starting point for a future assessment. Instead, the reference point for wage formation should be that the Riksbank will attain the inflation target of 2 percent… (Morin 2009, p. 15, translated from Swedish)

> [The Riksbank's inflation target] is an important starting point for the labor-market parties when they negotiate about new wages. …

[6] Lundberg and Sacklén have estimated the ADP long-run Phillips curve on Swedish data. Bryan and Palmqvist (2010) test some particular hypotheses that follow from the ADP assumptions.

> The parties should in negotiations about new wage settlements act as if the Riksbank will attain its inflation target. …
>
> While acting as if the Riksbank will attain its inflation target, the parties contribute to inflation expectations around 2 percent. … (Facken inom industrien 2011, p. 6-7, translated from Swedish)

Thus, according to these quotations central wage negotiations in Sweden are conducted with inflation expectations equal to 2 percent, regardless of the fact that average inflation has fallen short of 2 percent.

The long-run Phillips curve has become downward-sloping

If inflation expectations are anchored on the target in the sense that average inflation expectations equal the target even though average inflation deviates from the target, the long-run expectations-augmented Phillips curve is no longer vertical but downward-sloping.[7] Consider the simplest expectations-augmented Phillips curve,

$$\pi_t = \pi_t^e - \gamma(u_t - u^*) + \varepsilon_t, \tag{1}$$

where π_t denotes inflation in quarter t; π_t^e denotes inflation expectations; u_t denotes the unemployment rate; u^* denotes the RESS rate; ε_t denotes possibly serially-correlated cost push shocks with an unconditional mean equal to zero, $\mathrm{E}[\varepsilon_t] = 0$; and γ is a positive constant. For a New Keynesian Phillips curve, π_t^e is the expectation in period t of inflation in period $t + 1$; for a New Classical Phillips curve, π_t^e is the expectations in period $t - 1$ of inflation in period t. Taking the unconditional mean of the Phillips curve (1) then results in the long-run relation between inflation, inflation expectations, and unemployment,

$$\pi = \pi^e - \gamma(u - u^*), \tag{2}$$

where $\pi = \mathrm{E}[\pi_t]$, $\pi^e = \mathrm{E}[\pi_t^e]$, and $u = \mathrm{E}[u_t]$ denote the unconditional means of inflation, inflation expectations and the unemployment rate. Under rational expectations, the unconditional mean of inflation and inflation expectations are equal,

$$\pi = \pi^e, \tag{3}$$

so from (2) and (3) it follows that the unconditional mean of the unemployment rate and the RESS rate are equal,

$$u = u^*. \tag{4}$$

Then the long-run Phillips curve is vertical, the unconditional mean of the unemployment rate is independent of the unconditional mean of inflation, and there is no long-run tradeoff between inflation and unemployment.

[7] The anchoring of U.S. inflation expectations to 2 percent and the resulting downward-sloping U.S. Phillips curve have been noted by Fuhrer (2011).

However, if the unconditional mean of inflation expectations equals the inflation target, π^*, regardless of the unconditional mean of inflation, the long-run Phillips curve will be

$$\pi - \pi^* = -\gamma(u - u^*) . \qquad (5)$$

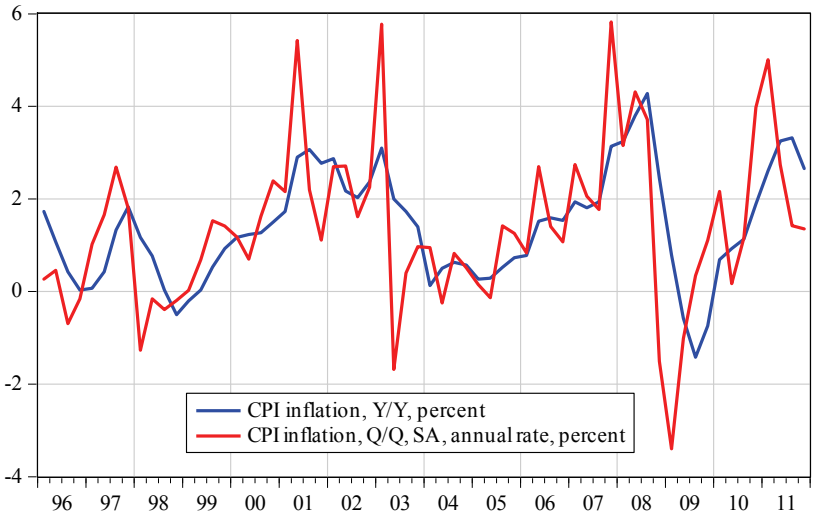
The long-run Phillips curve is then downward-sloping with (negative) slope γ, and there is a long-run tradeoff between inflation and unemployment. When average inflation expectations equal the inflation target, average inflation below target will imply average unemployment above the RESS rate.

In order to estimate a long-run inflation Phillips curve, I first estimate a short-run Phillips curve with quarterly real-time seasonally adjusted CPI inflation at an annual rate as the dependent variable and the change in and one lag of unemployment as explanatory variables,[8]

$$\pi_t - 2 = \gamma_0 - \gamma_1(u_t - u_{t-1}) - \gamma u_{t-1} + \varepsilon_t , \qquad (6)$$

where the error term ε_t has mean zero and is assumed to be uncorrelated with the unemployment rate and the lagged inflation.[9] That is, unemployment is here assumed to be predetermined one quarter; alternative hypotheses are examined in robustness tests below. The quarterly seasonally adjusted CPI inflation is shown in figure 4.[10]

Figure 4. CPI inflation, annual and quarterly seasonally adjusted at annual rate



Sources: Statistics Sweden and own calculations.

[8] I find it convenient to express the Phillips curve in terms of inflation deviations from 2 percent. This will only affect the estimate of the intercept, γ_0.

[9] A previous version of the paper estimated a short-run Phillips curve with annual inflation as the dependent variable. Using annual inflation means using overlapping data, which introduces serial correlation in error terms and other econometric complication. Using overlapping data has hardly any advantages according to Harri and Brorsen (2009) compared to using underlying non-overlapping data. In the present case, using quarterly inflation leads to a simpler short-run Phillips curve and is in line with other studies of the Phillips curve. The estimated slope of the long-run Phillips curve is about the same regardless of whether quarterly or annual inflation is used.

[10] The seasonal adjustment of the quarterly inflation is done with EViews and Census X12, additive.

Taking the unconditional mean of the short-run Phillips curve (6) and using $\pi = \mathrm{E}[\pi_t]$, $u = \mathrm{E}[u_t]$, and $\mathrm{E}[\varepsilon_t] = 0$ then results in the long-run Phillips curve

$$\pi - 2 = \gamma_0 - \gamma u \,, \tag{7}$$

where thus γ is the slope of the long-run Phillips curve.

The result of estimating (6) for the sample 1997Q4-2011Q4 is shown in table 1. The coefficients on the unemployment change and lagged unemployment are highly significant. Serial correlation of the error term can be rejected at the 5 percent confidence level.

Table 1. Short-run Phillips curve, 1997Q4-2011Q4

Coefficient	Estimate	Std. Error	t-Statistic	Prob.
γ_0	5.192254	1.359700	3.818676	0.0003
γ_1	2.700178	0.723132	3.734002	0.0005
γ	0.806734	0.186279	4.330787	0.0001

Note: OLS, $R^2 = 0.30$, adjusted $R^2 = 0.27$, S.E. = 1.53, DW = 1.77.

From the estimates in table 1 it follows that the slope of the long-run Phillips curve is about 0.8. With a standard error of 0.19, it is fairly precisely estimated. A 95-percent confidence interval of the slope is the interval from 0.43 to 1.18. Clearly, the hypothesis of a vertical Phillips curve, an infinite slope, can be rejected.

The rejection of a vertical Phillips curve is in contrast to the case in Rudebusch and Svensson (1999). There, a Phillips curve for the U.S. economy is estimated for the sample 1961Q1-1996Q2. The hypothesis that the coefficients on lagged inflation sum to unity cannot be rejected. Instead, the estimation is done under the restriction that the coefficients sum to unity and the long-run Phillips curve is vertical.

Figure 5 shows the long-run Phillips curve (7) for the estimates in table 1 (black solid and dashed line) with a scatter plot with quarterly CPI inflation at an annual rate and unemployment for the sample 1997Q4-2011Q4 (red circles with connecting lines). The long-run Phillips curve is solid for average inflation rates less than 1 pp from 2 percent and dashed for average inflation rates farther from 2 percent, in order to emphasize that it is derived under the assumption that average inflation expectations are equal to 2 percent. It may apply only if average inflation does not deviate too far from 2 percent. If average inflation would deviate far from 2 percent, in line with the reasoning of ADP, a higher fraction of the private-sector would have rational expectations and the long-run Phillips curve would bend toward the RESS rate.

The slope of the long-run Phillips curve is sensitive to the starting date of the sample. Figure 6 shows the long-run Phillips curve and the scatter plot for the sample 1997Q1-2011Q4, with an earlier sample start. The curve slope is less, 0.46. We see in figure 6 that the observations in early 1997, to the right in the figure with high unemployment and inflation not too far from 2 percent, make a flatter long-run Phillips curve fit better.

Figure 5. The long-run Phillips curve and scatter plot, 1997Q4-2011Q4

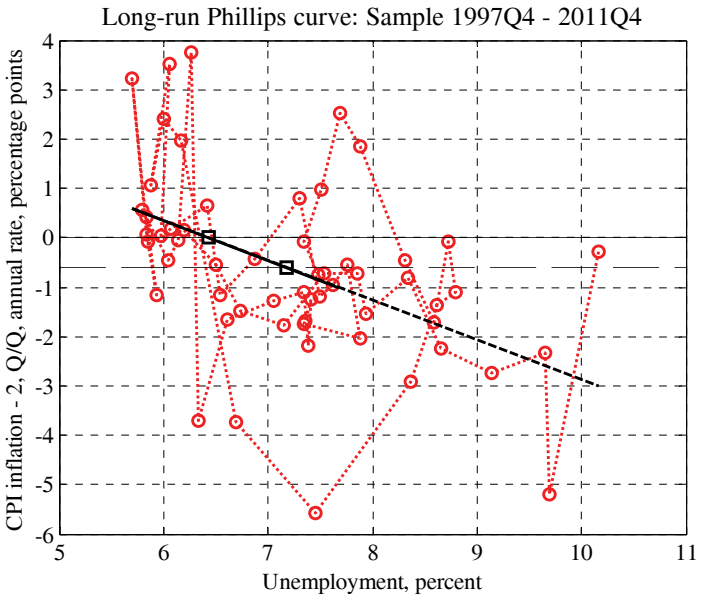


Figure 6. The long-run Phillips curve and scatter plot, 1997Q1-2011Q4

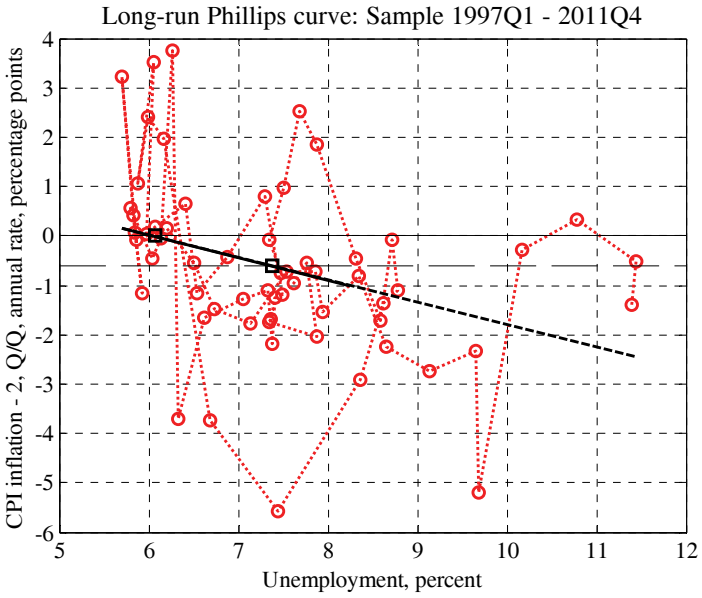
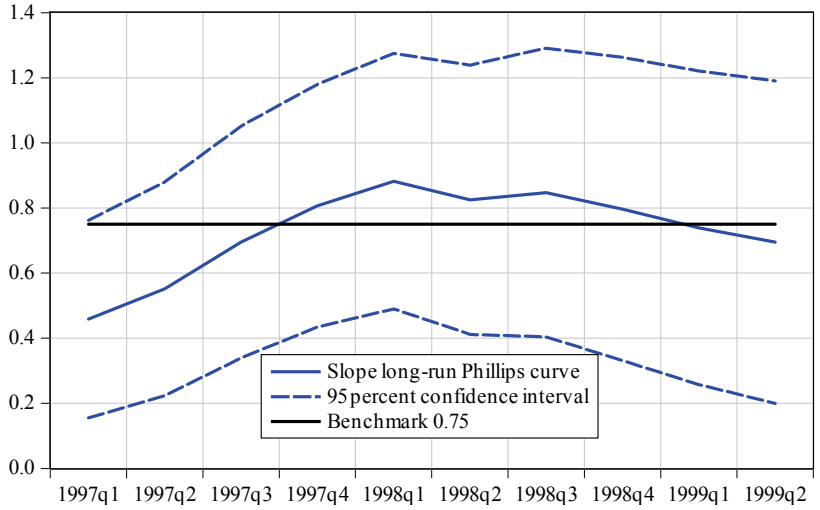


Figure 7 shows the slope of the long-run Phillips curve, the coefficient γ, as a function of the sample starting date, with all samples ending 2011Q4. The figure also shows 95-percent confidence intervals (plus/minus two standard errors of the estimate of the slope). The slope varies from a minimum of 0.46 for the sample start 1997Q1 to a maximum of 0.88 for 1998Q1 and then falls to 0.7 for 1999Q2. The average over the sample starts 1997Q1-199Q2 is 0.73. A low slope will result in a high unemployment cost of average inflation below the target, whereas a high slope will result in a low unemployment cost. The highest lower bound of the 95-percent confidence intervals is 0.49 and occurs for the sample start 1998Q1.

The lowest higher bound of the 95-percent confidence interval is 0.76 and occurs for 1997Q1. From this, a benchmark of 0.75, a relatively high slope of the long-run Phillips curve, close to the lowest higher bound of the 95-percent confidence interval, seems a rather conservative estimate that will not exaggerate the unemployment cost. It is a bit lower than the slope of the long-run Phillips curve for the sample 1997Q4-2011Q4 reported in table 1 and figure 5.

As a benchmark 95-percent confidence interval around the benchmark slope of 0.75 I will use ± 0.35, that is, the interval [0.4, 1.1]. The benchmark slope is the average of the estimated slope for the sample starts 1997Q3 and 1997Q4 in figure 7, and the benchmark confidence interval is then the average of the estimated confidence intervals for these sample starts.

Figure 7. The slope of the long-run Phillips curve: Sample start 1997Q1-1999Q2



The unemployment cost of average inflation below a credible target

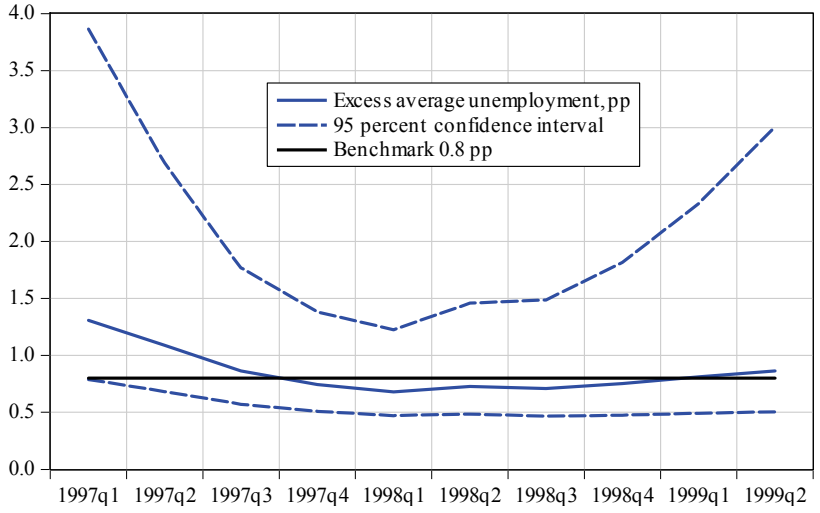
The benchmark slope of the long-run Phillips curve, 0.75, implies that 1 pp lower average inflation is associated with 1/0.75 = 1.33 pp higher average unemployment. This means that the benchmark 0.6 pp average inflation below target implies a benchmark of 0.6/0.75 = 0.8 pp higher average unemployment. Using the estimate in table 1 and figure 5, for the sample 1997Q4-2011Q4, as an illustration, the rightmost black square on the long-run Phillips curve in figure 5 shows the average unemployment associated with average inflation 0.6 pp below target. It is 7.18 percent. The leftmost black square shows the average unemployment associated with average inflation on target. It is 6.44 percent.[11] The horizontal distance between the squares shows the unemployment cost of average inflation having fallen short of the target by

[11] Under the assumption of a constant RESS rate u^*, from (7) and (5) and table 1 it follows that $u^* = \gamma_0/\gamma = 5.19/0.81 = 6.44$, so this number can be seen as an estimate of a constant RESS rate during 1997Q1-2011Q4. (The long-run Phillips curve estimated for 1997Q4-2011Q4 is considered to apply also for the beginning of 1997, and average inflation over 1997Q1-2011Q4 is used.) However, in the last few years, substantial structural reforms, tax changes, and other factors, including demography and labor force composition, have according to Forslund (2008), Ministry of Finance (2011), and National Institute of Economic Research (2011) probably reduced the RESS rate substantially.

0.6 pp. It is 0.74, a bit less than the benchmark 0.8, since the slope of the long-run Phillips curve in figure 5 is 0.81 and a bit steeper than the benchmark 0.75.

Since the slope of the long-run Phillips curve is sensitive to the sample start, so is the excess average unemployment. Figure 8 shows the excess average unemployment, calculated as 0.6 divided by the slope of the long-run Phillips curve, as a function of the sample start. The figure also shows 95-percent confidence intervals, calculated as 0.6 divided by the upper and lower bound of the confidence intervals for the slope of the long-run Phillips curve. The lowest lower bound for the 95-percent confidence interval for the excess average unemployment is 0.46 pp and occurs for 1998Q3. An excess average unemployment of close to 0.5 pp for 15 years is still pretty high. The highest lower bound is 0.79 pp and occurs for 1997Q1. The lowest upper bound for the excess average unemployment is 1.22 pp and occurs for 1998Q1. From this it follows that the benchmark 0.8 pp for the excess average unemployment is a rather conservative benchmark and hardly an exaggeration of the unemployment cost of average inflation below the target.

Figure 8. Excess average unemployment, sample start 1997Q1-1999Q2



Thus, this analysis leads to a benchmark unemployment cost of about 0.8 pp excess unemployment on average for 15 years due to average inflation having undershot the target by 0.6 pp during this period. This is a large unemployment cost of undershooting the inflation target.

I calculate the benchmark 95-percent confidence interval around the benchmark unemployment cost from the benchmark confidence interval of the slope, [0.4, 1.1]. This results in a benchmark confidence interval of [0.6/1.1, 0.6/0.4] = [0.55, 1.5] percentage points for the unemployment cost. It is approximately equal to the average of the confidence intervals in figure 8 for the sample starts 1997Q3 and 1997Q4.

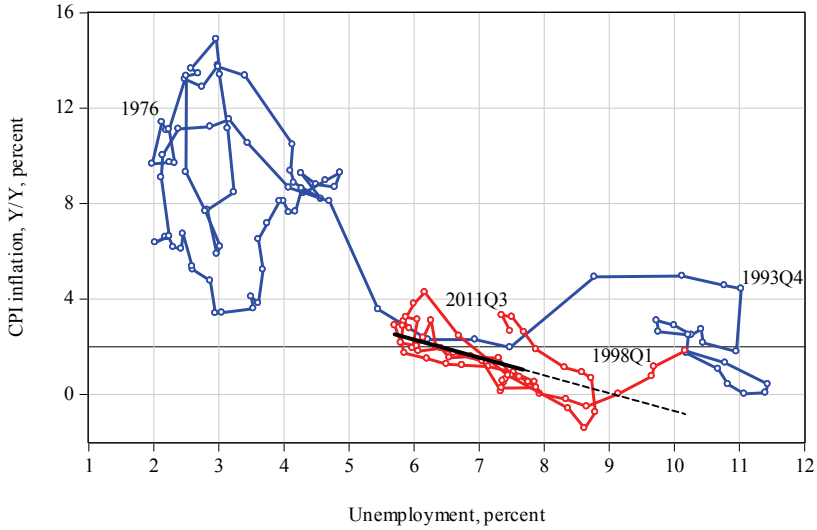
Some robustness tests

Figure 9 shows a scatter plot with unemployment and annual CPI inflation from 1976Q1 through 2011Q4. We see that the observations during the 1970s and the 1980s with large fluctuations in inflation give the impression that the long-run Phillips curve was vertical. The observations to the far right are from the big

crisis in the early 1990s. The sample 1997Q4-2011Q4 is marked in red. The observations indicate a non-vertical Phillips curve for that sample. The Riksbank's inflation targeting and inflation expectations anchored to the target imply a regime shift. The figure also shows the benchmark long-run Phillips curve for that sample from table 1 and figure 5.[12]

One could argue that the crisis years 2008-2011 are special. If one limits the sample to 1997Q1-2007Q4, the average annual CPI inflation is 1.31, so the average inflation is about 0.7 pp below target. The estimated slope a long-run Phillips curve for 1997Q4-2007Q4 is 0.83, so the average unemployment cost is about 0.7/0.83 = 0.85 pp, a bit higher than the benchmark unemployment cost; see figure 10.

Figure 9. Unemployment and annual CPI inflation, 1976Q1-2011Q4, and the benchmark long-run Phillips curve



Through the *Monetary Policy Update* of April 2008, the Riksbank used CPIX inflation as an operational target rather than CPI inflation. From the *Monetary Policy Report* of July 2008, the Riksbank has emphasized CPIF inflation rather than CPIX inflation. As explained in Sveriges Riksbank (2008), the price index CPIX differs from the CPI in that the effects of changes in mortgage costs and the direct effects of changes in indirect taxes and subsidies are excluded. The price index CPIF differs from the CPI in that mortgage costs are calculated with a constant mortgage rate. Given this, one may want to consider the long-run Phillips curve with CPIX/CPIF inflation instead of CPI inflation, where CPIX/CPIF inflation refers to CPIX inflation through 2008Q1 and CPIF inflation from 2008Q2.[13]

The Riksbank has also published an estimate of time-varying "long-term" unemployment.[14] One may want to consider a long-run Phillips curve for an unemployment gap between unemployment and the

[12] The benchmark long-run Phillips curve, with its (negative) slope of 0.8, is in figure 9 drawn through the point where average unemployment is 7.2 percent and average inflation is 1.4 percent.
[13] Andersson, Palmqvist, and Österholm (2012) discuss Riksbank target attainment for 1995-2011 in terms of CPIF inflation, and at the same time emphasize the relevance of using real-time data. Since the CPIF index did not exist before 2008 and the Riksbank used CPIX inflation before 2008 as an operational target, it is arguably more relevant to discuss target attainment in terms of CPIX inflation than in terms of CPIF inflation.
[14] The Riksbank's estimate of long-term unemployment is shown in Sveriges Riksbank (2010, figure B23).

Riksbank's long-term unemployment instead of just the unemployment rate. Figure 11 shows CPIX/CPIF inflation and the Riksbank's estimate of long-term unemployment together with CPI inflation and unemployment.

Figure 10. The long-run Phillips curve and scatter plot, 1997Q4-2007Q4

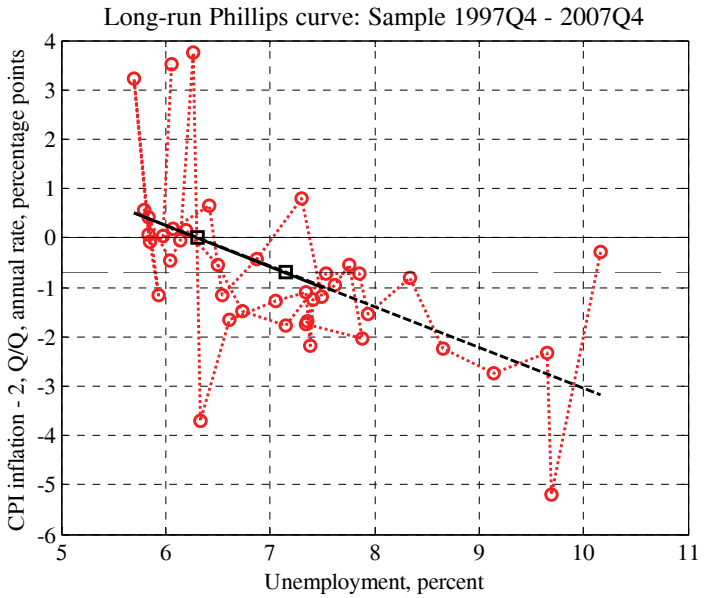
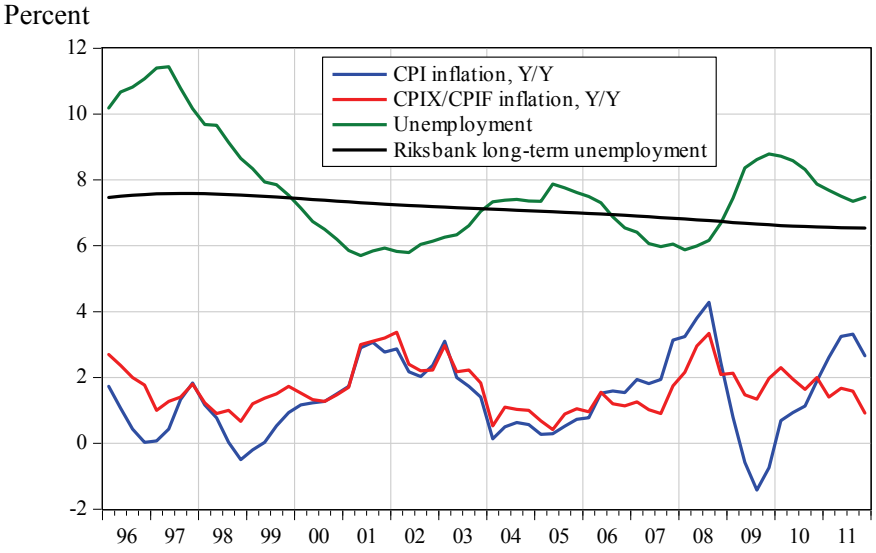


Figure 11. Annual CPI and CPIX/CPIF inflation, unemployment, and the Riksbank's estimate of long-term unemployment

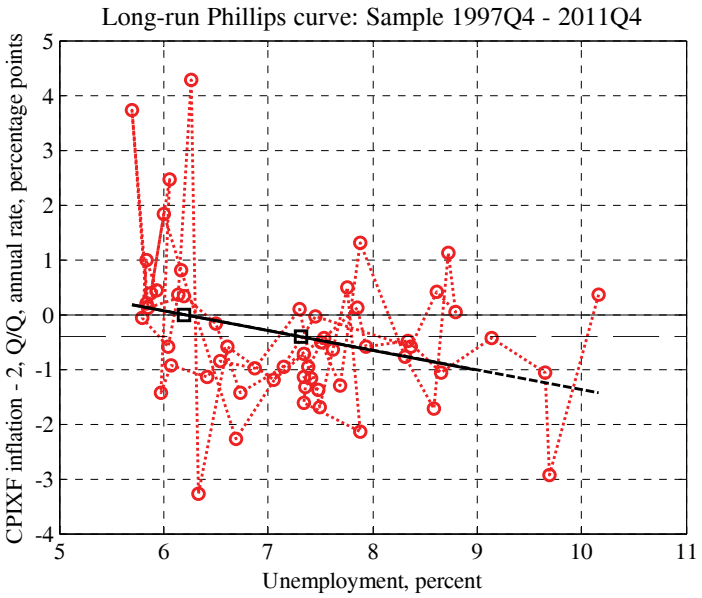


Sources: The Riksbank and Statistics Sweden.

Average real-time CPIX/CPIF inflation was 1.64 percent during 1997-2011 and hence fell short of the target by about 0.4 pp. Estimating a long-run Phillips curve from the short-run Phillips curve (6) for unemployment with quarterly seasonally adjusted CPIX/CPIF inflation at an annual rate instead of CPI inflation leads to a flatter long-run Phillips curve with a slope of 0.36 and a higher unemployment cost of

0.4/0.36 = 1.1 pp. This is shown in figure 12. For CPIX/CPIF inflation, the fit is not as good as for CPI inflation. R^2 and adjusted R^2 are only 0.09 and 0.05 for CPIX/CPIF inflation compared with 0.30 and 0.27 for CPI inflation.

Figure 12. The long-run Phillips curve with CPIX/CPIF inflation and unemployment, 1997Q4-2011Q4



Using CPI inflation with the gap between unemployment and the Riksbank's estimate of long-term unemployment instead of just unemployment means estimating a short-run Phillips curve such as

$$\pi_t - 2 = \gamma_0 + \gamma_1[(u_t - u_t^*) - (u_{t-1} - u_{t-1}^*)] + \gamma(u_{t-1} - u_{t-1}^*) + \varepsilon_t, \qquad (8)$$

where u_t^* denotes a time-varying long-term unemployment rate rather than a constant RESS rate. This leads to a flatter long-run Phillips curve with a slope of 0.65 and a larger unemployment (gap) cost, 0.93 pp, see figure 13. The fit is worse than with unemployment, with R^2 and adjusted R^2 equal to 0.22 and 0.19, respectively.

Interestingly, the average unemployment gap associated with average inflation equal to target is –0.75, as shown by the leftmost black square in figure 13. This indicates that the Riksbank's estimate is biased upwards. Of course, estimates of any long-run unemployment rate from observed data from this sample period under the maintained assumption of rational expectations (or even just unbiased expectations) will be biased upwards, given that average inflation has systematically undershot average inflation expectations. Figure 14 shows a revised Riksbank estimate, constructed by just subtracting 0.75 from the Riksbank's estimate of the long-term unemployment rate.[15]

[15] Riksbank (2012) presents a new Riksbank estimate of the long-run sustainable rate of unemployment of 6.25 percent (the midpoint of an interval between 5 and 7.5 percent). In Svensson (2012), I argue that this estimate has an upward bias of 0.75 pp, and that a corrected Riksbank estimate should therefore be 5.5 percent.

Figure 13. The long-run Phillips curve with CPI inflation and the Riksbank's unemployment gap, 1997Q4-2011Q4

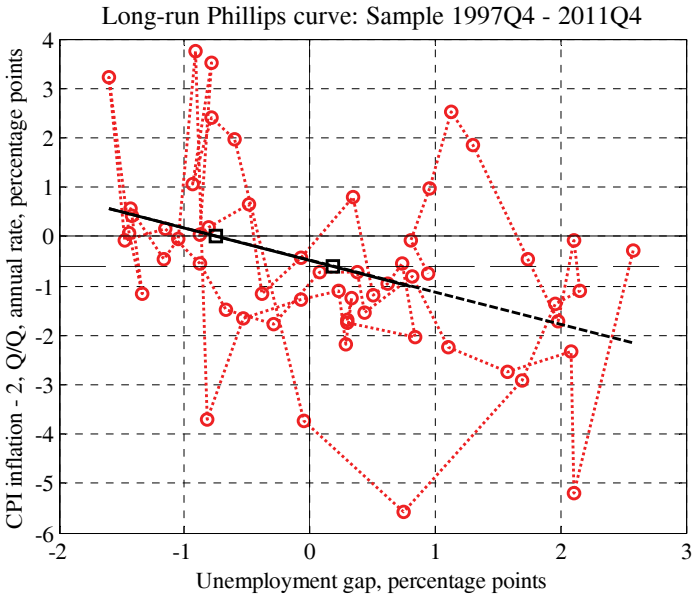
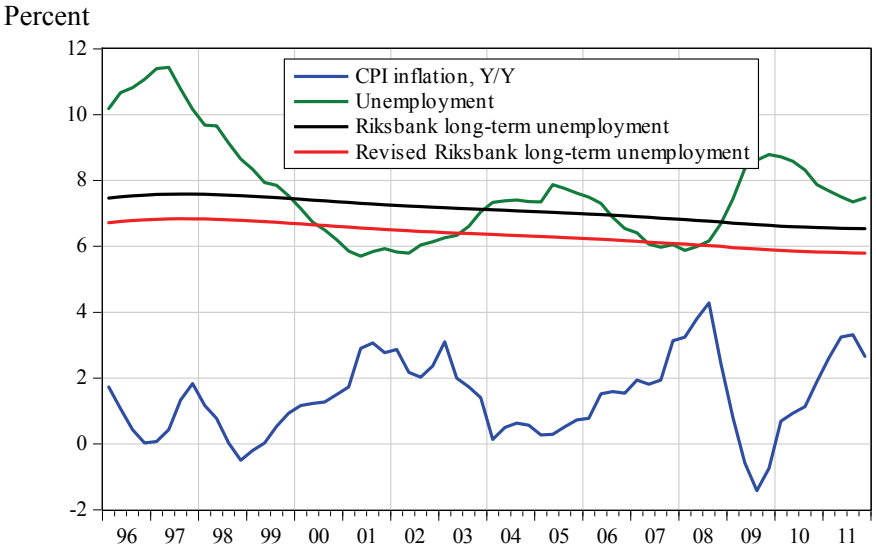


Figure 14. A revised Riksbank estimate of long-term unemployment, the Riksbank's estimate of long-term unemployment, and annual CPI inflation



Sources: The Riksbank, Statistics Sweden, and own calculations.

In the estimated short-run Phillip curve (6), unemployment is considered predetermined and therefore uncorrelated with the error term. If we instead use the lagged change in unemployment rate and a second lag of the unemployment rate as explanatory variables, that is, $u_{t-1} - u_{t-2}$ and u_{t-2} on the right side of (6), we get a flatter long-run Phillips curve with a slope of 0.64 and a higher unemployment cost of 0.93 pp; see figure 15. The fit is worse with lagged unemployment than with current unemployment, with R^2 and adjusted R^2 equal to 0.23 and 0.20, respectively.

Another way to handle possible endogeneity and correlation between unemployment and the error term in (6) is to use instrumental variables. Table 2 shows the results of a two-stage least squares estimation with three lags of unemployment as instrumental variables. The slope is 0.83, a bit higher than the benchmark, and the average unemployment cost is 0.72, a bit smaller than the benchmark.

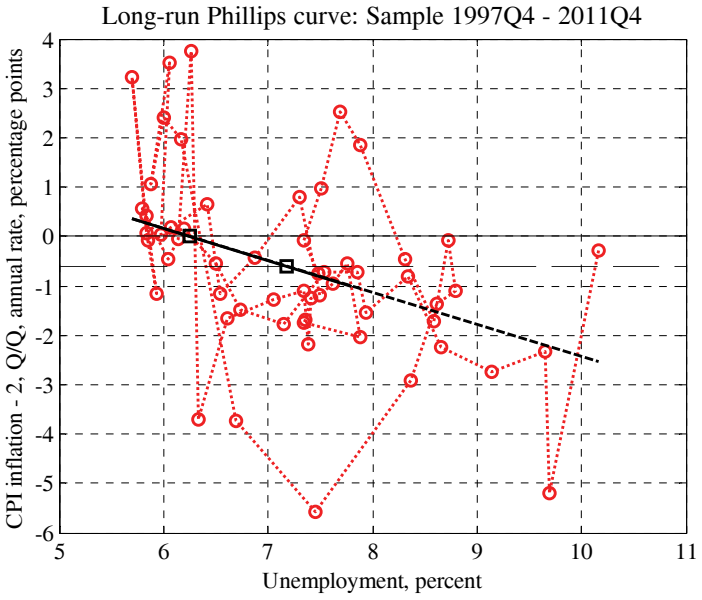
Table 2. Short-run Phillips curve, 1997Q4-2011Q4
Two-stage least squares, instruments three lags of the unemployment rate

Coefficient	Estimate	Std. Error	t-Statistic	Prob.
γ_0	5.343972	1.461589	3.656275	0.0006
γ_1	2.908611	1.029998	2.823899	0.0066
γ	0.829147	0.202397	4.096646	0.0001

Note: Two-stage least squares, $R^2 = 0.30$, adjusted $R^2 = 0.27$, S.E. = 1.54, DW = 1.78.

A possible source of correlation between unemployment and the error term might be inflation expectations depending on unemployment. In (1), if inflation expectations, π_t^e would depend on unemployment, u_t, the error term, ε_t, in (6) would be correlated with u_t. However, a regression of inflation expectations on unemployment, lagged inflation, and lagged inflation expectations shows that inflation expectations do not depend on unemployment. The coefficient on employment is very small and not significant (see table A1 in the appendix).

Figure 15. The long-run Phillips curve with CPI inflation and the lagged change in unemployment and a second lag of unemployment, 1997Q4-2011Q4



Other countries

One cannot of course expect average inflation to have been exactly on target over the last 15 years. To get an idea of what is possible, however, we can compare average inflation in Sweden to average inflation in other countries that have had a fixed inflation target as long as Sweden, that is, since the early 1990s. Those countries are Australia, Canada, and the U.K. The first country to introduce explicit inflation targeting was New Zealand in 1990, but its inflation target has not been fixed but adjusted up twice. It is also reasonable to exempt the very first years of the new inflation-targeting regime for Sweden and other countries. I therefore compare average inflation over the same period as for Sweden, 1997-2011.

The comparison is summarized in table 3. Australia has had an inflation target since mid-1993. The target is to achieve an average CPI inflation rate of between 2 and 3 percent over the business cycle. As shown in the table, average CPI inflation over 1997-2011 has been 2.7 percent, exceeding the midpoint of the target range by 0.2 pp. Canada has had an inflation target since 1991, which from the end of 1995 is 2 percent for CPI inflation. Average CPI inflation over 1997–2011 is 2.0 percent.

Table 3. Inflation target, average inflation, and average deviation from target for Australia, Canada, Sweden, and the U.K.; implicit inflation target and average inflation for the euro area and the U.S

Country	Target	Index	Period	Average	Average less target
Australia	2–3	CPI	1997–2011	2.7	0.2
Canada	2	CPI	1997–2011	2.0	0.0
Sweden	**2**	CPI	1997-2011	**1.4**	**–0.6**
Sweden	**2**	CPI	1997-2007	**1.3**	**–0.7**
U.K.	2.5 (1992–2003)	RPIX	1997-2003	2.4	–0.1
	2 (2004–)	CPI	2004–2007	2.0	0.0
	2 (2004–)	CPI	2008–2011	3.4	1.4
Euro area	(< 2)	HICP	2000–2011	2.1	
U.S.	(2, < 2)	Core CPI	2000–2011	2.0	
	(2, < 2)	Core PCE	2000–2011	1.9	

Source: Reuters Ecowin and Statistics Sweden

The U.K. has had an inflation target from the end of 1992, which was however somewhat modified at the end of 2003. Up to the end of 2003, the UK inflation target was 2.5 percent for the RPIX price index.[16] Average RPIX inflation over 1997–2003 was 2.5 percent. With effect from 2004 the inflation target has been 2 percent for the CPI price index. I do not regard that as any significant change in the inflation target, since CPI inflation has on average been about 0.75 pp lower than RPIX inflation.[17] The average CPI inflation rate over 2004–2007 was 2.0 percent, while the average over the crisis years 2008–2011 is higher, at 3.4 percent. However, given the high unemployment rate in the United Kingdom during the crisis, optimal policy implies that inflation should overshoot the target. As noted previously, one might argue that the crisis years are special and could be excluded. If they are excluded for Sweden, the average CPI inflation rate over 1997-2007 was 1.3 percent, 0.7 pp below the target.

[16] In the period 1992-1996 the target was expressed as 2.5 percent *or lower* in terms of the RPIX price index [italics added].

[17] The CPI price index in the U.K. is the same as the HICP price index. Since 1993 average CPI inflation has been 0.75 pp lower than average RPIX inflation.

How have things turned out for the large economies, the euro area and the United States? The euro area has had a target for inflation, although during a shorter period than the countries mentioned earlier. The target is that HICP inflation should be below but close to 2 percent. The average HICP inflation rate in the euro area in the period 2000-2011 was 2.1 percent. The United States, on the other hand, did not have an explicit inflation target until the Federal Reserve announced a target of 2 percent for PCE inflation in January 2012.[18] However, a common view is that the Federal Reserve has even prior to this targeted a core inflation rate of 2 percent or somewhat lower. The average for core CPI inflation in the United States in the period 2000-2011 was 2.0 percent and for core PCE inflation 1.9 percent.

In this comparison, Sweden stands out, with average CPI inflation having significantly undershot the inflation target, whereas for the other countries average inflation has been quite close to the target or slightly overshot the target (except the U.K. for 2008–2011 when inflation substantially overshot the target).

Conclusions

By 1997, the new inflation-targeting regime had been established, in the sense that the inflation target was credible (inflation expectations were in line with the target), the repo rate (the Riksbank's policy rate) had been lowered to a normal level, and the Riksbank had had a few years to learn how to conduct inflation targeting. Over the last 15 years since then, 1997-2011, average CPI inflation has fallen short of the inflation target of 2 percent by 0.6 percentage points. But average inflation expectations according to the TNS Sifo Prospera survey have been close to the target. Thus, average inflation expectations have been anchored to the target and the target has become credible. If average inflation expectations are anchored to the target when average inflation differs from the target, the long-run Phillips curve is not vertical. Then lower average inflation means higher average unemployment. The data indicate that average inflation below target has been associated with average unemployment being about 0.8 percentage points higher over the last 15 years than would have been the case if average inflation had been equal to the target. This is a large unemployment cost of average inflation below a credible target. Some simple robustness tests indicate that the estimate of the unemployment cost is rather robust, but the estimate remains preliminary and further scrutiny may be needed to assess its robustness.

The difference between average inflation and average inflation expectations and the evidence of the existence of a downward-sloping long-run Phillips curve raises several questions that I believe need to be addressed. Why has average inflation fallen below the target for 15 years? Certainly, the experience of Australia, Canada, and the U.K. shows that it is possible to instead keep average inflation quite close to target during such a long period. What are the policy implications for the future? Do these findings make price-level targeting or the targeting of average inflation over a longer period relatively more attractive, since they would better ensure that average inflation over longer periods equals the target?

In a background study of the 2012 IMF Article-IV report on Sweden, Batini and Ishi (2012) note four possible reasons why the Riksbank has undershot the inflation target during the last 15 years:

> One possibility is that (1) the Riksbank may have conducted monetary policy in an asymmetric manner, de facto favoring lower inflation outcomes to higher ones. Alternatively, despite

[18] PCE inflation is inflation measured with the personal consumption expenditure deflator.

> symmetric stabilization preferences, (2) the Bank may have systematically overestimated potential unemployment. (This is reminiscent of the argument of Orphanides that the Fed caused too high inflation in the 1970s by underestimating potential unemployment). Or more generally, the Riksbank may have systematically overestimated inflationary pressures, one story being that (3) imported inflation systematically came in below expectations and (4) growth in productivity higher than expected. Last but not least, (5) (at least since the Great Recession) the pass-through from the repo rate to other rates, notably the mortgage rate, may have weakened, meaning that easy monetary conditions were not reflected de facto in an easier monetary stance, and implying a stronger disinflationary effect of policy than desired. (p. 39-40, numbers added)

To this one could add that (6) the Riksbank has missed or neglected a downward trend in mortgage rates, which has contributed to average CPI inflation being lower than average CPIX and CPIF inflation (this is a possible reason emphasized in Andersson, Palmqvist, and Österholm 2012) . Reason (2)-(4) and (6) involve systematic mistakes or neglects during the last 15 years, mistakes or neglects without which average inflation might have been on target and unemployment about 0.8 pp higher. The last reason, if applying only since the Great Recession, can account only for the last third of the last 15 years. However, if there is a suspicion that monetary policy is too tight because it is less effective, the appropriate policy response is easier policy than otherwise warranted. (This is an argument that I have put forward several times at the policy meetings.) Thus, these reasons hardly provide an excuse for undershooting the target and achieving higher average unemployment than necessary.

More generally, regardless of the reasons for the systematic undershooting of the inflation target, more expansionary policy during 1997-2011 could have brought both average inflation in line with the target and lower average unemployment. Given this, the unemployment loss during the last 15 years was unnecessary.

What are the policy implications for the future? One immediate conclusion is that it is important to keep average inflation over a longer period in line with the target, a kind of average inflation targeting (Nessén and Vestin 2005). This could also be seen as an additional argument in favor of price-level targeting, with a price-level target rising at the rate of the inflation target. On the other hand, in Australia, Canada, and the U.K., and more recently in the Euro area and the U.S., the central banks have managed to keep average inflation on or close to the target (the implicit target when it is not explicit) without an explicit price-level targeting framework.

Should the central bank try to exploit the downward-sloping long-run Phillips curve and secretly try to keep average inflation a bit above the target, so as to induce lower average unemployment than for average inflation on target? My answer to that question is no. It would involve saying one thing (the target is 2 percent) and deliberately doing another (keeping average inflation above 2 percent). This would be cheating and inconsistent with an open and transparent monetary policy. Regardless of the moral quality of the policy, the truth might eventually be leaked or discovered, in which case the inflation target would lose credibility and inflation expectations rise above the target, in which case the possible benefit of inflation above target would vanish.

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Appendix

Inflation expectations depending on the unemployment rate

A possible source of correlation between unemployment and the error term might be inflation expectations depending on unemployment. In (1), if inflation expectations π_t^e would depend on unemployment u_t, the error term ε_t in (6) would be correlated with u_t. However, an OLS regression of inflation expectations,

$$\pi_t^e - 2 = \beta_0 + \beta_1(\pi_{t-1}^e - 2) + \beta_2(\pi_{t-1} - 2) + \beta_3(\pi_{t-2} - 2) + \beta_4 u_t + \varepsilon_t ,$$

shows that inflation expectations do not depend on unemployment. As seen in table A1, the coefficient on unemployment is very small and not significant.

Table A1. Regression of one-year- ahead inflation expectations on annual CPI inflation and unemployment, 1996Q2-2011Q4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Const.	0.305724	0.167610	1.824021	0.0733
$\pi^e_{t\text{-}1}$	0.529811	0.132555	3.996910	0.0002
$\pi_{t\text{-}1}$	0.421106	0.061617	6.834281	0.0000
$\pi_{t\text{-}2}$	-0.320164	0.054593	-5.864521	0.0000
u_t	-0.037169	0.022897	-1.623345	0.1099

Note: OLS, $R^2 = 0.84$, adjusted $R^2 = 0.83$, S.E. of regression = 0.23, Durbin-Watson = 1.77