ISSN 1651-0852

FIEF Working Paper Series 2003

No. 188

Low-Inflation Targeting and Unemployment Persistence*

by

Per Lundborg and Hans Sacklén**

Abstract

A recent model by Akerlof, Dickens and Perry (2000) (ADP) predicts that low inflation may cause unemployment to persist at high levels. This finding should be of major interest to European countries where inflation is targeted at low levels. We specify a small open economy version of the ADP model and apply it to Swedish data. The results indicate that raising the Swedish inflation target from 2 to 4% would bring long-run unemployment down by two percentage points, to 2.0-2.5%. EMU membership, with inflation at the average of the present 0-2% band, would raise unemployment to around 6%. Membership thus implies a rejection of a national inflation target that could maximize employment. Given that long run unemployment-inflation trade-offs can be found in other countries as well, there is nothing to suggest that these trade-offs are identical across countries. A single inflation rate in the EMU may then cause unemployment to widely exceed the lowest sustainable rate in individual countries. We also extend the ADP model by showing theoretically that the unemployment minimizing inflation rate could lead to too low output. However, empirically we find, both for Sweden and the U.S., that minimum unemployment and maximum output occur at roughly the same rate of inflation.

Keywords: Phillips curve; Efficiency wages; Near-rationality.
JEL classification: E24; E31; J41

May 7, 2003

---

*We are grateful to George A. Akerlof for discussions. We have benefited from comments by Lawrence Ball, Mikael Apel and other participants at the workshop "The Phillips Curve: New Theory and Evidence" in Stockholm, May 2002. We also acknowledge useful comments from seminar participants at FIEF, Institute for International Economic Studies, the Riksbank, the Economic Council, Stockholm University and Göteborg University. The paper was presented at the XVI Congress of the European Economic Association in Lausanne, Switzerland.
** Professor Per Lundborg, FIEF, Wallingatan 38, S-111 24 STOCKHOLM, Sweden. Tel: 46 (8) 6969 912, Fax: 46 (8) 20 73 13, E-mail: p.lundborg@fief.se

1. Introduction

Following a wave of heavy anti-inflationary policies during the last decades, inflation targeting has today become the leading principle of monetary policy in many European economies. In the Euro area, the UK and Sweden, the targets are in the range 0-2.5 percent, which in a historical perspective is strikingly low; no OECD country has experienced inflation below two percent for any extended period after WWII and up to the 1990s.

The widespread implementation of low-inflation targets suggests a strong commitment to the idea of a vertical long run Phillips curve. According to this view, inflation has no long run effects on unemployment, implying that low unemployment in principle could coexist with low rates of inflation.[1] However, combinations of low unemployment and inflation in the range of 0-2 percent have not been observed other than for very short periods. Indeed, in sustained periods of low unemployment, inflation has been considerably higher than two percent.[2] Similarly, the period of low inflation since the early 1990s has been characterized by high, or very high, jobless rates.

A number of empirical studies have challenged the conventional wisdom that the long run Phillips curve is vertical. In particular, several studies have found adverse long run effects of *low* inflation. For example, Bullard and Keating (1995) reported a negative long run response of output to a reduction in inflation in European countries with low inflation. Studies on the U.S. by King and Watson (1994) and Fair (2000) suggest a long-run unemployment-inflation trade-off.

The possibility of an unemployment-inflation trade-off raises several intriguing questions. Rather than attributing high unemployment to shifts in the vertical Phillips curve, a trade-off would imply that heavy anti-inflationary policies might have caused unemployment to persist at high levels. This, of course, should be of special concern to countries aiming at very low inflation. If a trade-off exists, there should also be some concern about the viability of the EMU project. Since there is nothing to suggest that the trade-off is identical across member countries, how should an inflation target for the whole Euro area be determined? Given that

---

[1] Friedman (1968) and Phelps (1968) worked out the theoretical arguments for the vertical Phillips curve.

[2] A case in point is the period 1955-68 when average unemployment in the 19 OECD countries was around two percent and average inflation around four percent, i.e., substantially higher than the present targets.

membership implies a common (and low) inflation rate, could a country obtain more output and employment outside the union by opting for a country specific inflation target?

In addition to the empirical studies mentioned above, a growing literature has provided micro-economic rationales for a trade-off between unemployment and inflation at low inflation rates. One category of models builds on the existence of nominal wage rigidity. Using a wage bargaining approach, Akerlof, Dickens and Perry (1996) relies on the adverse effects of low inflation on real wage flexibility as originally discussed by Tobin (1972). If the inflation rate falls from, say, three to zero percent, some firms cannot reduce the nominal wage and are thus exposed to a real wage shock that causes unemployment to rise. Holden (2001) constructs a bargaining model based on legislation features that rule out unilateral nominal wage cuts, giving workers a stronger bargaining position at low inflation. The key implication of both models is a long run trade-off between unemployment and inflation at low inflation rates. Akerlof *et al.* (1996) applied their model to U.S. data, and later Djoudad and Sargent (1997) and Fortin and Dumont (2000) presented results based on Canadian data. Dickens (2001) included the same mechanism for a set of European countries. All these studies reject the traditional vertical Phillips curve in favor of the idea that wage rigidity yields a negatively sloped Phillips curve at low inflation.

Another approach relies on near-rationality, i.e., that agents under certain conditions may deviate from profit- or utility maximizing behavior. Already thirty years ago, Eckstein and Brinner (1972) noted that in the U.S., wage- and price-setters partially ignored inflation during years of low inflation. Building on this idea, and referring to extensive sociological and psychological evidence, George Akerlof, William Dickens and George Perry (2000) (henceforth ADP) present an efficiency wage model in which agents' behavior change as the economy shifts between high and low inflation regimes. If inflation is disregarded at low rates, the firm sets a lower wage and a lower price relative to nominal aggregate demand. As a result, unemployment can be sustained at lower levels than if inflation were fully accounted for. When tested on U.S. data, the standard Phillips relation is rejected in favor of the near-rationality hypothesis. Fortin and Dumont (2000) and Dickens (2001) provide further empirical support for the ADP model, for Canada and a number of European countries, respectively.[3]

[3]Also, without relying on money illusion, permanent nominal rigidities or departures from full rationality, Karanassou, Sala and Snower (2002) present a model based on "frictional growth" from which a long run trade-off can be derived.

The Phillips curve implied by the ADP model has several important implications. Above all, the model identifies an inflation rate that *minimizes* long run unemployment. Departures from this rate could potentially cause large costs in terms of unemployment. This feature makes the model particularly interesting to a country like Sweden, where inflation is targeted at a low level (two percent) and where full employment is given a high priority. For this reason, our primary objective in this paper is to estimate an open economy version of the ADP model on Swedish data. This allows us to examine whether a different inflation target would tend to bring long run unemployment down to a lower level. Our preferred regressions (based on survey data on inflation expectations) show that, by opting for an inflation target of 3.5-4.5 percent, unemployment could come down by two percentage points, to 2.0-2.5 percent.

Another important implication of the ADP model is that productivity changes with the rate of inflation. Consequently, there is no *a priori* reason why maximum output and minimum unemployment would coincide at some inflation rate. This aspect of the model was largely neglected by Akerlof *et al.* Therefore, our second objective in this paper is to extend their analysis to social optima other than minimum unemployment. We show that, in their theoretical model, minimum unemployment and *minimum* output can in fact occur at the same rate of inflation. However, our analysis of their empirical results indicates that low unemployment and high output more or less go hand-in-hand. Calculations based on our estimates of the Swedish long run Phillips curve yield similar results.

In the section that follows we first discuss agents' rationales for not taking low inflation fully into account. We then proceed to present a version of the ADP model suited for a small open economy, and we also extend the basic ADP model by analysing how effort (productivity) and output respond to changes in the rate of inflation. The econometric specifications and our data are introduced in section 3, which also contains the empirical results. In the final section we discuss the policy implications of our findings.

2. Near-rationality and the Phillips curve

2.1 Why inflation is disregarded at low rates

The ADP model recognizes that, during high inflation, all firms behave rationally by taking inflation fully into account when they set wages and prices. However, a special feature of the model is that some firms tend to disregard inflation when it is low and hence behave near-rationally.

Why would firms disregard low inflation? ADP present a large number of arguments (see ADP pp. 4-10 for a comprehensive survey), of which the so-called *editing* argument presumably is the most fundamental. Firms face a myriad of every-day decisions concerning product design, whom to employ, investments, cost reductions etc, that all are of some importance to profits. In such complex situations, firms tend to ignore factors that have little effect on profits. ADP show convincingly that losses from disregarding inflation in wage- and price-setting actually become negligible at low inflation rates. Hence, low-level inflation may simply disappear as a variable of relevance to profits.[4]

Is there any empirical support for the existence of near-rational behavior? ADP present a range of such evidence for the U.S.[5] For instance, the importance of inflation expectations in determining wages seems to depend on the inflation rate. ADP show that the magnitude of the coefficient on expected inflation depends crucially on the level of inflation. High inflation periods tend to yield coefficients around one while low inflation periods tend to yield estimated coefficients between zero and .5.[6]

ADP develop their arguments in an efficiency wage framework, implying that firms set wages unilaterally. This may be an adequate description of the U.S. labor market, but less so of European markets where collective bargaining dominates. However, any economy contains elements of both unilateral wage setting and bargaining. When applying the ADP model to Swedish data we implicitly assume that firms have enough latitude for efficiency wage setting. Studies by Agell and Lundborg (1995, 2003) have also shown that even for a typical bargaining economy like the

---

[4]At some low level, inflation may be perceived as price stability. Or, as argued in Blinder *et al.* (1998), “a prominent definition of price stability is inflation so low that it ceases to be a factor in influencing decisions”.

[5] See ADP pp 19-27.

[6] A consequence of inflation being disregarded would be a more frequent occurrence of nominal price contracts, which seems consistent with casual observations.

Swedish, firms' wage setting is affected by efficiency wage considerations.[7]

2.2 The ADP model for a small open economy

2.2.1 Effort and wage setting

Firms may, at any point in time, behave either rationally (indexed *r*) or near-rationally (*nr*). Rationality is characterized by firms' wage setting behavior. Rational firms know their workers' inflation expectations and incorporate these in wage setting. For reasons discussed in section 2.1, "near-rational" firms neglect to incorporate inflation when it is low. Whether a firm behaves rationally or near-rationally is not exogenously given but will be determined by the rate of inflation.

Firms set efficiency wages that minimize labor cost per expected efficiency unit, w_j/e_j^e. Let the effort that a firm of type $j=r,\ nr$ expects from their employees be a function of the wage, w_j, relative an expected reference wage, w_j^{eR}, and expected unemployment, u^e. Firms paying w_j expect the effort level

$$e_j^e = -A + B\left(\frac{w_j}{w_j^{eR}}\right)^{\alpha} + Cu^e, \tag{1}$$

where α is a constant in the zero to unity interval. *A*, *B* and *C* are all positive constants.

Firms set wages for the next period after having projected the effects of inflation on the reference wage of their workers. This *expected* reference wage, w_j^{eR}, determines the wage that a firm should pay and is specified as:

$$w_r^{eR} = \bar{w}_{-1}(1+\pi^e) \tag{2a}$$

$$w_{nr}^{eR} = \bar{w}_{-1} \tag{2b}$$

where $\bar{w}_{-1}$ is last period's average wage and π^e is expected consumer price inflation.[8] Minimizing w_j/e_j^e implies that the Solow condition will be

[7] See also Chen and Edin (2002).

[8] One could generalize (2b) such that some fraction of inflation is incorporated. ADP specify the theoretical model in this way, but in their empirical work they apply (2b).

satisfied, i.e., that the elasticity of expected effort with respect to the wage rate equals unity. Solving for the wage we obtain

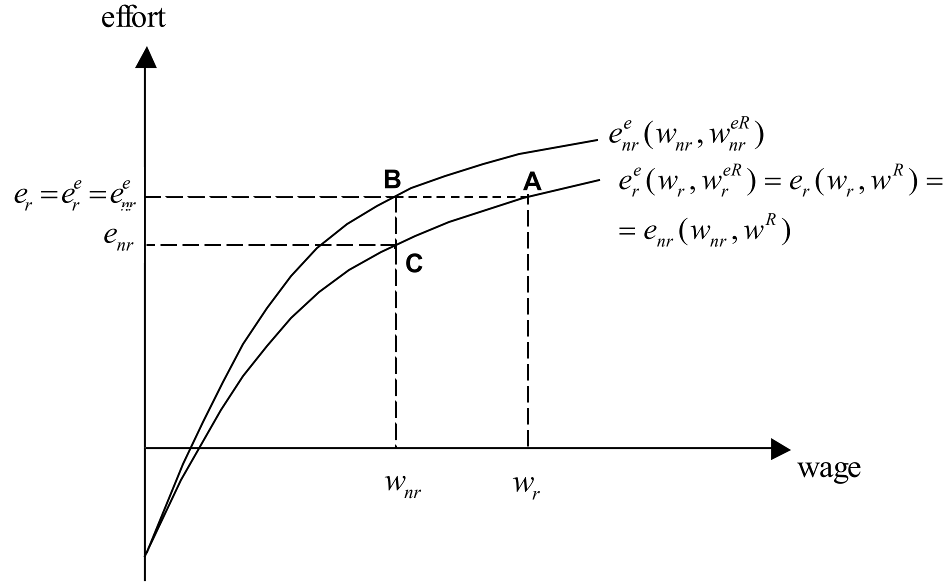
$$w_j = \left[\frac{A - Cu^e}{B(1-\alpha)} \right]^{1/\alpha} w_j^{eR} . \tag{3}$$

Workers' *actual* reference wage is specified as $w^R = \bar{w}_{-1}(1+\pi^e)$, i.e., all workers form their reference wage on the basis of last period's average wage. In addition, *all* workers want full compensation for expected inflation in consumer prices. If inflation is above zero, the implication is that rational firms base their wage setting decision on workers' true reference wage whereas near-rational firms underestimate it. The effort level supplied by workers in firm type *j*, e_j, can be found by substituting w^R for w_j^{eR} in (1); that is, $e_j = -A + B(w_j / w^R)^\alpha + Cu^e$.

The essence of the ADP model is summarized in *Figure 1*. Assuming a positive rate of inflation, near-rational firms base their wage setting on a reference wage that is lower than the one applied by fully rational firms ($w_{nr}^{eR} < w_r^{eR}$; see equation (2)). Hence, at a given wage rate, it follows from (1) that near-rational firms expect a higher effort level. The vertical distance between the two curves in Figure 1 illustrates this. We assume that the Solow condition is satisfied at point A for rational firms. From (3) we infer that the relation between the wage and the expected reference wage should be identical in the two types of firms. Thus, wages will be set such that expected effort is identical in all firms: while rational firms opt for point A, near-rational firms end up at point B.

Actual effort in rational firms is, of course, identical to expected effort. This is however not the case for near-rational firms. Since all workers have identical reference wages, it follows that workers in near-rational firms react to the lower wage (point B) by opting for a lower effort level. This outcome is illustrated by point C in Figure 1. (Note that only the lower curve is consistent with workers' true reference wage.) Hence, at the wage rate paid by near-rational firms, the Solow condition will be satisfied with respect to expected effort, but *not* with respect to actual effort.

Figure 1. Wages and effort levels



As will become clear below, wage differences across different types of firms will remain in place also in the long run.[9] One can, of course, question this property of the model. However, we can think of at least two arguments that can be put forward in its defense. As noted by ADP, the differences are small at reasonable levels of inflation. Moreover, it can be argued that workers compare wage rates per effort unit rather than just wages. Rational firms will indeed pay higher wages per effort unit, but the difference across firms will be even smaller than the difference in wages.[10]

2.2.2 Prices and profits

In an open economy, as assumed here, the average consumer price level $\bar{p}$ is determined as a weighted average of the prices set by domestic and foreign producers:

$$\bar{p} = (1-m)\bar{p}^d + m\bar{p}^m. \tag{4}$$

[9] It should be noted that the wage difference across firms does not cumulate over time. From (2) and (3) we see that wages in both types of firms are multiples of last period's average wage, which means that the relation $w_r / w_{nr} = (1+\pi^e)$ holds in each period.

[10] For positive inflation rates, equations (1)-(3) imply that $w_r / w_{nr} = (1+\pi) > (w_r / e_r) \div (w_{nr} / e_{nr}) = \alpha(1+\pi) / \left[(1+\pi)^{-\alpha} + \alpha - 1\right] > 1$.

$\bar{p}^d$ is the domestic consumer price, $\bar{p}^m$ the price of imported consumer goods and m the value of imported consumer goods as a share of total consumption. The quantity theory, with a constant normalized to unity, then gives us real income (aggregate demand) as $M/\bar{p}$, where M is the supply of money. We assume n monopolistically competitive firms that divide total aggregate demand between them according to the relative prices for their respective goods. These firms are either domestic or foreign, but in the following we focus solely on the behavior of domestic firms.

Domestic firms set the price p_j^d for their products and demand is given by $(M/n\bar{p})(p_j^d/\bar{p})^{-\beta}$, where β is the price elasticity of demand. The first order condition of the profit maximization problem implies that

$$p_j^d = \frac{\beta}{\beta-1}\frac{w_j}{e_j^e}. \tag{5}$$

Thus the domestic price is determined as a markup $\beta/(\beta\text{-}1)$ on the expected unit efficiency labor cost.

Profits, r_j, are determined as

$$r_j = \frac{M}{n\bar{p}}\left(\frac{p_j^d}{\bar{p}}\right)^{-\beta}\left[p_j^d - \frac{w_j}{e_j}\right], \tag{6}$$

where the term outside brackets represents the share of total demand for a firm of type j. The expression within brackets shows the profit per unit of output sold, i.e., the price less the wage in units of actual effort. Using our expressions for prices, wages and actual effort levels, it follows from (6) that near-rationality causes a relative decrease in profits equal to[11]

$$\frac{r_r - r_{nr}}{r_r} = 1-(1+\pi)^{\beta-1}\left[\beta-(\beta-1)\frac{\alpha}{(1+\pi)^{-\alpha}-1+\alpha}\right]. \tag{7}$$

2.2.3 Share of near-rational firms and the Phillips curve

A closer examination of (7) suggests that the losses of disregarding low inflation (say, below five percent) are negligible. As inflation increases, however, the losses will eventually become substantial. (See ADP pp.15-

[11] In these calculations expected and actual inflation are assumed to be identical.

16.) In line with the reasoning in section 2.1, one would therefore expect near-rational firms to become increasingly aware of foregone profits as inflation increases. Assuming that this "tolerance" towards losses differs across firms, it then follows that more and more firms would switch to fully rational behavior. When inflation reaches a sufficiently high level, all firms incorporate inflation in wage- and price setting, and we are back in a world of fully rational agents.

In the ADP model the above mechanism is specified in terms of threshold levels for losses induced by near-rational behavior relative to profits under full rationality. Once the relative loss reaches this threshold level, the firm switches from near-rational to fully rational behavior, or vice versa.[12] Heterogeneity enters by assuming a normal distribution of these thresholds, with mean μ and standard deviation σ. From (7) we then obtain the fraction of near-rational price setters as:

$$1-\Phi\left\{\frac{1-(1+\pi)^{\beta-1}\left[\beta-(\beta-1)\dfrac{\alpha}{(1+\pi)^{-\alpha}-1+\alpha}\right]-\mu}{\sigma}\right\}, \qquad (8)$$

where Φ is the standard cumulative normal distribution.

To derive the price Phillips curve, we proceed as follows.[13] Using equations (1) and (3) in equation (5) we may determine $p^d_{nr,t}$ and $p^d_{r,t}$. These are then used in

$$\overline{p}^d_t = \Phi_t p^d_{r,t} + (1-\Phi_t) p^d_{nr,t} \qquad (9)$$

which determines the average price level as a weighted average of prices set by rational and near-rational firms. With the corresponding expression at *t-1*, and some tedious calculations, we obtain the domestic short-run price Phillips curve as

[12] That is, the same mechanism applies whether the loss crosses the threshold from above or from below.

[13] We can summarize the equation system on level form as follows. The model consists of equation (4), two equations (2), two equations (1), two equations (3) and two equations (5). These nine equations determine nine unknowns $\overline{p}$, w^{eR}_r, w^{eR}_{nr}, e^e_r, e^e_{nr}, w_r, w_{nr}, p^d_r and p^d_{nr}.

$$(1+\pi_t^d)=\left(\frac{A-Cu_t^e}{A-Cu_{t-1}}\right)^{\frac{1-\alpha}{\alpha}}\left(\frac{A-Cu_{t-1}}{B(1-\alpha)}\right)^{\frac{1}{\alpha}}(1+\Phi_t\pi_t^e). \qquad (10)$$

The long run steady-state Phillips relation is characterized by equality between actual and expected inflation and by a constant (and known) unemployment rate. In our open economy version, inflation in consumer prices (π) is a weighted average of inflation in prices of domestically produced goods (π^d) and inflation in prices of imported goods (π^m), or, $\pi = (1\text{-}m)\pi^d + m\pi^m$. We assume that exchange rates adjust so that, expressed in domestic currency, $\pi^m = \pi^d = \pi$ holds for the long run. The Phillips relation then reduces to

$$u=\frac{A-B(1-\alpha)}{C}\left(\frac{1+\pi}{1+\Phi\pi}\right)^{\alpha}. \qquad (11)$$

The standard, fully vertical long run Phillips curve, which implies that unemployment always equals a "natural" rate, is derived under the assumption of full rationality. By allowing for near-rationality, we may note from (11) that this Phillips curve will, in general, not be vertical. Hence, the conventional concept of a "natural" rate of unemployment is less relevant for the ADP model; in the following we let the natural rate denote the level of unemployment that obtains when all firms behave rationally. This special case of (11) occurs if inflation is sufficiently high such that Φ =1. Since disregarding zero inflation is equivalent to fully rational behavior, the natural rate also obtains at $\pi = 0$. From (11) we see that the natural rate is given by is $u^n = (A\text{-}B(1\text{-}\alpha))/C$. The properties of the long run Phillips curve in (11) will be discussed in greater detail in section 2.3.1 below.

2.3 Extensions: Analysis of social optima

The Phillips curve in equation (11) implies a long run unemployment-inflation trade-off. ADP focused entirely on this trade-off and the inflation rate that minimizes unemployment. However, in a footnote they also recognized that, in their model, "…productivity varies with the rate of inflation. Therefore, at the minimum unemployment rate, output is not at its maximum." (ADP p.19, footnote 28). The purpose of this section is to extend ADP's analysis beyond the unemployment-inflation trade-off in order to gain a deeper understanding of the relation between inflation and welfare. Specifically, we shall explore the relation between inflation and other variables of importance to welfare, like effort and output (consumption). A major insight verified below is that the model does not rule out an effort-inflation trade-off at low inflation rates. Consequently, since employment and effort may go in different directions, we cannot rule out the possibility that output drops as inflation rises. In this situation, government decision-making obviously becomes more complicated than just directing monetary policy towards the inflation rate that minimizes unemployment.

The question whether effort and output increases or decreases in inflation is thus an empirical issue. Therefore, in order to give some quantitative content to the discussion below, we use the estimates reported by ADP for the U.S. in one of their "representative" Phillips curve regressions (see the first column of their Table 2 (p. 32)). This will serve as an illustration of the theoretical implications of the model as well as providing a firmer foundation for ADP's results with respect to the welfare-inflation relation.

This section is outlined as follows. First we briefly recapitulate the theoretical implications of the Phillips curve derived in the previous section (see ADP for a more detailed discussion). We then turn to the relation between effort and inflation, and, in the final subsection, the relation between output and inflation. Throughout this section we limit the analysis to the case where $\pi \geq 0$.[14]

2.3.1 Employment

Starting at price stability (i.e., $\pi = 0$), we see from (11) that unemployment equals the natural rate. As inflation increases above zero, however, near-rational firms opt for a wage that is lower than the wage set by fully rational firms. As this implies a lower average wage compared to the wage in an economy where all firms always behave rationally, unemployment will be lower than the natural rate. Consequently, the long run Phillips curve has a negatively sloped segment at low inflation rates.

As inflation rises, there are two opposing forces at work. While near-rational firms disregard *more* inflation, which tends to further reduce unemployment, it also becomes increasingly costly for firms to behave this way. More and more firms therefore switch to full rationality, and hence set

[14] Note also that we do not assign any direct costs to inflation. We are not aware of studies that have found any significant negative social costs of inflation in the low to medium ranges that we have in mind.

higher wages, which tends to increase unemployment. Eventually, at some inflation rate, the share of rational firms has increased to such an extent that unemployment actually starts to increase. This process continues until inflation has reached the level at which all firms have switched to fully rational behavior. At this level of inflation and above, unemployment is again at its natural rate.

Thus, the theoretical model yields the hump-shaped long run Phillips curve that ADP show in their Figure 1 (p. 18). Moreover, their empirical analysis forcefully supports the model. The shape of the Phillips curve has several interesting implications. Firstly there exists a lowest sustainable unemployment rate of inflation (LSURI), yielding the lowest sustainable unemployment rate (LSUR). Formally, the LSURI is the inflation rate where $\partial u/\partial \pi = 0$ in (11). Secondly, we may conclude that price stability is associated with maximum unemployment.

2.3.2 Effort

We consider, in turn, effort in rational firms, effort in near-rational firms, and average effort. For rational firms, using (3) and (11) in actual effort, $e_r = -A + Cu + B(w_r / w^R)^{\alpha}$, where $w^R = \bar{w}_{-1}(1+\pi)$, we find that long-run effort is given by

$$e_r = \alpha B \left[\frac{1+\pi}{1+\Phi\pi} \right]^{\alpha}. \tag{12}$$

Differentiating (12) with respect to inflation and evaluating at $\pi = 0$ shows that effort rises as we leave price stability. Comparing (11) and (12), it is obvious that the inflation rate that minimizes unemployment (LSURI) also is the rate that maximizes effort in rational firms. Thus, effort in rational firms will have the properties of the curve labeled "e_r" in *Figure 2*, which we have derived from the estimation results reported by ADP. As inflation increases from zero to a positive number, unemployment drops and this will tend to reduce effort. In the new equilibrium, however, firms have raised the wage relative to the reference wage - which tends to increase effort - in order to restore the Solow condition. It can easily be shown that this condition implies that the wage effect always dominates the direct effect of a change in unemployment. When inflation rises beyond the LSURI, and unemployment starts to increase, firms will set a lower wage relative to the reference wage, implying that effort starts to decline.

Repeating the calculations for near-rational firms, we obtain

$$e_{nr} = e_r \left[\frac{(1+\pi)^{-\alpha} + \alpha - 1}{\alpha} \right]. \qquad (13)$$

As expected, the two effort levels, e_r and e_{nr}, are identical at $\pi = 0$. However, that is where the similarities end. Differentiating e_{nr}, it can be shown that $\partial e_{nr} / \partial \pi \leq 0$ for any non-negative inflation rate. Thus, unlike effort in rational firms, effort in near-rational firms *decreases* as we leave price stability, and it continues to decline as inflation increases. This is illustrated by the curve labeled "e_{nr}" in Figure 2 (again based on the empirical results reported by ADP for the U.S.). Why does effort in rational and near-rational firms differ? As inflation increases from zero, the reduction in unemployment tends to lower effort in both types of firms. However, as noted above, firms will react by setting a higher wage so as to restore the Solow condition. This is true also for the near-rational firms, but by neglecting inflation the wage increase will be smaller than the increase in workers' reference wage. As a consequence, workers in these firms face both lower unemployment *and* a lower wage relative to the reference wage, and both effects have a negative impact on effort.[15]

Hence, effort in the two types of firms responds very differently as inflation increases, and the relative strength of the responses will be important in determining average effort. By definition, average effort is $e = \Phi e_r + (1-\Phi)e_{nr}$, and using (12) and (13) we obtain

$$e = e_r \left[\Phi + (1-\Phi) \frac{(1+\pi)^{-\alpha} + \alpha - 1}{\alpha} \right], \qquad (14)$$

where the share of rational firms, Φ, increases in inflation. Differentiating e with respect to π, and evaluating at $\pi = 0$, yields

$$\left. \frac{\partial e}{\partial \pi} \right|_{\pi=0} = -\alpha B(1-\Phi)(1-\alpha) \leq 0 \qquad (15)$$

[15] Note that the theoretical model above relies on the assumption that near-rational firms disregard *all* inflation. ADP also make this assumption in their empirical specification. In this case, effort in near-rational firms must decrease as inflation rises. However, if only some fraction of inflation is disregarded, effort in near-rational firms can (for some parameter configurations) actually increase in inflation, but still by less than in rational firms.

We thus infer that average effort drops as we move from price stability to positive inflation.[16] Since $e = e_r$ at $\pi = 0$, and since e again approaches e_r when inflation becomes sufficiently high, average effort will have a minimum at some intermediate inflation rate. Consider, for example, how average effort changes at the inflation rate that minimizes unemployment (LSURI):

$$\left.\frac{\partial e}{\partial \pi}\right|_{\pi=LSURI} = e_r \left\{ \frac{\partial \Phi}{\partial \pi} \left[\frac{1-(1+\pi)^{-\alpha}}{\alpha} \right] - (1+\pi)^{-\alpha-1} \right\} \begin{matrix} > \\ < \end{matrix} 0. \qquad (16)$$

From (16) we note that the inflation rate associated with minimum effort may be either lower or higher than the LSURI. As indicated by the curve labeled "*e*" in Figure 2, the estimation results reported by ADP for the U.S. suggest that average effort reaches a minimum at an inflation rate very close to the LSURI.

2.3.3 Output

Normalizing the labor force to unity, we define output (Q) as

$$Q = (1-u)e\,, \qquad (18)$$

where the unemployment rate, u, and average effort, e, are given by (11) and (14), respectively. As discussed above, the model predicts that employment and effort will move in opposite directions as inflation increases from zero to a small positive number. This, of course, opens for the possibility that output can go in either direction, depending on whether the boost in employment outweighs the reduction in effort. Differentiating (18) with respect to inflation, the first order condition for optimum output requires that

$$\varepsilon_\pi^e = -\varepsilon_\pi^{(1-u)}, \qquad (19)$$

where ε_π^e is the elasticity of average effort with respect to inflation and ε_π^{1-u} the elasticity of employment with respect to inflation. Equation (19) states that, at maximum output, the two elasticities should match, i.e., inflation should be determined so that the percentage change in employment equals the percentage change in effort.

[16] As discussed in the previous footnote, the model can be constructed such that effort in near-rational firms increases in inflation when inflation is low. Average effort would then, of course, also be positively related to inflation.

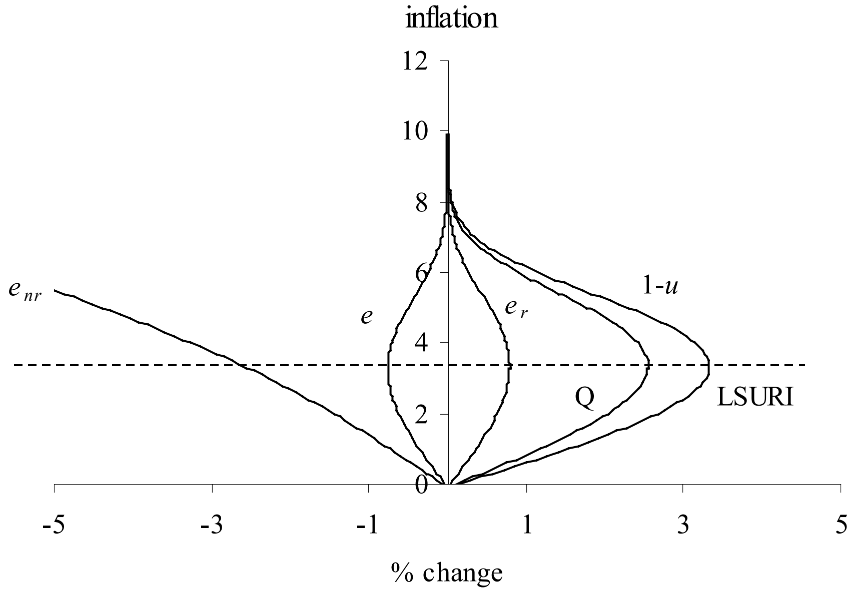
To see how output changes with inflation, we first evaluate the derivative $\partial Q/\partial \pi$ at $\pi = 0$. It is straightforward to verify that the sign of the derivative is indeterminate; that is, output may increase *or* decrease as inflation rises above zero. Thus, theory does not rule out a trade-off between output and inflation at low inflation rates. What does ADP's Phillips curve regression imply about the relation between output and inflation for the U.S.? Figure 2 illustrates how employment (1-*u*) and effort (*e*) move in different directions. At low rates of inflation the increase in employment more than outweighs the reduction in effort, which suggests that there is a positive relation between output (*Q*) and inflation. Output then rises as inflation accelerates, and this continues until the change in employment exactly balances the change in effort (i.e., until the condition in (19) is satisfied). Our calculations show that the output maximizing rate of inflation is very close to the LSURI. Output is maximized at an inflation rate of 3.5 percent, while maximum employment obtains at a slightly lower inflation rate, 3.4 percent.

To sum up this section, what can be said about the overall welfare implications of the model? For simplicity, let us disregard distributional issues and consider a function in which welfare depends positively on output (consumption) and negatively on effort and unemployment. If the unemployment-inflation trade-off were significantly stronger than the effort-inflation trade-off, then output maximum and unemployment minimum would occur at roughly the same rate of inflation. Hence, since both output and employment would be high and effort low, the LSURI would unambiguously be associated with a high level of welfare.[17] If, on the other hand, the effort-inflation trade-off were significantly stronger than the unemployment-inflation trade-off, then there would be an output-inflation trade-off as well. In this case, the level of welfare associated with the LSURI would be ambiguous.

In ADP's representative regression the welfare implications appear unambiguous. Not only does the LSURI yield minimum unemployment and, roughly, maximum output, but it also implies an effort level very close to its minimum. Hence, all three arguments tend to affect welfare favorably.

[17] If the unemployment-inflation and the effort-inflation trade-offs were approximately the same, then output would remain unaffected by changes in inflation. As a result, since employment would be high and effort low, the LSURI would again be associated with a high level of welfare.

Figure 2. Employment, effort, output and inflation in the U.S. Derived from the results in Akerlof et al. (2000)



Note: The curves are based on ADP´s regression presented in the first column of their Table 2 (p. 32). Each variable is expressed in terms of the percentage change compared to the value at price stability. For instance, the value of *e* at π=2% equals $((e_{\pi=2} - e_{\pi=0})/ e_{\pi=0})*100$. The employment curve (1-*u*) can be derived directly from the estimated Phillips curve. For the effort functions, however, we note that ADP's empirical specification leaves the parameters *A, B, C*, and α unidentified. By expressing the variables in terms of relative changes rather than levels, the only unknown parameter is α. To simplify the exposition, we have drawn the curves for $\alpha = 0.5$. As this parameter is in the zero to unity interval, one can easily study how the curves change as this parameter changes. For example, the average effort curve (*e*) shifts to the right as α increases, and for α approaching unity the curve becomes almost vertical. As a consequence, the output curve (*Q*) approaches the employment curve (1-*u*).

ADP applied the model to the U.S., but it can be argued that their model is of even greater interest to economies with explicit inflation targets (or bands). In the section that follows, we shall apply the model to Sweden, where an inflation target of two percent has been in operation since the mid-90s. We ask to what extent conclusions for the U.S. carry over to a small open economy, how the Phillips curves at low inflation differ between Sweden and the U.S., and, in particular, if the present Swedish inflation target is far off Sweden's LSURI and output maximizing inflation level. This analysis may also promote a better understanding of the consequences of membership in the EMU, where countries when entering give up the possibility of setting a national inflation target.

3. The Swedish long-run Phillips curve

3.1 Empirical specifications and data

In order to proceed towards an empirical specification, we return to equation (10). Taking logs and making the same approximations as ADP yields

$$\pi_t^d = d - gu_t^e + \Phi_t \pi_t^e + \gamma \Delta u_t^e. \qquad (20)$$

In line with ADP, we approximate the argument in the standard normal c.d.f. as derived in (8) by $D + E\pi_L^2$, where D and E are parameters.[18] π_L represents the effects of past inflation on the likelihood that people act rationally toward inflation. The Phillips relation that we estimate then becomes:

$$\pi_t^d = d + a_1 u_t^e + a_2 u_{t-1} + \Phi(D + E\pi_{L,t}^2)\pi_t^e + kX_t + \varepsilon_t, \qquad (21)$$

where d, D, E, a_1, a_2 and k are parameters, X is a vector of dummy variables, and ε_i is the error term.

We proxy π_L by several different specifications suggested by ADP. One is a geometrically declining weighted moving average of past inflation:

$$\pi_{L,t} = (1-\delta)\pi_{L,t-1} + \delta\pi_{t-1}, \qquad (22)$$

in which δ is estimated. An alternative specification is

$$\pi_{L,t} = \frac{\sum_{i=1}^{I}(1-i\lambda)\pi_{t-i}}{\sum_{i=1}^{I}(1-i\lambda)}, \qquad (23)$$

[18] When ADP in a number of simulations approximated the loss function by $E\pi_L^2$ (where E was chosen so that the approximation was identical to the "true" loss at five percent inflation) this loss was never off by more than three percent of the true loss. Moreover, a constant term, D, was added so as not to constrain the share of rational firms to 50 percent at zero inflation. (For details, see ADP pp.28-29.)

where λ is estimated, i indexes quarters and I is set to 16 quarters. In addition to these formulations, we also apply the following weighting procedure

$$\pi_{L,t} = \sum_{i=1}^{I} g_i \pi_{t-i}, \tag{24}$$

in which the weights g_i are estimated ($0 \leq g_i \leq 1$ and $\sum_{i=1}^{I} g_i = 1$) and the lag length I is set to 16 quarters. To reduce the number of parameters in estimation we simplify (24) by restricting the weights to be identical within each year.

To control for inflation expectations, π^e, the predominant method has been to apply some adaptive expectations scheme. Like ADP, we shall first follow this estimation procedure and apply (22)-(24) also for this variable. We also run regressions allowing the weights in (24) to differ across quarters. In addition, we are fortunate to have an interesting set of survey data on households' inflation expectations that we shall utilize.

In determining expected unemployment, u^e, we set the lag length to either two or twelve periods. We first run regressions on open unemployment, but later vary these to include several alternative measures of unemployment.

Our relevant price inflation index for the dependent variable is one that measures prices of goods produced domestically and consumed domestically. For a large economy like the U.S. (for which ADP estimate their model), the consumer price index may be a relevant index. This, however, would not be the case for a small open economy like the Swedish. Taking the differences of (4), holding the import share constant, we may derive the relevant price inflation for goods produced and consumed in a small open economy as

$$\pi_t^d = \frac{\Delta p_t - m_t \Delta p_t^m}{p_{t-1} - m_t p_{t-1}^m}, \tag{25}$$

which is our dependent variable.

We use quarterly data from 1963:1 to 2000:2 which are annualized by calculating the percentage change in the relevant price indices during the last four quarters.[19]

[19] Our quarterly data are in turn based on the average value of the price level of the three months that constitute each quarter.

Estimating the model for a small open economy implies that one must consider the dependence on external factors. As mentioned above, our dependent variable, inflation in products produced and consumed in Sweden, is determined as the difference between CPI and imported inflation. However, our inflation series for imported goods includes not only consumption goods but also intermediary goods. This introduces a measurement error into our domestic inflation series in periods when prices of intermediate goods move differently than prices of consumption goods. To account for this, we introduce a number of dummy variables to capture oil price increases in 1973-74 and 1979-1981, and decreases in 1986. Dummies also cover price hikes on food inputs in the early 1970s, the Swedish tax reform in 1990-91 and the extreme wage increases in 1995-96 that can be traced to foreign increases in prices of pulp and paper. All variables are defined in greater detail in Appendix 1.

3.2 Results

Using maximum-likelihood methods, we have estimated a total of 120 specifications. The regressions differ with respect to sample periods, measures of unemployment and the way in which inflation expectations are accounted for. We consider 113 regressions to have come out without any major problems in terms of identification, meaningful parameter estimates etc.[20]

The following result section deals exclusively with the long-run Phillips curve.[21] We first focus on the results using estimated (adaptive) inflation expectations, not because we place more trust in these results, but simply because this is the conventional way of dealing with expectations. We then present what we consider to be a more reliable set of results based on surveys of inflation expectations.

---

[20] For the remaining cases we ran into similar problems as ADP did for the U.S. For instance, in some regressions, the estimates of D and E tended to approach minus infinity and infinity, respectively. We cannot say whether this is due to data limitations or if data actually reject the hypothesis that Φ varies with inflation; if the true value of Φ is unity, then E and D cannot be identified.

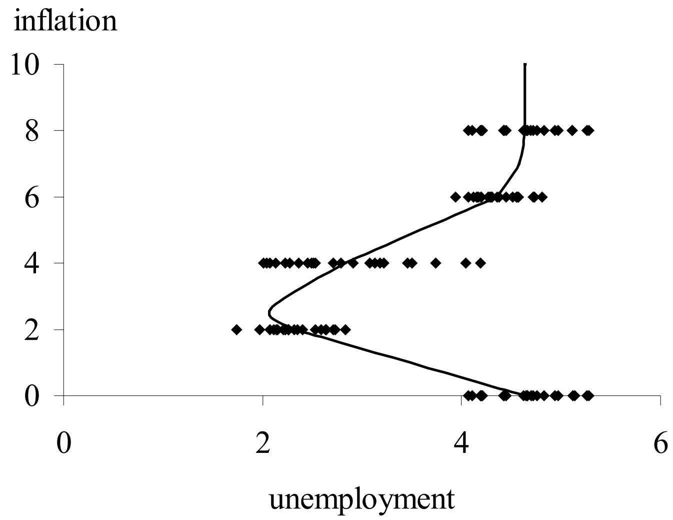
[21] Imposing equality between expected and actual inflation, and a constant unemployment rate, the long run Phillips relation implied by (20) is $u = (d/g) - (1-\Phi)\pi/g$. The "natural" rate of unemployment, defined as the rate that obtains when all firms are rational, is thus given as $u^n = d/g$.

3.2.1 Estimated expectations

If the parameter *E* is zero, the coefficient on expectations will not vary with inflation, which would reject the theory. In 23 of our 24 regressions we find, though, that *E* is significantly positive as predicted by theory.[22] The average estimate of the LSUR is 2.08 percent, obtained when inflation is targeted at 2.61 percent. The vast majority of LSURs ranges between 1.6 and 2.5 percent and the associated LSURIs range between 2.0 and 3.0 percent.[23]

Figure 3 summarizes some crucial features of the long run Phillips curves implied by the regressions. For each regression we have evaluated the unemployment rate associated with zero, two, four, six and eight percent inflation. To obtain a "representative" Phillips curve we then fitted a curve through the average unemployment rate at the different levels of inflation.[24] For instance, consider the effect on unemployment of changing the rate of inflation from zero to the LSURI. The gains are large as we leave absolute price stability. The marginal gains are then gradually reduced as we approach the LSURI, where the total reduction in unemployment amounts to almost 2.5 percentage points.

Figure 3. Estimated expectations: the "average" Phillips curve



[22] As discussed in section 3.1, we use four alternative measures for π^e, three measures for π_L, and two alternative lag lengths for unemployment. This gives us 24 possible combinations. In one regression we obtained estimates that implied a value of Φ equal to unity regardless of the rate of inflation. We deleted this single regression in the following presentation.

[23] These results are summarized in *Figure 5*, in section 3.2, below.

[24] We capture the unemployment minimum by fitting the curve through the average LSUR and LSURI.

Table 1. Estimated parameters for the long run Phillips curve 1963-2000[a]

Independent variables and characteristics	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Constant	0.017 (5.07)	0.015 (3.73)	0.015 (4.13)	0.011 (2.94)	0.014 (4.08)	0.011 (3.36)
u_{t-1}	-1.177 (-2.55)	-0.975 (-1.85)	-1.139 (-2.41)	-1.070 (-2.00)	-1.089 (-2.36)	-1.035 (-2.02)
u_{t-2}	0.834 (1.78)	-0.002 (-0.01)	0.773 (1.60)	0.249 (0.28)	0.780 (1.67)	0.203 (0.22)
D (constant in coefficient on expectations)	-0.315 (-0.96)	0.047 (0.10)	0.259 (0.55)	0.466 (0.71)	0.141 (0.33)	0.570 (0.77)
E (coeff. of π_L in coeff. on expectations)	695.87 (3.43)	557.36 (2.28)	570.73 (4.58)	663.69 (2.95)	653.85 (3.73)	689.36 (3.04)
Method for constructing π_L	Geometrically declining weights, eq. (22)	Geometrically declining weights, eq. (23)	16-quarter MA with different weights for each year, eq. (24)	Geometrically declining weights, eq. (22)	Geometrically declining weights, eq. (23)	16-quarter MA with different weights for each year, eq. (24)
Method for constructing π^e	Geometrically declining weights, eq. (23)	16-quarter MA with different weights for each year, eq. (24)	16-quarter MA with different weights for each year, eq. (24)	Geometrically declining weights, eq. (22)	16-quarter lag with different weights for each quarter, eq. (24)	16-quarter lag with different weights for each quarter, eq. (24)
Unemployment measure	Open unempl.	Open unempl.	Open unempl.	Open unempl.	Open unempl.	Open unempl.
No. of unempl. lags	2	12	2	12	2	12
Sample period	1963:1-2000:2	1963:1-2000:2	1963:1-2000:2	1963:1-2000:2	1963:1-2000:2	1963:1-2000:2
LSURI	**2.98**	**2.81**	**2.64**	**2.38**	**2.54**	**2.23**
LSUR	**1.61**	**1.94**	**2.26**	**2.57**	**2.08**	**2.71**
$\Phi(\pi=0.0)$	0.300	0.519	0.602	0.679	0.556	0.716
$\Phi(\pi=2.0)$	0.399	0.606	0.687	0.764	0.655	0.801
$\Phi(\pi=4.0)$	0.707	0.826	0.879	0.931	0.882	0.953
$\Phi(\pi=6.0)$	0.970	0.980	0.990	0.997	0.994	0.999
$u(\pi=0.0)$	0.053	0.047	0.041	0.047	0.044	0.042
$u(\pi=2.0)$	0.022	0.022	0.024	0.026	0.022	0.027
$u(\pi=4.0)$	0.022	0.025	0.028	0.035	0.029	0.035
$u(\pi=6.0)$	0.048	0.043	0.039	0.046	0.043	0.042
DW-statistic	1.531	1.506	1.348	1.619	1.518	1.551
R^2	0.868	0.873	0.860	0.871	0.879	0.886

[a] Asymptotic t-values in parentheses. Detailed results for all regressions are available on request.

In *Table 1* we present detailed results of six selected regressions. For example, the table shows the size of the coefficient on inflationary expectations, Φ, when evaluated at different rates of inflation. At zero inflation, the size varies across models from .30 (model 1) to .72 (model 6). The coefficient then increases with inflation and is close to unity when inflation reaches six percent. Recall that the theoretical model interprets the coefficient Φ as the share of fully rational firms. This interpretation thus suggests that many firms take inflation fully into account already at price stability, and almost all firms behave rationally at six percent inflation.

So far, the results have indicated a great deal of robustness to variations in the way expectations are estimated. However, we are also interested in investigating how the model performs with respect to other definitions of unemployment and to other sample periods. The results are presented in some detail in Appendix 2. The LSURI does not change in any significant way when open unemployment is replaced by total unemployment or unemployment among prime aged males. In some regressions we excluded the turbulent 1990s. This shifted the LSURs downwards while the LSURIs were not significantly affected.

3.2.2 Direct measures of expected inflation

It is far from obvious that estimated adaptive expectations capture households' true expectations on inflation. To illustrate this point, *Figure 4* contrasts the expectations implied by model 5 in Table 1 to survey data on households' expectations which is available for the period 1979:3-2000:2. The estimated series follows CPI quite closely. Notable is that there are apparent deviations from the directly measured inflation expectations. Given that the survey data better reflect households' true inflation expectations, one might suspect that the results obtained above could be misleading.

Although our survey data are restricted to 1979-2000, we re-estimated the model using these data. The results for some of our regressions are reported in *Table 2*, as models 1, 2 and 3. A vital observation is that the change of data does not cause a rejection of the overall results discussed above. The parameter *E* is still, without exception, significantly positive. Hence, as predicted by theory, the reaction coefficient of price inflation to expected inflation (Φ) is significantly smaller in low- than in high-inflation periods. *Figure 5* shows that the average LSURI using survey data (4.01 percent) is somewhat higher than the average obtained with estimated expectations (2.61 percent). Similarly, the average LSUR increases when we substitute survey data for estimated expectations (from 2.08 to 2.85 percent).

One disadvantage of using the relatively short survey data series is that we are unable to utilize the full length of the data on inflation and unemployment. Moreover, the relatively short sample period raises the question whether the results from these regressions may have been plagued by small sample bias. To address these issues, we next *imputed* survey data for the period 1963:1-1979:2 in order to obtain a full survey data series for 1963:1-2000:2.[25] Table 2, models 4-6, shows detailed results from some regressions based on this extended survey data set. The plot in Figure 5 illustrates the most important result, namely that the LSURIs are very similar to those obtained using the original survey data. Hence, the LSURIs appear not to be affected by the sample period.

To give an idea of what the individual Phillips curves look like, *Figure 6* displays two representative curves from the regressions where we used survey data on inflation expectations. There is a clear indication that inflation needs to be around four percent in order to be compatible with the lowest sustainable rate of unemployment. Note also that a monetary policy aiming at price stability appears to bring large costs in terms of high unemployment, around seven percent, which should be compared to the 2-2.5 percent associated with four percent inflation.

Can the Phillips curve(s) in Figure 6 predict Sweden's recent macroeconomic performance? The problem is, of course, that we cannot tell whether actual observations on unemployment and inflation reflect a long run relation or merely capture short run deviations from the long run Phillips curve. However, the fact that the Swedish Riksbank during the last ten years[26] has targeted inflation (at two percent) is helpful in this respect. After a short period of virtual price stability, inflation gradually converged to two percent and has been stable around this level for a period exceeding two years. Unemployment fell continuously during the latter part of the 1990s, from around eight percent in 1997 down to four percent, a level at which it has been stable for more than two years. At two percent inflation, unemployment has thus remained at the level predicted by our survey data regressions.

[25] We fitted a regression model that determines our survey data as a non-linear function of lagged CPI and predicted a series for the 1963:1-1979:2 period.

[26] An inflation target of two percent (with a lower and upper bound of one and three percent, respectively) was announced in 1993, and the Riksbank assessed that the target would be met during the twelve months of 1995.

Table 2. Estimated parameters for the long run Phillips curve[a]

Independent variables and characteristics	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Constant	0.032 (6.17)	0.042 (8.48)	0.035 (6.25)	0.044 (10.0)	0.039 (9.49)	0.043 (9.90)
u_{t-1}	-0.595 (-1.40)	-0.896 (-1.66)	-0.223 (-0.53)	-0.904 (-1.54)	-0.405 (-0.79)	-0.952 (-1.59)
u_{t-2}	0.169 (0.39)	-0.870 (-0.85)	-0.249 (-0.59)	0.630 (0.66)	-0.111 (-0.22)	0.606 (0.52)
D (constant in coefficient on expectations)	-1.126 (-1.79)	-0.906 (2.03)	-0.509 (-1.58)	-1.306 (3.81)	-1.356 (3.54)	-1.318 (-3.59)
E (coeff. of π_L in coeff. on expectations)	578.51 (2.63)	451.83 (3.46)	373.20 (4.76)	442.75 (4.59)	688.38 (4.61)	451.61 (4.23)
Method for constructing π_L	Geometrically declining weights, eq. (22)	16-quarter MA with different weights for each year, eq. (24)	Geometrically declining weights, eq. (23)	Geometrically declining weights, eq. (22)	16-quarter MA with different weights for each year, eq. (24)	Geometrically declining weights, eq. (23)
Method for constructing π^e	Survey data	Survey data	Survey data	Survey data for 1979:3-2000:2, imputed survey data for 1963:1-1979:2.	Survey data for 1979:3-2000:2, imputed survey data for 1963:1-1979:2.	Survey data for 1979:3-2000:2, imputed survey data for 1963:1-1979:2.
Unemployment measure	Open unempl.	Open unempl.	Open unempl.	Open unempl.	Open unempl.	Open unempl.
No. of unempl. lags	2	12	2	12	2	12
Sample period	1979:3-2000:2	1979:3-2000:2	1979:3-2000:2	1963:1-2000:2	1963:1-2000:2	1963:1-2000:2
LSURI*100	**3.76**	**4.01**	**3.97**	**4.50**	**3.83**	**4.47**
LSUR*100	**2.09**	**2.96**	**3.52**	**2.31**	**2.35**	**2.26**
$\Phi(\pi=0.0)$	0.130	0.182	0.305	0.096	0.063	0.094
$\Phi(\pi=2.0)$	0.185	0.234	0.360	0.130	0.104	0.128
$\Phi(\pi=4.0)$	0.420	0.427	0.535	0.275	0.332	0.276
$\Phi(\pi=6.0)$	0.831	0.764	0.798	0.613	0.827	0.621
$u(\pi=0.0)$	0.076	0.065	0.075	0.073	0.076	0.072
$u(\pi=2.0)$	0.038	0.041	0.047	0.044	0.041	0.043
$u(\pi=4.0)$	0.021	0.030	0.035	0.024	0.024	0.024
$u(\pi=6.0)$	0.052	0.043	0.049	0.034	0.055	0.034
DW-statistic	1.002	1.150	1.056	1.544	1.283	1.432
R^2	0.933	0.948	0.931	0.876	0.847	0.872

[a] Asymptotic t-values in parentheses. Detailed results for all regressions are available on request.

Figure 4. CPI and expected inflation

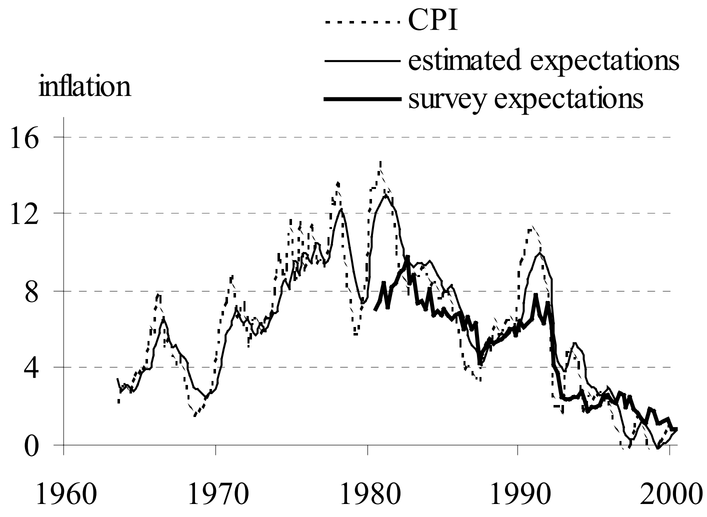


Figure 5. Inflation and minimum unemployment

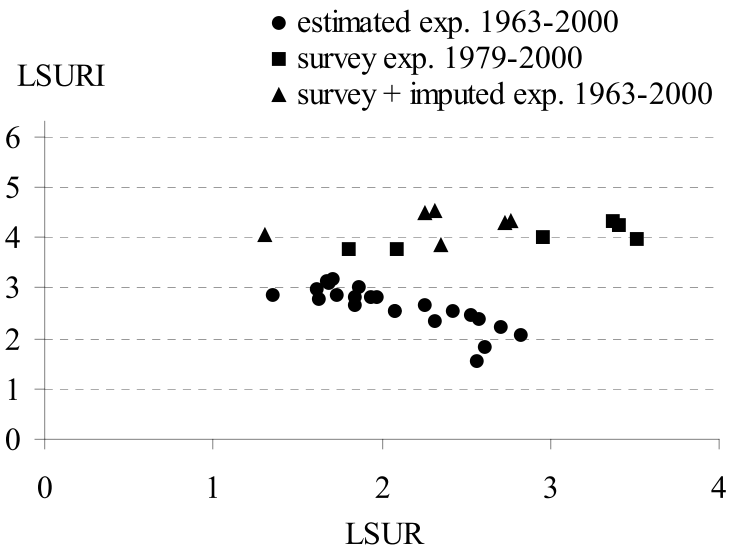


Figure 6. Survey data: two representative Phillips curves

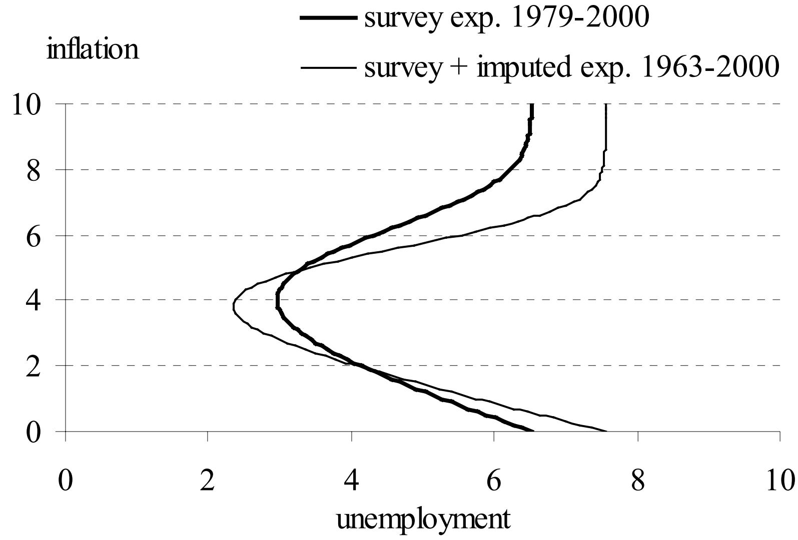
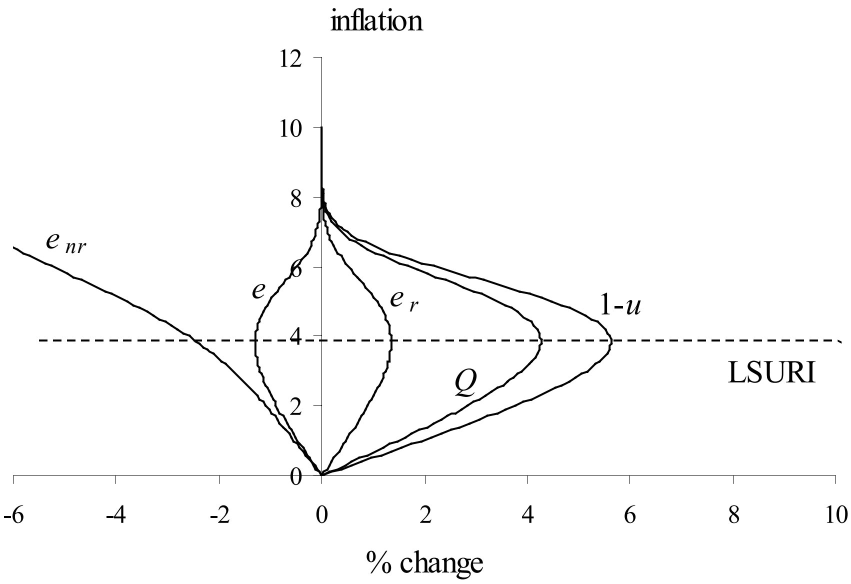


Figure 7. Employment, effort, output and inflation



Note: The curves are generated from the results for *Model 5* in Table 2. Each variable is expressed in terms of the percentage change compared to the value at price stability. By expressing the variables in terms of relative changes rather than levels, the only unknown parameter is α. To simplify the exposition, we have drawn the curves for $\alpha = 0.5$. (See the corresponding note in Figure 2 for more details.)

We have in this section focused entirely on the unemployment-inflation trade-off. However, as noted in section 2.3 above, alternative social optima may exist and the inflation rate that minimizes unemployment could in principle be associated with a low level of output. What do our regressions for Sweden imply about the relation between output and inflation? *Figure 7* explores the results for the regression based on survey data 1963-2000 that was shown in Figure 6 (model 5 in Table 2). First, our calculations show that average effort (*e*) reaches its minimum at an inflation rate very close to the LSURI. Second, the increase in employment (1-*u*) more than outweighs the reduction in effort, implying a positive relation between output (*Q*) and inflation when inflation is low. Moreover, output maximum and unemployment minimum occur at roughly the same rate of inflation, slightly below four percent. Moving from two to four percent inflation would thus increase employment and output, whereas average effort would drop.

4. Policy discussion

Akerlof *et al.* (2000) strongly rejected the vertical long run Phillips curve when their model was applied to U.S. data. In the present paper we have shown that Swedish data also reject the idea of a vertical curve. This finding has a number of interesting implications for the Swedish economy and, potentially, for other European countries as well.

First, a major consequence is that the level of the inflation target really matters. The Swedish two percent target appears to be far off the level that minimizes unemployment. By doubling inflation, unemployment could in the long run settle at 2-3 percent and have considerable output effects. Hence, the conclusion must be that the Swedish Riksbank has pursued a highly contractive monetary policy during the period of targeting, i.e., since the mid-1990s. We cannot say whether the ECB's policy has been contractive or not; however, with inflation targeted even lower than in Sweden, and with EURO-land experiencing very high unemployment rates, this could well be the case.

Secondly, our results suggest that if Sweden joins the EMU, and the ECB continues to aim at an inflation rate below two percent, then (*ceteris paribus*) Sweden would move even further away from a point of minimum unemployment and maximum output. With inflation targeted at one percent, i.e., at the average of the ECB's inflation band, Swedish unemployment would approach six percent.[27] The EEAG proposition that medium-run average inflation should be targeted at 2.5 percent is a step in the right direction but, nevertheless, too low a target from a Swedish perspective.[28]

Finally, our results may point at a potential problem inherent with the EMU project. As we compare our results to those for the U.S. in Akerlof *et al.* (2000), and for Canada in Fortin and Dumont (2000), we find that the lowest sustainable unemployment rate is considerably lower and the associated inflation rate slightly higher in Sweden.[29] While detailed studies on other countries are needed, there is, of course, nothing to suggest that the Phillips curves are similar, or even remotely so, across countries. For instance, with the present UK target set higher than the Swedish, EMU membership could very well imply a major unemployment increase also for this country. A crucial observation is that even if an inflation level could be determined that minimizes unemployment for the Euro area, this level could still generate unacceptable unemployment rates in individual member states. The rejection of a national inflation target would then be a major cost of EMU membership. If the unemployment-inflation trade-off differs greatly, it would be a highly delicate, and possibly insurmountable, issue for the union to agree on a common inflation target.

It could, of course, be argued that the model is specified without any costs of inflation that would make a target at, say, four percent less desirable. However, there is little or no evidence that four percent inflation would be significantly more costly than two percent. Changing the inflation target may involve short run adjustment costs as it takes time to establish credibility for a new target. (The alternative route of EMU membership would of course lead to similar adjustment costs.) Nevertheless, it must be difficult to argue convincingly that such costs would exceed the gains in terms of higher employment and output. As long as there are no costs of slightly higher inflation, even skeptics of the theoretical framework or the

[27] See the regressions based on survey data in Figure 6. Some argue that the ECB's effective target is 1.5 percent. This rate would yield a Swedish unemployment rate of 5-5.5 percent.

[28] See CESifo (2003). EEAG is the European Economic Advisory Group.

[29] A majority of the regressions for the U.S. suggests an LSURI in the 2.5-3 percent range. The results for Canada point at an LSURI of approximately 2.8 percent. Using total rather than open unemployment would perhaps result in a more accurate comparison of our results to those for the U.S. and Canada (open unemployment would be considerably higher in Sweden in the absence of labor market programs). Regressions on total unemployment yield results closer to those reported for the U.S. and Canada (see *Figure A1* in Appendix 2).

empirical results should be able to accept a higher target as a measure to reduce the risk of persistently high unemployment.

References

Agell, J. and P. Lundborg (1995), ”Theories of Pay and Unemployment: Survey Evidence from Swedish Manufacturing Firms”, *Scandinavian Journal of Economics* 97, 295-307.

Agell J. and P. Lundborg (2003), ” Survey Evidence on Wage Rigidity and Unemployment: Sweden in the 1990s”, *Scandinavian Journal of Economics* (forthcoming).

Akerlof, G. A., W. T. Dickens and G. L. Perry (1996), ”The Macroeconomics of Low Inflation”, *Brookings Papers on Economic Activity*, 1, 1-59.

Akerlof, G. A., W. T. Dickens and G. L. Perry (2000), ”Near-Rational Wage and Price Setting and the Long Run Phillips Curve”, *Brookings Papers on Economic Activity*, 1, 1-44.

Blinder, A. S. et al. (1998), ”*Asking About Prices: A New Approach to Understanding Price Stickiness*”, New York: Russell Sage Foundation.

Bullard, J. and J. W. Keating (1995), ”The Long Run Relationship between Inflation and Output in Post-war Economies”, *Journal of Monetary Economics*, 36, 477-496.

CESifo (2003), Report on the European Economy 2003. Ifo Institute for Economic Research. Munich.

Chen P. and P. A. Edin (2002), ”Efficiency Wages and Industry Wage Differentials: A Comparison Across Methods of Pay”, *The Review of Economics and Statistics*, vol LXXXIV, November, no 4, 617-631.

Dickens W. T. (2001), ”Comments on Charles Wyplosz’s `Do We Know How Low Inflation Should Be?”, mimeo, the Brookings Institution, Washington.

Djoudad, R. and T. C. Sargent (1997), ”Does the ADP Story Provide a Better Phillips Curve for Canada?”, Unpublished working paper, Economic Studies and Policy Analysis Division, Department of Finance, Ottawa, October.

Eckstein, O. and R. Brinner (1972), ”The Inflation Process in the United States”, Joint Economic Committee of the Congress of the United States. Government Printing Office.

Fair, R. (2000), ”Testing the NAIRU Model for the United States”, *Review of Economics and Statistics*, 82(1), 64-71.

Fortin, P. (2001), ”Inflation Targeting: The Three Percent Solution”, *Policy Matters*, Vol 2(1), Institute for Research in Public Policy.

Friedman, M. (1968), ”The Role of Monetary Policy”, *American Economic Review*, 58(1), 1-17.

Holden, S. (2001), ”Monetary Policy and Nominal Rigidities under Low Inflation”, mimeo, Department of Economics, University of Oslo.

Karanassou, M., H. Sala and D. J. Snower (2002), ”A Reappraisal of the Inflation-Unemployment Tradeoff’, Department of Economics, Queen mary, University of London, WP no 479, December.

King, R. G. and M. W. Watson (1994), ”The Post-War U.S. Phillips Curve: A Revisionist Economic History”, *Carnegie-Rochester Conference Series on Public Policy* 41, 157-219.

Phelps, E. (1968), ”Money-Wage Dynamics and Labor-Market Equilibrium”, *Journal of Political Economy*, 76(4, part 2), 678-711.

Tobin, J. (1972), “Inflation and Unemployment”, *American Economic Review*, 62 (1), 1-18.

Appendix 1

Data

CPI (Consumer Price Index):
1959:1-2000:2 from Statistics Sweden.
Our quarterly data are calculated as arithmetic averages of the monthly figures.
We use an annualized inflation rate, obtained by $(CPI_t-CPI_{t-1})/CPI_{t-1}$.

IPI (Import Price Index):
1963:1-2000:2 from Statistics Sweden.
This index reflects the prices of goods imported to Sweden. Our quarterly data are calculated as arithmetic averages of the monthly figures.

Import shares:
1963-2000 from Statistics Sweden.
For each year we calculate the value of goods and services imported to Sweden as a share of GDP at market prices. We then assign the same import share to each quarter.

Survey data on expected inflation:
1979:3-2000:2 from the National Institute of Economic Research. Quarterly data on households' expectations on CPI one year ahead, collected every quarter.

Unemployment:
1959:1-2000:2 from Statistics Sweden (AKU).
Seasonally adjusted data on open unemployment as a share of the labor force (aged 16-64).

Total unemployment:
1965:1-2000:2 from Statistics Sweden (AKU). Seasonally adjusted data on open unemployment plus workers in active labor market programs (aged 16-64).

Male unemployment:
1959:1-2000:2 from Statistics Sweden (AKU). Seasonally adjusted data on open unemployment for men aged 25-54

Dummy variables:

1. D1=1 for 1970:3-1970:4, zero otherwise.
2. D2=1 for 1973:1-1974:1, zero otherwise.
3. D3=1 for 1974:3, zero otherwise.
4. D4=1 for 1975:3, zero otherwise.
5. D5=1 for 1979:1-1980:1, zero otherwise.
6. D6=1 for 1980:2-1981:3, zero otherwise.
7. D7=1 for 1981:4-1983:3, zero otherwise.
8. D8=1 for 1986:1-1986:4, zero otherwise.
9. D9=1 for 1990:1-1991:2, zero otherwise.
10. D10=1 for 1995:3-1996:2, zero otherwise.

Appendix 2

Robustness

Using estimated expectations, we first explore the relationship between inflation and total, rather than open, unemployment. Since government expenditures affect open unemployment, and also change over the business cycle, one could argue that total unemployment better captures the relevant labor market situation. We therefore want to see if the LSURI we obtained based on open unemployment also will yield a lowest sustainable total unemployment. Moreover, using total unemployment may simplify a comparison of our results to those that ADP obtained for the U.S. since open unemployment would be considerably higher in Sweden in the absence of labor market programs.

Figure A1. The Phillips curve: total and open unemployment

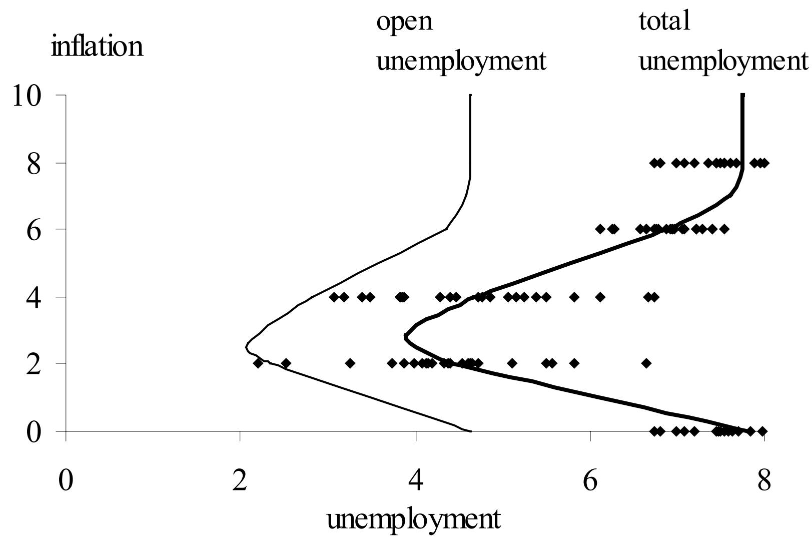


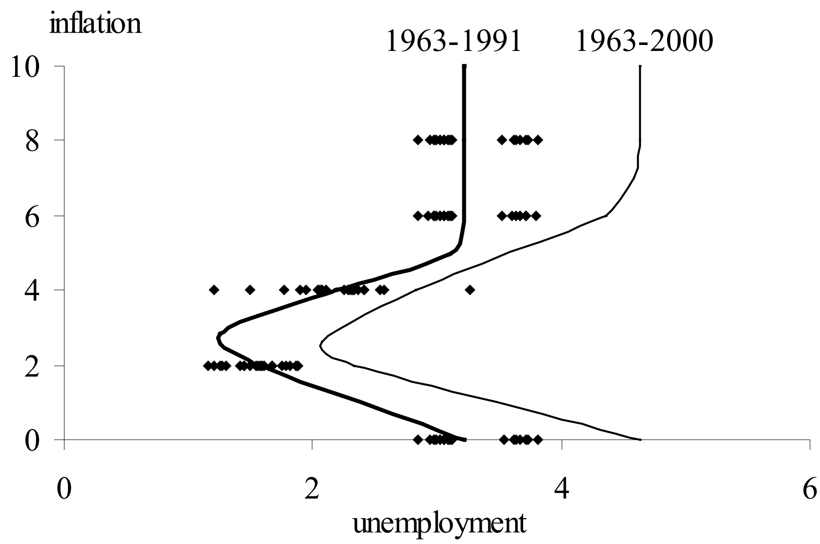
Table A1, models A1 and A2, displays some selected results based on total unemployment. A comparison with the results in *Table 1* above show that the LSURI estimates are similar. In *Figure A1*, we show the long run Phillips curve for total unemployment and, for comparison, we have reproduced the curve based on open unemployment (see *Figure 3*). If the purpose is to minimize the sustainable total unemployment, inflation should be at 2.83 percent, i.e., at approximately the same rate as previously obtained for open unemployment. The lowest sustainable total unemployment rate is 3.89 percent. While this figure is considerably closer to the LSURs estimated by ADP it still falls short of what appears to be the most common lowest unemployment rates in their study.[30] Many of their estimated LSURs exceed four percent.

[30] ADP never present an "average" estimate of their LSURs to which we may compare our estimates.

For sake of comparison with the results of ADP, we have also run some regressions based on prime aged males. The results based on open unemployment among males of ages 25-54 are presented in *Table A1* (models A3 and A4). As expected, this yielded considerably lower LSURs, but the corresponding inflation rates do not differ much from those previously obtained.

The turbulent Swedish labor market of the 1990s involved a major increase in unemployment and a drastic decrease in inflation. It seems reasonable to test if the exclusion of the 1990s yields very different results. In *Figure A2* we show the Phillips curve for 1963:1-1991:2 and (again) the Phillips curve for the period 1963:1-2000:2 . Excluding the 1990s implies a leftward shift of the curve: at a just slightly higher inflation rate than for 1963-2000, the average lowest sustainable unemployment rate is now as low as 1.26 percent. This result therefore suggests that the inclusion of the turbulent 1990s in data has some effect on LSUR, while the inflation rate remains stable.[31] The observed change in *Figure A2* could indicate that some parameter shifts may have occurred during the 1990s, which our model is unable to capture accurately. However, re-estimating the model for the period 1963-2000 and adding a dummy shift variable for the 1990s did not yield a significantly different Phillips curve.

Figure A2. The Phillips curve: 1963-1991 and 1963-2000



[31] *Table A1*, models A5 and A6, reports some results based on the period up until the 1990s. In particular the latter model yields a very low sustainable unemployment rate only slightly exceeding the one percent level.

Table A1. Estimated parameters for the long run Phillips curve[a]

Independent variables and characteristics	***Model A1***	***Model A2***	***Model A3***	***Model A4***	***Model A5***	***Model A6***
Constant	0.016 (4.32)	0.012 (2.76)	0.013 (2.39)	0.012 (3.82)	0.036 (3.28)	0.028 (2.85)
u_{t-1}	-0.535 (-1.47)	-0.145 (-0.29)	-0.996 (-2.12)	-0.113 (-0.19)	-1.245 (-1.64)	-1.059 (-1.17)
u_{t-2}	0.322 (0.89)	0.029 (0.04)	0.700 (1.51)	-1.117 (-1.11)	0.012 (0.02)	1.106 (1.00)
D (constant in coefficient on expectations)	0.168 (0.40)	0.598 (1.07)	0.090 (0.16)	0.187 (0.41)	-1.746 (2.08)	-1.489 (1.79)
E (coeff. of π_L in coeff. on expectations)	541.04 (2.87)	400.03 (3.64)	668.45 (4.44)	587.17 (3.13)	1368.6 (3.36)	1351.2 (2.42)
Method for constructing π_L	Geometrically declining weights, eq. (22)	Geometrically declining weights, eq. (23)	Geometrically declining weights, eq. (22)	Geometrically declining weights, eq. (23)	16-quarter MA with different weights for each year, eq. (24)	Geometrically declining weights, eq. (22)
Method for constructing π^e	16-quarter lag with different weights for each quarter, eq. (24)	16-quarter lag with different weights for each quarter, eq. (24)	Geometrically declining weights, eq. (22)	16-quarter MA with different weights for each year, eq. (24)	16-quarter lag with different weights for each quarter, eq. (24)	Geometrically declining weights, eq. (23)
Unemployment measure	Total unempl.	Total unempl.	Male unempl.	Male unempl.	Open unempl.	Open unempl.
No. of unempl. lags	2	12	2	12	2	12
Sample period	1965:1-2000:2	1965:1-2000:2	1963:1-2000:2	1963:1-2000:2	1963:1-1991:2	1963:1-1991:2
LSURI*100	**2.77**	**2.91**	**2.54**	**2.65**	**2.86**	**2.70**
LSUR*100	**4.06**	**4.26**	**1.67**	**1.61**	**1.32**	**1.18**
$\Phi(\pi=0.0)$	0.567	0.725	0.536	0.574	0.040	0.068
$\Phi(\pi=2.0)$	0.650	0.776	0.639	0.664	0.115	0.171
$\Phi(\pi=4.0)$	0.843	0.892	0.877	0.870	0.671	0.749
$\Phi(\pi=6.0)$	0.983	0.979	0.994	0.989	0.999	1.000
$u(\pi=0.0)$	0.077	0.076	0.043	0.040	0.030	0.035
$u(\pi=2.0)$	0.044	0.047	0.018	0.018	0.016	0.015
$u(\pi=4.0)$	0.049	0.048	0.026	0.023	0.019	0.023
$u(\pi=6.0)$	0.072	0.068	0.041	0.038	0.030	0.035
DW-statistic	1.524	1.534	1.500	1.523	1.509	1.797
R^2	0.876	0.891	0.872	0.872	0.839	0.839

[a] Asymptotic t-values in parentheses. Detailed results for all regressions are available on request.

Working Paper Series/Arbetsrapport

FIEF Working Paper Series was initiated in 1985. A complete list is available from FIEF upon request. Information about the series is also available at our website: http://www.fief.se/Publications/WP.html.

2001

166. **Hansson, Pär**, “Skill Upgrading and Production Transfer within Swedish Multinationals in the 1990s”, 27 pp.

167. **Arai, Mahmood** and **Skogman Thoursie, Peter**, “Incentives and Selection in Cyclical Absenteeism”, 15 pp.

168. **Hansen, Sten and Persson, Joakim,** “Direkta undanträngningseffekter av arbetsmarknadspolitiska åtgärder”, 27 pp.

169. **Arai, Mahmood** and **Vilhelmsson, Roger**, ”Immigrants’ and Natives’ Unemployment-risk: Productivity Differentials or Discrimination?”, 27 pp.

170. **Johansson, Sten** och **Selén, Jan**, ”Arbetslöshetsförsäkringen och arbetslösheten (2). Reformeffekt vid 1993 års sänkning av ersättningsgraden i arbetslöshetsförsäkringen?”, 39 pp.
171. **Johansson, Sten**, ”Conceptualizing and Measuring Quality of Life for National Policy”, 18 pp.

172. **Arai, Mahmood** and **Heyman, Fredrik**, “Wages, Profits and Individual Unemployment Risk: Evidence from Matched Worker-Firm Data”, 27 pp.

173. **Lundborg, Per** and **Sacklén, Hans**, “Is There a Long Run Unemployment- Inflation Trade-off in Sweden?”, 29 pp.

174. **Alexius, Annika** and **Carlsson, Mikael**, “Measures of Technology and the Business Cycle: Evidence from Sweden and the U.S.”, 47 pp.

175. **Alexius, Annika**, “How to Beat the Random Walk”, 21 pp.

2002

176. **Gustavsson, Patrik**, “The Dynamics of European Industrial Structure”, 41 pp.

177. **Selén, Jan**, “Taxable Income Responses to Tax Changes – A Panel Analysis of the 1990/91 Swedish Reform”, 30 pp.

178. **Eriksson, Clas** and **Persson, Joakim**, “Economic Growth, Inequality, Democratization, and the Environment”, 21 pp.

179. **Granqvist, Lena, Selén, Jan** and **Ståhlberg, Ann-Charlotte**, "Mandatory Earnings-Related Insurance Rights, Human Capital and the Gender Earnings Gap in Sweden", 21 pp.

180. **Larsson, Anna**, "The Swedish Real Exchange Rate under Different Currency Regimes", 22 pp.

181. **Heyman, Fredrik**, "Wage Dispersion and Job Turnover: Evidence from Sweden", 28 pp.

182. **Nekby, Lena**, "Gender Differences in Recent Sharing and its Implications for the Gender Wage Gap", 22 pp.

183. **Johansson, Sten** and **Selén, Jan**, "Coping with Heterogeneities in the Difference in Differences Design", 13 pp.

184. **Pekkarinen, Tuomas** and **Vartiainen, Juhana**, "Gender Differences in Job Assignment and Promotion in a Complexity Ladder of Jobs", 27 pp.

185. **Nekby, Lena**, "How Long Does it Take to Integrate? Employment Convergence of Immigrants and Natives in Sweden", 33 pp.

186. **Heyman, Fredrik**, "Pay Inequality and Firm Performance: Evidence from Matched Employer-Employee Data", 38 pp.

187. **Lundborg, Per** and **Rechea, Calin**, "Will Transition Countries Benefit or Lose from the Brain Drain?", 18 pp.

2003

188. **Lundborg, Per** and **Sacklén, Hans**, "Low-Inflation Targeting and Unemployment Persistence", 34 pp.