Explaining wage developments

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Assessments of wage developments are important for any central bank that conducts monetary policy focused on price stability. This article discusses the advantages and disadvantages of various empirical approaches to explaining wage developments. The first approach – the "naive" expectations-augmented Phillips curve – provides simple and easily comprehensible estimates. However, one problem is that the equilibrium level of unemployment appears to have changed during the 1990s. The second approach – models with equilibrium unemployment that varies over time – attempts to adjust the unemployment series for cyclical fluctuations in order to determine the development of equilibrium unemployment. However, these models cannot explain the reasons for changes in equilibrium unemployment. The third approach – models with wage-setting curves – has the advantage that the theoretical framework clearly states how factors such as taxes, unemployment insurance and wage-bargaining systems affect wage formation. Developing this approach can further clarify the relationship between wage formation and unemployment, and whether this relationship has changed over time. In our opinion, models that use wage-setting curves are the most suitable approach to explaining wage developments.

Reliable inflation forecasts are a prerequisite for conducting effective monetary policy in an inflation target regime. The development of wage costs is an important factor in the assessment since wage cost increases are a main determinant of

The question "If I were to make wage forecasts for one to two years ahead, I would…" was discussed at a seminar on wage formation held at the Riksbank on 29 March 2001 for invited participants. This paper develops the ideas taken up in Lars Calmfors' speech and in the ensuing discussion at the seminar. We would like to thank Kent Friberg, Per Jansson, Kerstin Mitlid and Staffan Viotti for their comments. Kent Friberg has also contributed data for diagrams and tables. Finally, we would like to thank Göran Zettergren from the Riksbank and David Turner from the OECD for providing us with estimates of equilibrium unemployment.

price increases on domestically produced goods and services. To predict wage developments as accurately as possible, it is wise to base forecasts on the insights that recent labour market research can provide. The purpose of this article is to discuss different models that can be used to explain wage developments. The article also contains a more general discussion of the value of these models for forecasting.

Reliable inflation forecasts are a prerequisite for conducting effective monetary policy in an inflation target regime.

The first section looks at key issues that have arisen as a result of Swedish labour market developments in the 1990s. The second section discusses the well-known Phillips curve, which shows the relationship between wage increases and unemployment. The third section presents the theory of equilibrium unemployment with the help of price-setting and wage-setting curves. These theoretical approaches are then related to empirical research in the field. We describe estimations of wage equations based on a "naive" expectations-augmented Phillips curve, estimates of equilibrium unemployment in time series models and estimations of wage-setting curves. This is followed by a discussion – based on empirical studies – of whether the structural changes that have taken place in the bargaining system and monetary policy have had an impact on wage formation. In conclusion, we summarise the advantages and disadvantages of the various models for explaining wage developments.

Key issues

A suitable starting point for the discussion is Figures 1 and 2, which illustrate the development of wages and unemployment in Sweden since the early 1980s. Figure 1 shows how unemployment quadrupled in the early 1990s. Figure 2 illustrates how the annual rate of nominal wage increase more than halved during the same period, from around 10 per cent to around 4 per cent. Nominal wage increases have subsequently remained at a level of around 4 per cent per annum (with the exception of a rise in 1996–1997), despite a significant reduction in unemployment in recent years.

The development gives rise to two main questions. The first question concerns the sensitivity of wage increases to variations in the labour market situation. Although wage increases slowed significantly in the early 1990s, this decline appears to have been relatively small in the light of the dra-

Two main questions arise: the first question concerns the sensitivity of wage increases to variations in the labour market situation.

matic increase in unemployment. It is also surprising that the rapid decrease in unemployment towards the end of the 1990s did not lead to a sharp acceleration in wage increases. These observations relate directly to the debate regarding the level of equilibrium unemployment.

Equilibrium unemployment is normally defined as the level of unemployment at which the rate of wage increase (or the rate of inflation) can be kept stable. One interpretation of the development in the first half of the 1990s may be that equilibrium unemployment rose compared with previous years, while the development in more recent years may instead reflect the fact that equilibrium unemployment has once again fallen.

Figure 1. Changes in nominal and real wages in Sweden (entire economy)

Per cent

Note. The change in real wages has been calculated as the change in nominal wages minus CPI inflation.

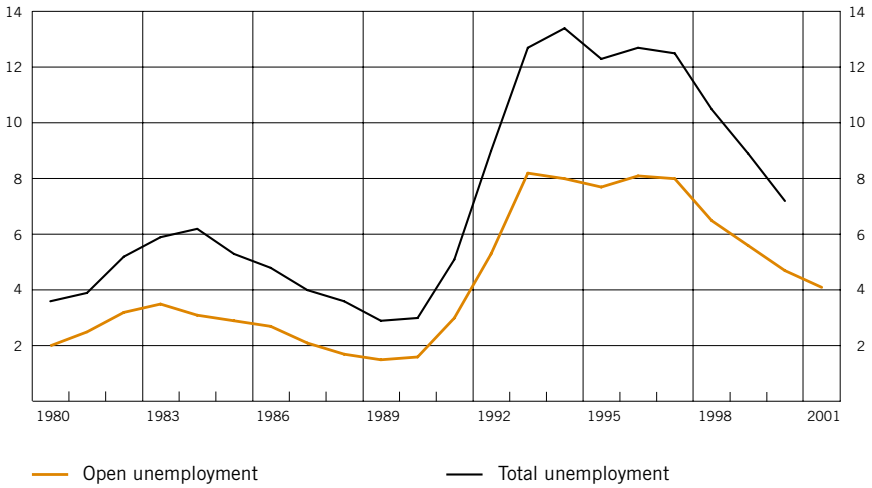
Sources: National Institute of Economic Research and Statistics Sweden. Forecasts for 2001 by Sveriges Riksbank (2001).

The second question concerns whether structural changes in the bargaining system and macroeconomic policy have had an impact on wage formation and equilibrium unemployment.

The second obvious question concerns whether structural changes in the bargaining system and macroeconomic policy have had an impact on wage formation and equilibrium unemployment. A number of such structural changes took place in the 1980s and 1990s. Since 1983, the locus of collective bargaining has increasingly shifted to the industry level. Furthermore, in the 1990s,

Figure 2. Unemployment in Sweden

Per cent



Note. Total unemployment is the sum of open unemployment and participation in labour market programmes as a percentage of the labour force.

Sources: The National Labour Market Board and Statistics Sweden.
Open unemployment forecast for 2001 by Sveriges Riksbank (2001).

the agreements at the industry level have focused on determining aggregate (average) wage increases. At the same time, the distribution of the aggregate wage increases among the individual employees at companies has increasingly been determined through negotiations at the local level. In the most recent years, a new form of "informal" co-ordination of collective bargaining appears to have emerged, based on the Agreement on Industrial Development and Wage Formation signed in 1997. A further comprehensive structural change was the adoption of a new monetary policy regime in conjunction with the change to a floating exchange rate in 1992 and the introduction of an inflation target in 1993.

The relationship between wage increases and unemployment

At the end of the 1950s, Phillips showed that a stable negative relationship between wage increases and unemployment existed in the UK.

Traditional analysis of the relationship between wages and unemployment is based on the Phillips curve relationship formulated in the late 1950s by the New Zealand economist Phillips. He demonstrated that a stable negative relationship existed between wage

increases and unemployment in the UK for the period 1861–1957.[1] Assuming that prices are determined as a mark-up on wage costs, this relationship also implies a negative relationship between inflation and unemployment. If the Phillips curve relationship were a stable one, forecasts of wage increases and inflation would be relatively simple. However, developments since the early 1970s have demonstrated that the relationship is very unstable.[2]

At the end of the 1960s, the Phillips curve relationship was reformulated and emphasis was placed on the significance of inflation expectation.

At the end of the 1960s, the American economists Friedman and Phelps reformulated the Phillips curve relationship by emphasising the role of inflation expectations.[3] It has later become generally accepted that the rate of nominal wage increase depends on the labour market situation and on the expected rate of price or wage increases. Nowadays, the relationship is usually formulated as:

$$\Delta w = \Delta p^e + \Delta q^e - \alpha(U - U^*) \quad (1)$$

or

$$\Delta w = \Delta w^e - \beta(U - U^*), \quad (2)$$

where Δw is the rate of increase in nominal wages, Δp^e is expected inflation, Δq^e is expected productivity growth, Δw^e is the expected rate of wage increase, U is the actual unemployment rate, and U^* is equilibrium unemployment. The coefficients α and β show how the rate of wage increase changes when the difference between actual unemployment and equilibrium unemployment changes. This difference is often referred to as the unemployment gap and is a measure of resource utilisation in the labour market.[4]

The implication of the expectations-augmented Phillips curve is that no stable negative relationship exists between the rate of nominal wage change and unemployment. The Phillips curve relationship in the short term instead depends on expectations regarding productivity changes, inflation and/or wage changes.

[1] See Phillips (1958).
[2] See e.g. Johansson et al. (1999).
[3] See Friedman (1968) and Phelps (1968).
[4] The unemployment gap can be related to the output gap, which is a measure of total resource utilisation. The output gap is defined as the difference between actual and potential output. A common way of linking the two gaps is to use the Okun relationship. According to this, a 1 per cent fall in actual GDP relative to potential output will cause the unemployment gap to increase by approximately one half of a percentage point (see Apel and Jansson (1999)).

In the long term, when expectations have adjusted to the actual development, actual unemployment will be the same as equilibrium unemployment (and the unemployment gap will be zero).

The implication of the expectations-augmented Phillips curve is that no stable negative relationship exists between the rate of nominal wage change and unemployment.

By making different assumptions, equations (1) and (2) can be used to describe the long-run equilibrium. If in equation (1) we assume that expected price and productivity increases are equal to actual increases ($\Delta p^e = \Delta p$ and $\Delta q^e = \Delta q$), the relationship can be interpreted such that the unemployment gap determines the change in the *wage share* (i.e. the share of wages in value added):[5]

$$\Delta w - \Delta p - \Delta q = -\alpha(U - U^*). \qquad (3)$$

With this interpretation, equilibrium unemployment is therefore the level of unemployment at which the wage share remains constant ($\Delta w - \Delta p - \Delta q = 0$). At the equilibrium level of unemployment, when the unemployment gap is zero, the real wage is thus assumed to change at the same rate as productivity.

If in equation (2) we assume that the expectations are backward-looking, so that the expected rate of nominal wage increase is equal to the rate of wage increase the previous year ($\Delta w^e = \Delta w_{-1}$),[6] we get the following relationship between *the change in the rate of wage increase* and unemployment:

$$\Delta w - \Delta w_{-1} = -\beta(U - U^*). \qquad (4)$$

Equilibrium unemployment is now equal to the level of unemployment at which the rate of wage increase can be kept stable ($\Delta w - \Delta w_{-1} = 0$). In equilibrium, when the unemployment gap is zero, the rate of wage increase is thus assumed to remain the same from year to year.

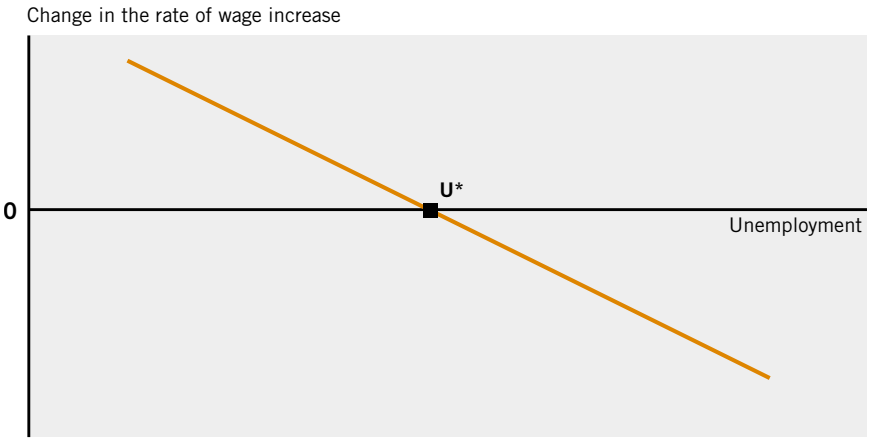
Figure 3 illustrates how the *change in the rate of wage increase* depends on unemployment in accordance with equation (4). The figure can be compared with the conventional illustration of the Phillips curve, where the rate of wage increase

[5] The rate of change in the wage share is by definition equal to the difference between the rates of change in the real wage and productivity, $\Delta w - \Delta p - \Delta q$.

[6] The index –1 states that a variable relates to the previous period.

(and not its change) is related to unemployment.[7] Equilibrium unemployment U^* is shown in the figure by the point at which the line intersects the horizontal axis, i.e. the point at which the rate of wage increase is stable ($\Delta w = \Delta w_{-1}$).[8]

Figure 3. Phillips curve relationship between the change in the rate of wage increase and unemployment



In more general terms, equilibrium unemployment can be interpreted as the level of unemployment around which cyclical fluctuations take place.

In more general terms, equilibrium unemployment can be interpreted as the level of unemployment around which cyclical fluctuations take place. The unemployment gap then corresponds to what is usually termed cyclical unemployment. If the rate of wage increase slows, then unemployment according to equation (4) is higher than equilibrium unemployment (i.e. cyclical unemployment is positive) and the economy finds itself in a recession. Correspondingly, according to equation (4), an upswing is characterised by an accelerating rate of wage increase and a level of unemployment that is lower than equilibrium unemployment (i.e. cyclical unemployment is negative).[9]

If equilibrium unemployment were constant over time, the expectations-aug-

[7] See, for example, Apel and Heikensten (1996) for a discussion of the traditional Phillips curve analysis.

[8] With this interpretation, which is based on backward-looking expectations of wage increases, equilibrium unemployment is normally termed NAWRU (the Non-Accelerating Wage Rate of Unemployment). The level of equilibrium unemployment at which the inflation rate is constant, when inflation expectations are correspondingly backward-looking, is normally termed NAIRU (the Non-Accelerating Inflation Rate of Unemployment).

[9] According to equation (3), cyclical unemployment (which is positive in a recession) will instead lead to a falling wage share (and negative cyclical unemployment in an upswing will lead to a rising wage share).

mented Phillips curve would be a fairly straightforward approach to making forecasts of wage developments. However, a fundamental problem is that equilibrium unemployment appears to vary over time. Figure 5 illustrates the actual development of the change in the rate of wage increase and unemployment in Sweden since the late 1980s. If equilibrium unemployment had remained unchanged over time (and expectations had been backward-looking), all observations would have been close to a negatively sloping line as in Figure 3. As can be seen from Figure 4, however, this has not been the case.

If equilibrium unemployment were constant over time, the expectations-augmented Phillips curve would be a fairly straightforward approach to making forecasts of wage developments.

Figure 4. The change in the rate of wage increase and unemployment

Note. A linear relationship has been adjusted to the years 1997–2000.
Sources: National Institute of Economic Research and Statistics Sweden.

During the period 1987–1991, a relatively stable relationship in the figure can be discerned, suggesting that equilibrium unemployment may have been around 2 per cent. Observations between 1993-1996 instead suggest an equilibrium unemployment of almost 8 per cent. A bold interpretation of the developments in 1997–2000 would be that equilibrium unemployment has fallen back to around 5 per cent. As the rate of wage increase for 2001 appears to be approximately the same as in 2000, despite the fall in open unemployment to around 4 per cent, the latest developments suggest that equilibrium unemployment may have fallen even more.

The above reasoning illustrates the need for a theory of equilibrium unemployment. One such theory is discussed in the next section.

The determination of equilibrium unemployment

The theory of equilibrium unemployment is based on an analysis of both the supply and demand side of the labour market.

The theory of equilibrium unemployment is based on an analysis of both the supply and demand side of the labour market. Equilibrium employment, *N**, is given by the intersection between a *wage-setting curve* and a *price-setting curve*. This is illustrated in Figure 5. Equilibrium unemployment, U*, is obtained as the labour supply (LS in the figure) minus equilibrium employment.

The wage-setting curve describes a positive relationship between the levels of real wages and employment.

The wage-setting curve describes a positive relationship between the levels of real wages and employment. This relationship can be derived from several theoretical models of wage formation. The perhaps most intuitive – and relevant – approach for the Swedish labour market is a bargaining model, which explains which factors affect the collective wage agreements negotiated between employers and trade unions. If the demand for labour increases (i.e. employment rises), the trade unions will demand and be able to obtain higher real wages, since union members run a lower risk of becoming unemployed.

The price-setting curve describes a negative relationship between real wages and employment.

The price-setting curve instead describes a negative relationship between real wages and employment. If firms operate in a competitive product market, this relationship can be interpreted as a regular demand curve for labour. If there is instead monopolistic competition and individual firms have certain "market power", a negative relationship will arise due to firms raising their profit margins (prices relative to wage costs) when demand (employment) is high.

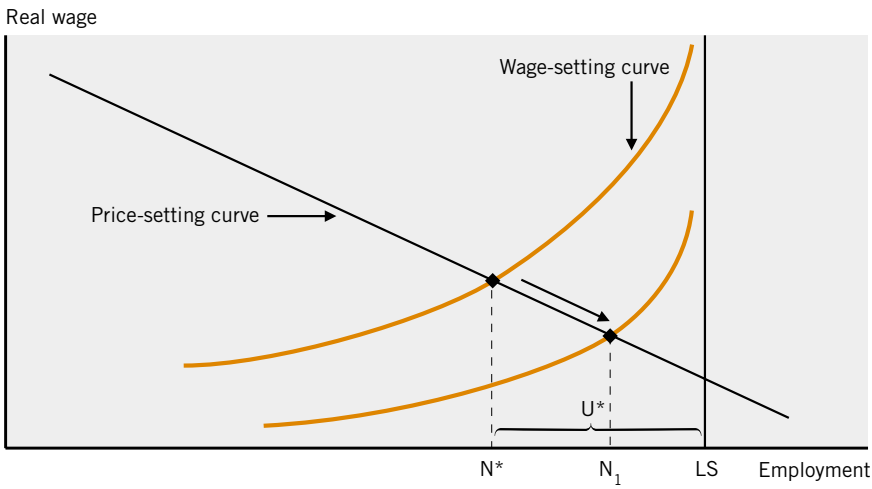
In the model described, equilibrium unemployment can be viewed as the level of unemployment at which the decisions of wage setters on wages and the decisions of firms on prices are consistent with each other.[10] Unemployment in equilibrium must be such that the relationship established between prices and wages is accepted by both price setters and wage setters.

[10] See Calmfors and Holmlund (2000) as well as Björklund et al. (2000) for a more detailed description of the model.

The model explains equilibrium unemployment as being caused by those factors that affect the wage-setting and price-setting relationships.

Within the framework of the model, equilibrium unemployment is explained by those factors that affect the wage-setting and price-setting (labour demand) relationships. According to accepted theory, the wage-setting relationship is influenced by factors such as the generosity of unemployment insurance and tax rates. More generous unemployment insurance or higher income taxes can be assumed to strengthen incentives for wage increases and thereby shift the wage-setting curve upward. The effect of this is lower equilibrium employment and higher equilibrium unemployment. The size of active labour market programmes can also affect the wage-setting curve, although it is unclear in which direction.[11] Another common hypothesis is that the wage-setting relationship is affected by the level of co-ordination in wage bargaining (see the section "Structural changes in wage formation").

Figure 5. A price and wage-setting model



The price-setting curve is affected by factors such as the degree of competition in the product and services markets. A higher degree of competition tends to reduce the price-cost mark-ups of firms (which is equivalent to higher real wages) and consequently shifts the price-setting curve upward. This shift causes higher equilibrium employment and lower equilibrium unemployment.

[11] On the one hand, an expansion of active labour market programmes can raise wage pressure since the risk of open unemployment declines. On the other hand, programmes that improve the competitiveness of the unemployed can restrain wages since there is more competition for the available jobs. See Calmfors et al. (2001a) for a more detailed discussion.

Inflation expectations play an important role in these models, too. The wage-setting curve in Figure 5 can be interpreted to show the real wage levels that the bargaining parties are *striving to achieve* at different levels of employment. However, decisions regarding nominal wage increases in the collective agreements must be based on expectations of future inflation. If prices rise unexpectedly after the wage agreements have been concluded, then *actual* real wages will be lower than the parties intended, which means that the wage-setting curve shifts downward. This will result in employment rising above the equilibrium level (to N_1) as illustrated in Figure 5. In the longer term, the negotiating parties will adjust their expectations to the higher prices, which will lead to higher nominal wages. The wage-setting curve then shifts back to the equilibrium position and employment returns to N^*.

Empirical studies of Swedish wage formation have been based on either some form of the expectations-augmented Phillips curve or wage-setting curves.

Empirical studies of Swedish wage formation have been based on either some form of the expectations-augmented Phillips curve or wage-setting curves of the type illustrated in Figure 5. Estimations based on a "naive" expectations-augmented Phillips curve are described below. This is followed by a discussion of attempts to identify, based on a Phillips curve relationship, how equilibrium unemployment has varied over time. Finally, estimations of wage-setting curves are discussed.

A "naive" expectations-augmented Phillips curve

Wage increases are explained by inflation expectations and alternative labour market variables.

In a recent study published in the Riksbank's Economic Review, Friberg and Uddén Sonnegård estimated "naive" expectations-augmented Phillips curves for industrial workers over varying periods of time until the end of 1999.[12] Table 1 shows some of these estimations. Wage increases are explained by inflation expectations – which are assumed to be backward-looking – and alternative labour market variables. Unemployment proved to be an unsatisfactory measure of the demand situation. On the other hand, unfilled job vacancies and the National Institute of Economic Research's measure of the shortage of skilled workers (in industry) were surprisingly good indicators, despite the fact that the proportion of reported job vacan-

[12] See Friberg and Uddén Sonnegård (2001).

Table 1. Phillips curve estimations using alternative specifications

Dependent variable: the rate of wage increase for industrial workers

Equation	Constant	Unemployment	Unfilled vacancies	Proportion of companies stating a shortage of skilled workers	Inflation expectations	Profit share previous year	Adjusted R^2	Time period
(2a)	3.728**	-0.095			0.728***		0.75	1979–1999
(2b)	2.426***		0.00035***		0.430***		0.66	1969–1999
(2c)	1.584***			0.121***	0.424***		0.59	1969–1999
(2e)	–23.275***			0.113***	0.801***	0.662***	0.70	1971–1999

Note. Household sector inflation expectations according to HIP survey by Statistics Sweden were used in equation (2a). In the other specifications inflation expectations are measured by CPI inflation for the previous year. **(***) indicates the significance level of 5 per cent and 1 per cent, respectively.
Source: Table 5 in Friberg and Uddén Sonnegård (2001).

cies can be assumed to vary considerably over time and the labour shortage measure is only a rough tool. It can also be seen from the table that profit shares from the previous year is a significant explanatory variable in one of the reported specifications (equation (2e) in Table 1). The estimate shows that a higher profit share leads to higher wage increases.

In some of the specifications, the estimated coefficients for inflation expectations are clearly lower than unity. This indicates that changes in the expected inflation rate do not lead to equally large changes in the rate of nominal wage increase, which is inconsistent with the theory. The estimations do not provide any clear answers to the question of whether structural changes in wage formation have taken place. On the one hand, a possible cause of the low explanatory value of estimations using open unemployment is that equilibrium unemployment has varied over time as a result of structural changes.[13] On the other hand, the stable relationships in the estimations using alternative labour market indicators can be interpreted such that no structural changes have occurred. Neither do various tests indicate the occurrence of any structural changes.[14] Friberg and Uddén Son-

One possible reason for the low explanatory value of the estimations using open unemployment is that equilibrium unemployment has varied over time due to structural changes.

[13] Another explanation may be that open unemployment is in itself a poor statistical measure of the labour market situation. See Sveriges Riksbank (2000) for a discussion of alternative measures of resource utilisation in the labour market.

[14] The different stability tests that were performed (recursive estimates, Chow's breakpoint test and tests using a number of dummy variables) do not indicate any structural changes apart from a period of exceptionally high nominal wage increases in 1975–1976. (See also the discussion in the section "Structural changes in wage formation".)

negård draw the conclusion that the low nominal wage increases during much of the 1990s can be explained primarily by the low inflation expectations and the weak labour market situation during this period.

The estimations of a "naive" expectations-augmented Phillips curve appear to work so well that, mainly because of their simplicity, they are valuable for making forecasts.[15] However, the estimations are only reliable if equilibrium unemployment has not varied substantially during the estimation period. As stated above, the simple approach that has been used does not provide any comprehensive answers to this question.

Models with time-varying equilibrium unemployment

Another method of analysing whether structural changes have occurred in wage formation is to try to estimate how equilibrium unemployment has varied over time.

Another method of analysing whether structural changes have occurred in wage formation is to try to estimate how equilibrium unemployment has varied over time. The estimates of equilibrium unemployment can be used to estimate the unemployment gap. This can then be included as an explanatory variable in an expectations-augmented Phillips curve to explain wage developments.[16]

There are a number of methods of estimating equilibrium unemployment when it varies over time. These are all based on some form of filtering technique, which means that one attempts to adjust the unemployment series for cyclical fluctuations. One method is to use so-called "unobserved components models". This method requires assumptions to be made on how the unobserved component (in this case equilibrium unemployment) moves randomly over time.[17] By utilising the information available on changes in the inflation rate, the rate of wage increase and other variables that may be thought to have an impact on price and wage formation, one then tries to identify how actual unemployment at different points in time relates to equilibrium unemployment. In principle, one thus attempts to find the

[15] The wage equations can be used for making inflation forecasts if they are supplemented with a price equation that explains how wage increases affect inflation. Since inflation is to a large extent affected also by developments in import prices, accurate forecasts for these prices are also required. This in turn assumes accurate forecasts of exchange rate developments and their impact on domestic import prices, which can be quite problematic.

[16] These stages can also be carried out simultaneously in a system model. See Apel and Jansson (1999).

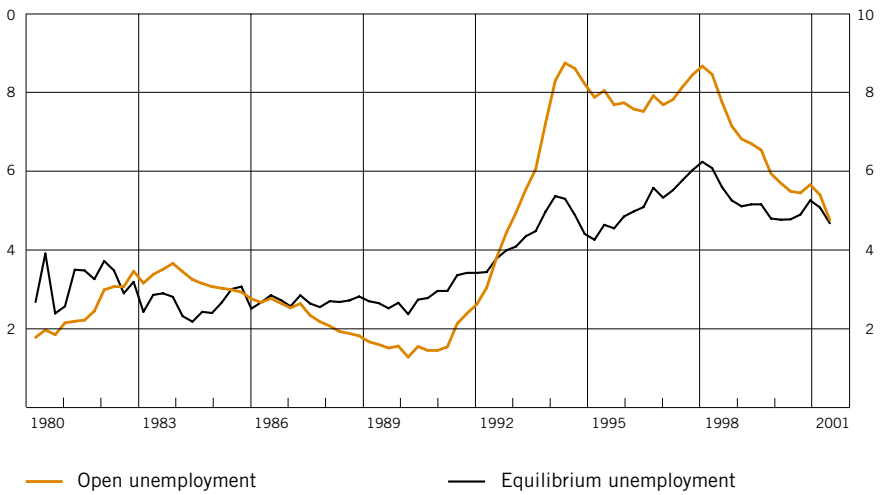
[17] A common assumption is that equilibrium unemployment is a random walk, which means that the *change* in each time period is random. This may also be expressed as that equilibrium unemployment in a certain period is the same as equilibrium unemployment in the previous period plus a random term (which could be positive or negative).

point where the Phillips curve relationship between the change in the rate of wage increase and unemployment in Figure 3 intersects the horizontal axis, i.e. the unemployment level at which the rate of wage increase (or the inflation rate) is stable.[18]

Figures 6a and 6b show some estimations of equilibrium unemployment made using different methods. One estimation is based on the methodology developed by Apel and Jansson, while the other two estimations are by Richardson et al.[19] All the estimates provide a picture of low, stable equilibrium unemployment until the late 1980s. Equilibrium unemployment subsequently rose during the first half of the 1990s and then fell again. In the early 1980s, the unemployment gap was positive, i.e. actual unemployment was higher than equilibrium unemployment. The unemployment gap became negative at some point in the mid or late 1980s and then became positive again during the 1990s. According to the estimations, the unemployment gap should by and large have closed in 1999; equilibrium unemployment should then have been around the same level as actual unemployment.

Figure 6a. Equilibrium unemployment according to Apel and Jansson's methodology, quarterly data

Per cent



Sources: Apel and Jansson (1999) and Sveriges Riksbank.

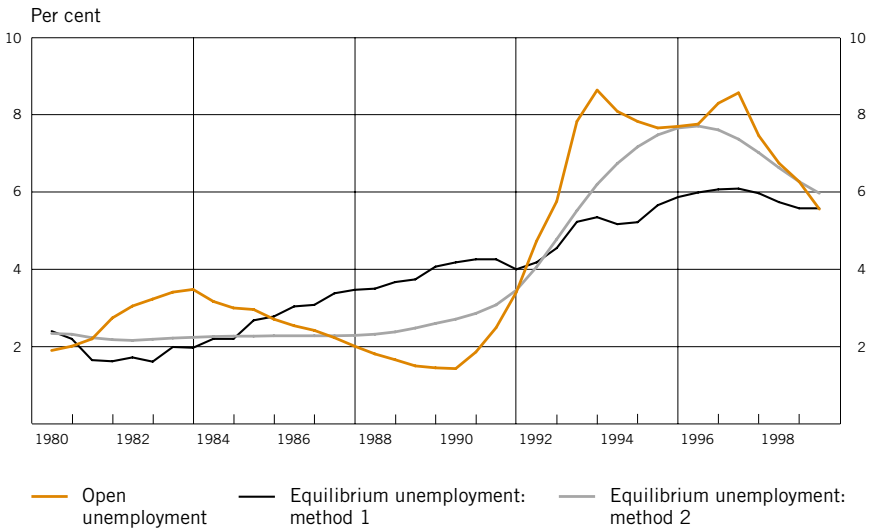
[18] The relationship between the change in the rate of wage increase and unemployment can be reformulated as a relationship between the change in the inflation rate and the unemployment gap. Relationship (4) can be written $\Delta p - \Delta p_{-1} = -\beta(U-U^*)$, assuming that the rate of price increase is the same as the rate of wage increase minus productivity growth in each period and that the latter is constant ($\Delta p = \Delta w - \Delta q$ and $\Delta q = \Delta q_{-1}$). A similar equation is obtained from relationship (1), assuming in addition that the expected productivity growth and inflation are backward-looking and equal to the rates of increase in the previous period ($\Delta q^e = \Delta q_{-1}$ and $\Delta p^e = \Delta p_{-1}$).

[19] See Apel and Jansson (1999) and Richardson et al. (2000).

Estimates of the sensitivity of wage increases to variations in the unemployment gap depend on the technique used to estimate the latter variable.

Even though equilibrium unemployment has developed in the same direction according to the different estimates, the size of the changes and thus the estimates of cyclical unemployment (the unemployment gap) differ substantially (see Figures 6a and 6b). This is obviously a problem when making forecasts of wage increases and inflation. Firstly, there is great uncertainty regarding the extent of cyclical unemployment. Secondly, it is difficult to form an opinion as to how sensitive wage increases (inflation) are to variations in cyclical unemployment. The results differ depending on which technique is used to estimate the unemployment gap. Measurements showing small variations in the unemployment gap during the 1990s (and consequently large variations in equilibrium unemployment) give the result that wage increases are very sensitive to variations in cyclical unemployment, while measurements showing large variations in the unemployment gap (and small variations in equilibrium unemployment) will instead give low sensitivity. This is illustrated in Table 2, which shows the estimates of the relationship between the change in the inflation rate and the unemployment gap using different methods.

Figure 6b. Equilibrium unemployment according to Richardson at al., half-yearly data



Note. In method 1, a Kalman filter is used. In method 2, a multi-variate Hodrick-Prescott filter is used.
Source: Richardson et al. (2000).

The different estimates of equilibrium unemployment in the late 1990s (see Figures 6a and 6b) reach fairly similar results. According to the estimates using the two methods in Richardson et al., equilibrium unemployment was around 5.5–6 per cent, while using Apel and Jansson's methodology it was just under 5 per cent in the first half of 1999. Actual unemployment was approximately 5.5 per cent at the same point in time.

The different estimates of equilibrium unemployment in the late 1990s reach fairly similar results.

Table 2. Estimations of the relationship between the change in the inflation rate and the unemployment gap

	Method 1 Richardson et al.	Method 2 Richardson et al.	Apel and Jansson
$d(\Delta p - \Delta p_{-1})/d(U-U^*)$	–0.43	–3.23	–0.026
Equilibrium unemployment first half of 1999	5.6	6.0	4.8

Sources: Apel and Jansson (1999), Richardson et al. (2000) and the Riksbank.

One reason why the estimates are close to one another is that wage and price increases were relatively stable during the late 1990s. This indicates that equilibrium unemployment should have been close to actual unemployment, since equilibrium unemployment is the level of unemployment at which the rate of wage increase (the rate of inflation) is stable. One interpretation of the fact that wage increases appear to have remained at around the same levels as previously in 2000–2001, when unemployment fell even further, is, however, that the estimates for the late 1990s were too high. (The increase in the inflation rate in 2001, is however, more consistent with the hypothesis that equilibrium unemployment was then higher than actual unemployment. But our interpretation is that the rise in inflation was mainly an effect of temporary price increases and therefore does not tell us much about equilibrium unemployment.)[20]

One reason why the estimates are close to one another is that wage and price increases were relatively stable during the late 1990s.

One reason why equilibrium unemployment may have been overestimated is that the relationship between the change in the rate of wage increase (or in the inflation rate) and the unemployment gap need not be linear, as is usually assumed (see equation (4)). Let us assume that we observe the combinations of changes in the rate of wage increase and unemployment shown in Figure 7. If we assume that the relationship is linear, we will draw the conclusion that equilibri-

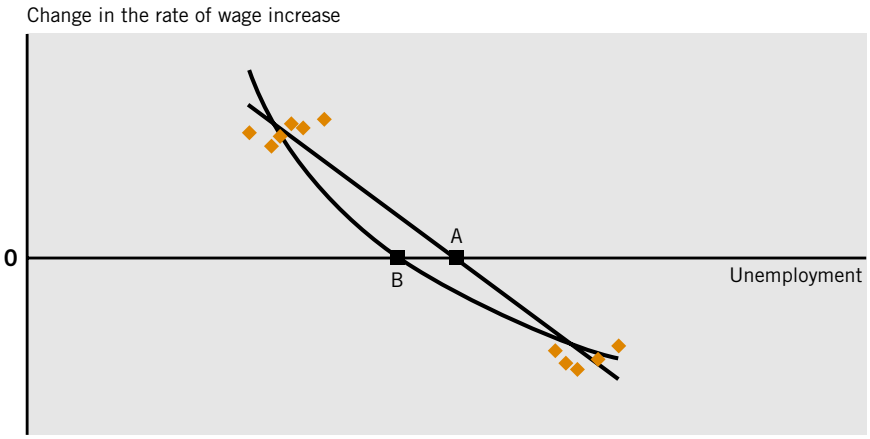
[20] See Sveriges Riksbank (2001).

um unemployment is indicated by point A. There is, however, much to suggest that rising unemployment has a gradually decreasing effect on wage increases. Such an assumption would give a non-linear relationship of the type shown in the figure. The estimated equilibrium unemployment would in this case be indicated instead by point B in the figure.

One disadvantage is that the methods do not explain what drives the changes in equilibrium unemployment.

One disadvantage of the time series models described above for forecasting purposes is that the estimates can differ substantially depending on which basic (identifying) assumptions are made. Another major disadvantage is that the methods do not explain what drives the changes in equilibrium unemployment. In the case of more short-term forecasts, an estimate of the initial level of equilibrium unemployment is of great value, since this probably does not change much in the short term. But more long-term forecasts require an understanding of how equilibrium unemployment may be affected by various structural changes. This assumes in turn a better empirical understanding of which factors may have led to variations in equilibrium unemployment during the past decade.

Figure 7. Estimates of equilibrium unemployment and various functional forms for the Phillips curve relationship



Wage-setting curves

Assuming that changes in the wage formation process determine the development of equilibrium unemployment, it may be sufficient to estimate the wage-setting curve.

If we want to be able to predict future equilibrium unemployment and wage developments, we need models with more explanatory variables than the time series models already discussed. One method is to estimate a so-called reduced form for unemployment. This means that unemployment is explained using all the factors that affect the wage-setting and price-setting curves. To express it differently, one attempts to determine the intersection of the two curves (according to Figure 5) and which factors affect this intersection. Assuming that it is primarily the wage formation process that determines the development of equilibrium unemployment, it may be sufficient to estimate the wage-setting curve. In equation form, this is usually formulated in one of the following ways:

$$w - p = g(U,Z) \tag{5}$$

or

$$w - p - q = h(U,Z), \tag{6}$$

where w represents the nominal wage level, p the price level, and q the productivity level. (These variables are stated in logarithms). U represents unemployment as previously and Z other variables, such as unemployment compensation, tax rates and labour market programmes, which according to the theory are expected to affect wages. The relationships thus seek to explain the level of the real wage $(w - p)$ or the level of the wage share $(w - p - q)$.

As a rule, the equations are estimated in dynamic form, where factors affecting the wage developments in both the short and long term are modelled. One assumes then that equations (5) and (6) represent long-run relationships. In the short run, however, the real wage or the wage share can deviate from the values indicated by the long-run relationships. But over time an adjustment to the long-run relationships occurs. If the real wage $(w - p)$ in equation (6) is too low in relation to productivity (the wage share is below the values indicated by the long-term relationship), real wage growth will in the short term – during the adjustment period – exceed productivity growth. The equations are therefore usually formulated as:

$$\Delta(w - p) = \varphi X - \gamma [w - p - g(U,Z)]_{-1} \quad (7)$$

or

$$\Delta(w - p - q) = \varepsilon X - \delta [w - p - q - h(U,Z)]_{-1}, \quad (8)$$

where Δ represents changes in the variables, X is the short-term factors affecting the adjustment, ϕ and ε state how X affects the "short-term dynamics", γ and δ give the speed of adjustment, and the whole expressions $[w - p - g(U,Z)]_{-1}$ and $[w - p - q - h(U,Z)]_{-1}$, respectively, are error correction terms, which indicate by how much the real wage level or the wage share in the previous period deviate from the long-run relationships. Unfortunately, the theory does not tell us much about which factors affect the adjustment (the X terms) and how the adjustment occurs. The analysis of the short-term dynamics is therefore fairly atheoretical; one simply has to test which "reasonable" variables have the highest explanatory value. Variables that usually function well are *changes* in the inflation rate, in import prices relative to domestic prices, in taxes and sometimes also in unemployment.

The results of four empirical studies of Swedish wage formation, which used data also from the 1990s, are shown in Table 3. The estimates are based on slightly different model approaches, but all use some form of wage-setting curve. The results have been expressed in the table so that they are as comparable as possible. The dependent variable is the rate of increase in *the nominal wage cost*, i.e. the wage plus employer contributions (both pay-roll taxes and negotiatied employer contributions). The table focuses on the short-run effects (the effects on wage cost increases the same year). The estimated long-run effects (the effects on the real wage cost or the wage share according to the long-run relationships) are shown in brackets. The results may be summarised as follows.

In three of the studies, dynamic homogeneity applies, which means that a change in the inflation rate leads to an equal change in the rate of wage cost increase. This means that equilibrium unemployment is independent of the inflation rate.

In three of the studies (the exception is Thomas), dynamic homogeneity applies. This means that a rise in inflation of 1 percentage point results also in a 1 percentage point higher rate of increase in the nominal wage cost. This means that *real* wage cost increases are not affected by a permanent increase in inflation and that equilibrium unemployment is independent of the inflation rate. This is consistent with the basic theory for the expectations-augmented Phillips curve.

The effects of a change in productivity growth differ between the studies. According to Forslund and Kolm as well as Johansson et al., a change in productivity growth leads to an equal change in the rate of wage cost increase. This means that

changes in productivity growth do not affect either the wage share or equilibrium unemployment. However, according to Rødseth and Nymoen and to Thomas, changes in productivity growth only affect wage cost increases partially. Consequently, an increase in the rate of productivity growth leads to a lower wage share in the long run and to a fall in equilibrium unemployment.

In two of the studies, a change in productivity growth leads to an equal change in the rate of wage cost increase. This means that equilibrium unemployment is independent of productivity growth.

The studies also indicate that an error correction mechanism is triggered when the levels of the real wage (the wage share) deviate from the values shown by the long-run relationships. According to Rødseth and Nymoen and to Johansson et al., between 20 and 40 per cent of such a deviation is eliminated each year (this is shown by the coefficient for the previous year's wage share in Table 3). In Forslund and Kolm's study, the adjustment coefficient is higher (-0.91). On the other hand, the wage cost developments are more sluggish in the latter study; if the rate of increase in the real wage cost has risen during the previous year, this also leads to a rise in the rate of increase this year (by the coefficient 0.43). Overall, the adjustment to equilibrium is about as strong as in the other studies over a one-year period (–0.91 + 0.43 = -0.48).[21]

The studies indicate that an error correction mechanism is triggered when the levels of the real wage (the wage share) deviate from the values shown by the long-run relationships.

The studies also provide support for the view that tax increases lead to higher wage cost increases in the short term (all studies) and possibly also higher real wage costs in the long term (Forslund & Kolm and Johansson et al. respectively). According to the theory, higher unemployment compensation leads to higher wages, but only one of the studies (Thomas) finds support for this. An increase in the size of active labour market programmes can, according to the theory, have both a wage-increasing and a wage-reducing effect. Earlier empirical studies have found that larger labour market programmes appear to raise the wage level. The results of the studies reported in this article differ substantially. Rødseth and Nymoen as well as

The studies provide support for the view that tax increases lead to higher wage cost increases in the short term. However, an increase in the size of active labour market programmes produces different results in the studies.

[21] The profit share in Friberg´s and Uddén Sonnegård's specification can also be interpreted as an error correction term. In their study, the estimates of the adjustment rate are slightly higher than in the studies discussed above, which are based on wage-setting curves (see equation (2e) in Table 1).

Table 3. Effects on the rate of change in the nominal wage cost of different variables, according to four studies of wage formation in Sweden

	Rødseth and Nymoen (1999)	Forslund and Kolm (2000)	Johansson et al. (1999)	Thomas (2001)
Estimation period	**1965–1994**	**1961–1997**	**1965–1998**	**1975–1998**
CPI inflation	0.58			0.05
Producer price change	0.42	1	1	
Productivity change	0.42	1	0.99	0.69
Change in CPI inflation			–0.47	
Previous year's change in the real product wage		0.43		
Income tax[i]				0.97
Pay-roll tax[ii]	0.74			0.54
Tax wedge[iii]		0.52 (0.16)	0.48 (1.9)	
Log open unemployment		–0.05 (–0.05)	–0.06 (–0.22)	–0.06 (–0.75)[iv] –0.03 (–0.33)[v]
Log total unemployment (open unemployment plus participation in active labour market programmes)	–0.03 (–0.09)		–0.03 (–0.13)[vi]	
Previous year's wage share (real product or real consumption wage)[vii]	–0.36	–0.91	–0.25	–0.08
Active labour market programmes	+	0	+	–
Change in unemployment	0	+	0	
Unemployment compensation	0	0		(+)[viii]
Stability	Higher wage increases 1975–1981; or alternatively lower wage increases 1983–1990.	Yes	Less short-term effect from open unemployment and slower adjustment to equilibrium 1965–1998 than 1965–1990.	Less dampening effect from open unemployment 1990–1998 than earlier.

Notes. The reported equations are from Table 6 in Rødseth and Nymoen; Table 6 in Forslund and Kolm (2000); Equation 5 in Table 2.1 in Johansson et al. (1999); and Table 4 in Thomas (2001). Our table gives the short-term effects within one year. The values stated in paranthesis are the long-run effects.

[i] Thomas variable is the change in income taxes in relation to GDP.

[ii] This variable is measured in Rødseth's and Nymoen's study as log $(1+\tau)$, where τ is the pay-roll tax as a percentage of the wage. Thomas measures this variable as the change in the pay-roll tax in relation to the wage.

[iii] This variable is measured as $\log(1+\tau)/(1-t)$, where τ and t are the pay-roll tax and the average income tax as a percentage of the wage.

[iv] The elasticity refers to the period 1975–1998.

[v] The elasticity refers to the period 1990–1998.

[vi] This estimate is from equation 6 in Table 2.1.

[vii] This variable is in log form. Rødseth and Nymoen as well as Forslund and Kolm use the previous year's wage share as the variable. Johansson et al. instead include the previous year's real product wage, while Thomas includes the previous year's real consumption wage.

[viii] This variable has not been included in the equation as reported here, but is significant in an alternative specification (see Table 6 in Thomas).

Johansson et al. find wage-increasing effects. Forslund and Kolm find no effects at all on wage formation in their main specifications, while Thomas finds wage-reducing effects.

Structural changes in wage formation

The estimations of wage-setting curves provide a measure of the sensitivity of wage costs to changes in unemployment, which can be used as rules of thumb when forecasting wage developments.

In our introduction (see the section "Key issues"), we posed the question of how sensitive wage increases are to changes in unemployment. The estimations of wage-setting curves provide a measure of the sensitivity of wage costs to changes in unemployment, which can potentially be used as rules of thumb when forecasting wage developments. The coefficients for unemployment in Table 3 are elasticities. These state by how many per cent the wage cost level (or by how many *percentage points* the rate of increase in the wage cost) changes when unemployment rises by 1 per cent. It is necessary to recalculate the estimates if we want to state the effects on wage cost increases of a change in unemployment of 1 *percentage point* (of the labour force). If unemployment falls from 5 per cent of the labour force to 4 per cent, this represents a reduction in unemployment of 20 per cent. In this case, the rate of nominal wage cost increase rises by 0.6 to 1.2 percentage points (20 x 0.03 to 20 x 0.06), according to the estimates in the studies.

A frequently used reference value for the long-run real wage elasticity is –0.1. The estimates show a large spread around the reference value.

Corresponding *long-run* elasticities for real wages (the values stated in brackets) provide a measure of the long-run sensitivity of real wages to unemployment. A frequently used reference value for the long-run real wage elasticity is -0.1.[22] Previous studies using Swedish data indicate that the real wage elasticity is higher in Sweden than in many other countries.[23] The estimates in the table show, however, a large spread around the reference value. In Thomas' study as well as Rødseth's and Nymoen's study, comparisons are made between Sweden and other countries. Thomas' results indicate a higher sensitivity for real wages in Sweden, while Rødseth and Nymoen draw the conclusion that the sensitivity in Sweden is about the same as in other countries.

There is also a discussion that wage cost increases depend not only on the

[22] See Blanchflower and Oswald (1994).
[23] See Layard et al. (1991).

level of unemployment but also on its change. One reason could be that employers have an incentive to raise wages more sharply if employment rises rapidly, to speed up the recruitment process (this is often referred to as a speed limit). Another reason may be that some unemployed persons become gradually less competitive in the labour market and therefore exert a smaller dampening effect on wage increases (hysteresis). Both assumptions indicate that wage cost increases – at a given unemployment level – should be higher if unemployment is falling than if it is rising. Wage cost increases should thus depend negatively not only on the level of unemployment but also on its change from the previous period. However, the studies discussed provide no support for this hypothesis. Forslund and Kolm in fact obtained a positive effect, which they themselves found "surprising".

According to the hump-shape hypothesis, the transition to industry level bargaining as from 1983 should have shifted the wage-setting curve upward. Correspondingly, the increased informal co-ordination of wage agreements since 1997 should have contributed to wage restraint.

The second key question we discussed in the introduction is how wage setting has been affected by the changes that occurred in the bargaining system and the monetary policy regime during the 1980s and 1990s. One argument is based on the so-called hump-shape hypothesis, according to which negotiations at the industry level produce higher wage costs than negotiations at either the central or local level.[24] The reasoning is that economy-wide considerations are of little importance when negotiations are conducted at the industry level, at the same time as the restraining market forces are weak. There is strong empirical support for this hypothesis in studies using panel data, i.e. utilising both cross-sectional and time series variations, for OECD countries.[25] According to the hump-shape hypothesis, the change to industry level bargaining as from 1983 should have shifted the wage-setting curve upward. This means higher wages, everything else equal. Correspondingly, the increased informal co-ordination of wage agreements, which has arisen since the Agreement on Industrial Development and Wage Formation was concluded in 1997, should have contributed to more wage restraint. The tendencies of the last decade towards greater possibilities for allocating wage increases at the local level may have operated in the same direction, since this may have lowered wage drift.

Another hypothesis put forward in the academic literature is that a monetary policy regime with an independent central bank and a credible inflation target

[24] See Calmfors and Driffill (1988) or Calmfors et al. (2001b).
[25] See Calmfors (2001).

should promote wage restraint.[26] It is obvious that lower inflation expectations lead to lower nominal wage increases. However, according to this hypothesis, a credible inflation target regime should also lead to a stronger incentive for *real* wage restraint, i.e. for the labour market parties to restrain wage increases relative to price and productivity increases, if the parties can expect large wage increases to lead to interest rate increases by the central bank. There is also some support for this hypothesis in panel data studies for OECD countries. According to the hypothesis, the change in the Swedish monetary policy regime during the 1990s should have contributed not only to lower nominal wage increases but also to a lower wage share and lower equilibrium unemployment.

Another hypothesis is that a monetary policy regime with an independent central bank and a credible inflation target should promote real wage restraint.

The studies reported in Table 3 do not, however, provide much support for the hypotheses on how the changes in the bargaining system and the monetary policy regime should have affected wage formation. Forslund and Kolm find no structural changes at all in the wage formation process in their study, which covers the period to 1997. Rødseth and Nymoen, whose study only covers the period to 1994, point instead to a tendency towards lower wage increases during 1983–1990 than during other periods. However, they make the reservation that it is rather the period 1975–1981, with exceptionally high wage increases, which explains the results. This conclusion has certain similarities with the results of the previously reported study by Friberg and Uddén Sonnegård (covering the period to 1999); the only structural change in wage formation they could find was remarkably high wage increases in 1975–1976.

The studies reported do not provide much support for the hypotheses on how the changes in the bargaining system and the monetary policy regime should have affected wage formation.

Thomas' study, which covers the period to 1998, is the one that finds most support for structural changes in wage formation. According to this study, the sensitivity of wage cost increases to variations in unemployment appears to have fallen during the 1990s. Thomas interprets this as support for the view that bargaining at the industry level leads to less wage restraint. One problem with this interpretation is, however, that the change to industry

According to Thomas' study, the sensitivity of wage cost increases to variations in unemployment appears to have fallen during the 1990s.

[26] See Calmfors (2001) for a discussion of the hypothesis.

level bargaining took place already in the 1980s. The findings by Johansson et al. are more difficult to interpret, but are to some extent similar to those of Thomas. When Johansson et al. estimate their wage equations for the whole period 1965–1998 instead of for the shorter period 1965–1990, they find wage cost increases to be less sensitive to variations in unemployment and to adjust more slowly to disequilibria.[27]

One factor which may have affected the results of the studies by Thomas and Johansson et al. is the fall in the rates of inflation and wage increase during the 1990s. It is a common hypothesis that nominal wage increases are less sensitive to variations in unemployment when the wage increases are low rather than high, since there are *social norms* that nominal wages should not be reduced and that everyone should have at least some nominal wage increase.[28]

Empirical support for the view that structural changes affected wage formation during the 1980s and 1990s is not substantial, but there are nevertheless indications of changes in the wage formation process.

Even though empirical support for the view that structural changes affected wage formation during the 1980s and 1990s is not substantial, there are nevertheless some indications of changes in the wage formation process. It is difficult, however, to relate these indications to the changes that took place in the bargaining system and in the monetary policy regime. Most surprising is that no support can be found for wage increases being higher during the 1980s than earlier – everything else equal. It is less surprising that no indications were found that the changes in the monetary policy regime slowed down wage cost increases relative to price and productivity increases. A possible explanation is that the credibility of the inflation target regime has probably only been established gradually – which is also indicated by the developments of inflation expectations[29] – and has therefore not yet had any impact in the studies.

Our conclusion is that estimations of wage-setting curves are the most promising approach to explaining wage formation.

The main advantage of estimating wage-setting curves is that they provide a theoretical framework for taking into account factors such as changes in unemployment insurance, taxes, bargaining systems and the monetary

[27] The conclusions only apply to the short-run effects. In the long run, real wage costs are more sensitive to changes in unemployment with the longer estimation period.
[28] See Calmfors et al. (2001b).
[29] The employers' and employees' inflation expectations have varied between 1.5 and 2 per cent since 1996. See Friberg and Uddén Sonnegård (2001).

policy regime. In practice, estimations of wage-setting curves have, however, produced very varying results, and it has been difficult, as pointed out above, to relate structural changes in the wage formation process to the institutional changes that have taken place. One reason may be that these institutional changes partly coincided in time. Our conclusion is nevertheless that estimations of wage-setting curves are the most promising approach to explaining wage formation of those we have discussed. A further development of these models and estimations based on more current data would therefore be of great help in making forecasts of wage developments.

Summary

Good monetary policy is based on reliable inflation forecasts. Reliable inflation forecasts assume in turn accurate forecasts of wage developments. Our article has discussed the advantages and disadvantages of different empirical approaches to explaining wage formation.

A first simple approach is to use a "naive" expectations-augmented Phillips curve. The hypothesis is then that inflation expectations and demand pressure in the labour market are the essential determinants of wage developments. This approach produces simple and easily comprehensible estimates, which is an advantage when making forecasts. One prerequisite for this approach to function well is, however, that the impact of the labour market situation on the wage increases does not vary over time. This may also be expressed as that equilibrium unemployment, i.e. the level of unemployment at which the rate of wage increase and/or the rate of inflation can be kept constant, does not vary substantially over time.

The approach using a "naive" expectations-augmented Phillips curve produces simple and easily comprehensible estimates, an advantage when forecasting.

The second approach we discussed deals with the problem of equilibrium unemployment that varies over time. By using time series models, it can be estimated directly how equilibrium unemployment has developed over time. The estimates of equilibrium unemployment can be used to estimate the unemployment gap (the difference between actual unemployment and equilibrium unemployment), which can be included as an explanatory variable in a more sophisticated expectations-augmented Phillips curve. The problem with the dif-

The second approach uses time series models to estimate directly how equilibrium unemployment has developed over time. The estimates are, however, very sensitive to the technique used.

ferent methods used to estimate equilibrium unemployment is that the estimates are very sensitive to the technique used and the basic assumptions made. Different assumptions produce a relatively consistent picture that equilibrium unemployment in the Swedish economy rose during the first half of the 1990s and then fell towards the end of the decade, but the differences between different estimates are nevertheless considerable. Another weakness of the time series models is that they do not explain the reasons for the variations in equilibrium unemployment, which limits their usefulness for forecasting purposes.

A third approach is to estimate wage-setting curves. In practice, the attempts made to explain Swedish wage formation have, however, produced varying results.

A third approach is to estimate wage-setting curves. These attempt to explain the long-term real wage developments on the basis of wage formation theory that takes direct account of the structure of the bargaining system and factors such as taxes, unemployment insurance, labour market programmes, etc. Such a long-run explanatory model is then linked up with short-run dynamics for nominal wage increases, which explain how the adjustment to the long-run relationships occurs. A *theoretical* advantage of wage-setting curves is that they aim to identify such changes in the wage formation process as can affect equilibrium unemployment. In *practice*, the attempts made to explain Swedish wage formation in this way have, however, produced varying results. One of the studies cannot demonstrate any structural changes at all. In the other studies, it is difficult to relate the structural changes in the wage-setting relationships found to the institutional changes in the bargaining system (the change to industry-level bargaining in 1983) and the monetary policy regime (the changeover to an inflation target regime in 1993) that took place. One interesting observation is, however, that a couple of studies find that wage increases during the 1990s were less sensitive to variations in unemployment than previously.

It should be emphasised that the estimations of wage-setting curves made have generally not covered the most recent years. This means that they do not take account of any effects of the increased degree of "informal" co-ordination of wage negotiations that appears to have arisen since the Agreement on Industrial Development and Wage Formation was concluded in 1997, and the strengthening of the new inflation target regime when the Riksbank was made more independent in 1999.

Our conclusion is that the three approaches to explaining wage developments we have discussed all have their value and complement each other. If we are to give any advice as to where most research resources should be invested, our

recommendation is to focus on estimations of wage-setting curves. The main advantage of these from a forecasting viewpoint is that they can more clearly identify structural changes in the wage formation process which may affect equilibrium unemployment. It should also be possible to "marry" these models to a greater extent with the time series models that directly attempt to estimate the development of equilibrium unemployment.

Our recommendation is to focus research resources on estimations of wage-setting curves.

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