Wage Development in Denmark
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Introduction

In recent years wage increases in Denmark have been at a historically low and stable level. From mid-1995 to the end of 1997 hourly wages for workers in manufacturing, which are the topic of this article, thus rose at a by and large unchanged rate of approximately 4 per cent per annum, cf. Chart 1. From the end of 1991 to 1995 the wage increases were even lower, ranging from 2 to 4 per cent per annum, a level otherwise not seen since 1950. This level of Danish wage increases to a great extent reflects an international trend following the general reduction in the inflation rates of many countries since the 1980s. In concrete terms, Danish prices have developed somewhat more slowly than wages in recent years, so that despite the low nominal wage increases real wages have risen. At the beginning of the 1990s the nominal wage development in Denmark was more subdued than for Denmark's most important trading partners. As from the start of 1995 this development reversed. The higher Danish wage increases coincide with stronger economic growth than in most trading-partner countries, and thereby a far more favourable development in unemployment than in other countries since 1993.

Chart 1  Nominal wage increases and real wages

[Diagram showing nominal wage increases and real wages from 1980q1 to 1997, with wage increases on the right-hand axis and real wages on the left-hand axis.]
In a small open economy like Denmark’s wage formation plays a central role in the ability of the economy to adapt to changes in external conditions, not least due to the great impact of wage formation on competitiveness. In the slightly longer term the effects of economic policy, including fiscal policy, are to a significant degree determined by the extent and speed that wages react to e.g. changes in output and employment. However, a number of other factors, including price formation in the commodities market, confidence and the development in interest rates, are also important in that context. The scope for manoeuvre of economic policy thus depends on other factors besides wage formation. This does not change the fact that it is important to have a clear idea of wage formation with regard to the compilation of Danish economic forecasts and when planning economic policy. The experience from the mid-1980s, when strong wage increases in 1987 made a decisive contribution to ending the economic upswing and to the onset of a long period of low growth, has had a strong impact. During 1997 unemployment fell to that same low level, with no indication of equivalent wage acceleration. These conditions in themselves call for a closer study of wage formation in Denmark.

It should be noted that the wage relation so far used by Danmarks Nationalbank in modelling the economy has not shown any signs of being off course. An important issue in this connection is whether the reaction pattern today is nonetheless different from that of the 1980s, including whether wage formation has undergone a structural shift, or the wage reaction is merely delayed as the labour-market dispute in the spring of 1998 might indicate.

This article describes an empirical analysis of hourly wages in manufacturing which takes alternative wage-formation hypotheses as the starting point. The first section reviews the results of the econometric analysis. Then follows a discussion of the stability of the estimated relationship, in particular whether a structural shift in the wage formation may have taken place. This is followed by concluding remarks. The actual empirical analysis of wage formation is described in the Appendix.

A wage equation for Denmark

The econometric analysis supports that the rate of wage increases can be described as a relatively stable function of the unemployment rate and price increases, as in a more traditional Phillips curve. Together with the

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1) The Phillips curve is named after A.W. Phillips (1958). The Relationship between Unemployment and the Rate of Change of Money Wages in the United Kingdom 1861-1957, *Economica*, vol. 25, November 1958. In this study the rate of wage increases is explained solely in terms of the unemployment rate. In many later studies the Phillips curve is expanded to include the rate of inflation as an explanatory factor. In this article the rate of wage increases is furthermore described in terms of a number of other explanatory variables and the wage relation is thus complicated further in relation to the Phillips curve.
difference between producer- and consumer-price increases, the changes in the number of annual working hours and the replacement ratio of unemployment benefits these factors in overall terms give a satisfactory description of the wage development from the mid-1970s until today. The preferred equation, cf. Table 5 of the Appendix, can be written as follows:

\[
\Delta w_t = 0.05 + 0.10 \cdot \Delta p_{C,t-2} + 0.16 \cdot \Delta p_{C,t-3} + 0.13 \cdot (\Delta p_{Y,t-3} - \Delta p_{C,t-3}) \\
- 0.78 \cdot \Delta h_t - 0.13 \cdot UR_{t-1} + 0.05 \cdot r_{t-1}
\]

Note: The contributions of the individual factors to the explanation of wage formation, represented by columns, is standardized to a total effect of zero over the estimation period, 1975-1995. The only exception is the number of working hours, which have been constant for most of the period. The effect on the growth rate of wages is therefore in this case represented by zero in most quarters.
$w$ is the hourly wage rate for workers in manufacturing, $p_c$ is the consumption deflator, $p_Y$ is the deflator for GDP at factor prices for the nonagricultural private sector, $h$ is the number of annual working hours, $UR$ is the unemployment rate, and $r$ is the replacement ratio on unemployment\(^1\).

Chart 2 shows the contribution to the wage development from each explanatory component in the wage relation.

The reaction of wages to economic cycles is captured primarily via the unemployment rate. In this connection it is noteworthy that in 1997 hourly wages increased considerably more slowly than in the second half of the 1980s, when unemployment fell to by and large the same level as today. According to the model the most significant explanation for this difference is the successive reductions of working hours which took place in the second half of the 1980s. These were partly the result of political decisions and were to a great extent granted with full wage compensation to wage-earners.

The inflation rate has fallen considerably during the period considered and has been lower in the 1990s than in the 1980s. This dampens inflation expectations and therefore the rate of increase in consumer prices contributes to explaining the change in the level of the rate of wage increases. The same applies to the average replacement ratio on unemployment, which today is lower than in the mid-1970s.

Moreover, wage increases are determined by the growth in producer prices since the offered wage will depend on the price development from the producer's viewpoint. In concrete terms the wage equation comprises the difference between the rates of increase in respectively producer and consumer prices. This element does not affect the trend of the wage development since in the longer term the two price series will move in parallel. However, in the short term the influence of this factor may be significant.

In general, the estimated relationship gives a good description of the wage development. The overall wage movements within the estimation period are captured, whereas major fluctuations from one quarter to the next are not always reflected, cf. Chart 3. Outside the estimation period the wage increases of recent years are likewise predicted with reasonable accuracy. It is noteworthy that during the most recent upswing the model-determined rate of wage increases is hardly affected, even if the estimation period stops in 1992 instead of 1995. This shows that the wage development in re-

\(^1\) Both here and in the Appendix letters in small type describe the logarithm of the corresponding large-type letters. The subscript $t$ is a time index, and $\Delta$ is the differential operator. On small changes the log difference, $\Delta x_t = \ln x_t - \ln x_{t-1}$, corresponds approximately to the percentage change in $x_t$. 


cent years does not give problems for the estimated relation and thus that the development can be explained without recourse to the hypothesis of a structural shift in wage formation.

Structural shift in wage formation?

The current debate on "new economics"¹, i.e. the idea that output and employment can rise without an upturn in the inflation rate, due to such factors as intensified competition and globalization, may imply that the Phillips curve has become flatter, i.e. a reduction of the marginal reaction of the rate of wage increases on changes in unemployment.

An obvious explanation for this structural shift might be a growing awareness that high wage increases have a tendency to be absorbed by equivalent price increases and a decrease in employment. Experience from the most recent decades shows that real wages have increased particularly in periods of low wage increases, cf. Chart 1.

The coincidence of low wage increases and a significant drop in unemployment might also be explained by a less tight labour market than the change in the unemployment figures might indicate. It could be the case that the labour-market policy pursued in recent years has reduced the level of unemployment at which wages normally begin to accelerate. This

¹) Cf. the discussion in Development in Inflation in the USA and EU - "New Economics"?, by Tom Nordin Christensen (1998), Danmarks Nationalbank, Monetary Review, 1st Quarter 1998.
corresponds to a sidewards shift to the left of the Phillips curve. The most remarkable results have been achieved in combatting youth unemployment, which has fallen considerably. The decline in unemployment has furthermore been distributed broadly across different sectors, and bottleneck problems on the same scale as during the upswing of the 1980s have not yet been seen.

A further possible explanation might be that the decline in unemployment to a significant degree is due to the transfer of the unemployed to leave schemes, transitional allowance and early-retirement benefit. In so far as this concerns unemployed with relatively loose ties to the labour market, who therefore have not made any significant contribution to keeping wages down, unemployment may have declined without leading to greater pressure on wages. This also corresponds to a shift of the Phillips curve to the left.

Overall, the estimated relation shows a stable relationship between the rate of wage increases and its explanatory factors, cf. the analysis of the stability properties in the Appendix, hence implying the absence of a structural shift in wage formation. However, the slope of the Phillips curve, i.e. the coefficient of unemployment, has evened out a little after 1993.

In an empirical analysis it is generally difficult to distinguish between the different explanations for the lower wage increases in recent years than during the upswing in the 1980s. However, there is no doubt that changes in annual working hours play a significant role. In formal terms all reductions of working hours have been accompanied by immediate wage compensation, although it is possible that this effect might be reduced subsequently. The most significant individual wage increases from one quarter to the next, i.e. in 1975, 1979 and 1987, thus took place in quarters with significant reductions of working hours, cf. the comparison of Charts 2 and 3.

Conclusion

It is shown that a limited number of factors can describe the wage development since the mid-1970s. There appear to be no significant problems in using the wage equation to explain the historically modest wage increases up to end-1997. However, as always, the results of the econometric analysis must be interpreted with caution and it cannot be denied that a more accelerated wage development is "waiting around the corner", in step with the increasingly tighter labour market in the present economic upswing. However, at the same time wage increases of around 4 per cent per annum must be assessed to be problematic in view of the latest collective wage agreements in Germany and the generally low wage increases abroad.
Appendix

This Appendix reviews an econometric analysis of wage formation in Denmark. The analysis is based on hourly wages in manufacturing. The following section gives a brief discussion of alternative models to explain wage formation, as the basis for the econometric analysis. Then follows a description of data and methodology. The article then reviews the estimation of each model separately, and tests the models against each other. Finally, the statistical properties of the preferred model are discussed, including stability and forecast properties.

Model framework

As mentioned previously, the basis for the analysis is alternative hypotheses, each of which has played a central role in existing empirical studies of the development in both Danish and foreign wages. The Phillips curve comes first chronologically and describes the rate of wage increases as a function of inflation and the unemployment rate. It has played a central role in many macroeconometric models, although it is often criticized for a lack of theoretical basis and sometimes also for empirical instability. The counterpart of the Phillips curve is equations which describe a relationship between real wages/wage share and e.g. unemployment. Chart 4 indicates that both Phillips curves and real-wage models might be of empirical interest, since both the rate of wage increases and the wage share appear to

Chart 4  Rate of wage increases, wage share and unemployment
have a negative correlation with the unemployment rate. However, in recent years this correlation appears to be broken. Whether there is a structural break will be investigated in the following.

In essence, the Phillips curve describes the rate of wage increases, $\Delta w$, as a function of expected inflation, $\Delta p^e$, and the unemployment rate, $UR$, and possibly also the change in the unemployment rate, $\Delta UR$,

$$\Delta w = \alpha \cdot \Delta p^e + f(UR, \Delta UR), \quad 0 \leq \alpha \leq 1, \quad f_1 \leq 0, \quad f_2 \leq 0$$

Expected inflation is normally approximated by lagged values of actual inflation, $\Delta p$. Other explanatory variables might well be included. As previously stated the Phillips curve has been criticized for giving a too simple description of wage formation. One of the most important points of criticism is that it does not explain the level of real wages at a given unemployment rate, but only the rate of increase in nominal wages. However, in a wider model context the Phillips curve does not necessarily imply that real wages are indeterminate. They may very well be included in both supply and demand for labour. In that case the Phillips curve will merely be the mechanism ensuring adjustment of real wages and creating equilibrium in the labour market. It should also be stated that the existence of a well-determined long-term level of unemployment does not necessarily imply a vertical Phillips curve, i.e. $\alpha=1$. With fixed exchange rates, unemployment in equilibrium must result in the same rate of wage increase as in the anchor area. This appears from e.g. multiplier simulations using the Nationalbank’s macroeconometric model\(^1\).

Wage bargaining models represent a more recent theory of wage formation. Real wages are determined by negotiation between trade unions and employers and will therefore depend on the relative bargaining power of the unions. The unemployment rate is used as a proxy, so that $W/P = g(UR)$, $g' < 0$. Real wages are normally also influenced by other factors such as payroll and corporate taxes, productivity, the replacement ratio of unemployment benefits, etc.\(^2\) As the basis for empirical determination of a model for real wages we will use the following log-linear specification where the expected sign of the parameters is stated:

$$w - p_C = f(q, h, UR, t_i, t_p, r, p_Y, p_C)$$

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\(^1\) Cf. e.g. Wage Flexibility and Macrostability - An Analysis of Mona-multipiers, unpublished manuscript by Niels Lynggård Hansen (1998).

\(^2\) A well-known example of this idea is S.J. Nickell and M. Andrews (1983), Unions, Real Wages and Employment in Britain 1951-79, *Oxford Economic Papers*, 508. The theoretical motivation for real-wage models is also found in e.g. the theory on efficiency wages.
\( p_C \) indicates consumer prices, \( p_Y \) producer prices, \( q \) labour productivity, \( h \) weekly working hours, \( t_i \) average income-tax rate, \( t_p \) payroll taxes, i.e. employers' indirect wage costs\(^1\), and \( r \) the replacement ratio. The wedge, \( WW \), between the employers' product real wages, \( W_1 = W \cdot T_p / P_Y \), and the employees' consumption real wages, \( W_2 = W \cdot T_i / P_C \), i.e. \( WW = p_C - p_Y + t_p - t_i \), is of relevance since employers and employees do not normally focus on the same wage concepts. The relevance of the wedge can be illustrated by the following wage equation with disposable consumption real wages on the left-hand side:

\[
W - p_C + t_i = \mu_1 (p_Y - p_C) + \mu_2 t_i + \mu_3 t_p + \ldots
\]

where \( 0 \leq \mu_1 \leq 1 \), \( 0 \leq \mu_2 \leq 1 \), \(-1 \leq \mu_3 \leq 0 \)

If \( \mu_1 = \mu_2 = \mu_3 = 0 \), the consumption real wages will be invariant to changes in the wedge components, whereas product real wages are invariant if \( \mu_1 = \mu_2 = -\mu_3 = 1 \). Ultimately, the size of the coefficients is determined by the bargaining power of the unions, i.e. their ability to pass on changes in income tax and consumer prices to wages, and equivalently prevent business enterprises from passing on changes in indirect wage costs to wages. A tax symmetry in the wage formation might be envisaged, i.e. \( \mu_1 = \mu_2 = -\mu_3 \), so that a simple restructuring of the tax system has no real effects through changes in real wages, although this need not be the case.

**Data and methodology**

Quarterly data from the Nationalbank's Mona model are used. The estimation period is from the 1st quarter of 1975 to the 4th quarter of 1995, whereas data until end-1997 is used for out-of-sample predictions. The following series are used:

- \( W \) hourly wage index for workers in manufacturing\(^2\)
- \( P_C \) private consumption deflator
- \( P_Y \) deflator for GDP at factor prices for the private sector, excluding agriculture, energy and housing

\(^1\) In practice, \( t_i \) signifies one less the income-tax rate and thus the ratio between wage-earners' income before and after tax, while \( t_p \) signifies the ratio between business enterprises' total wage costs, including and excluding indirect wage costs. This implied notation is used throughout the article.

\(^2\) At the end of 1993 wage statistics for the manufacturing sector were restructured from a monthly to a quarterly basis. The restructuring implies that the wage concept now includes pension contributions. The first significant contributions to labour-market pension schemes were adopted in the collective agreements of 1993. The only retrospective correction for pension payments therefore concerns 1993. In conjunction with the restructuring of the wage statistics the hourly-wage index for industrial workers as applied in this article and the monthly-wage index for industrial white-collar workers are discontinued by the end of 1997. These indices are replaced by sectoral indices covering the entire private sector.
In the first instance a unit root test is used to study the integration order of the time series. For this purpose an augmented Dickey-Fuller test based on the following equation is used. A time trend, $t$, is included when relevant in economic terms as an alternative to a stochastic trend.

$$\Delta x_t = \alpha + \beta \cdot t + \gamma \cdot x_{t-1} + \sum_{i=1}^{\rho} \delta_i \cdot \Delta x_{t-i}$$

The study of the series’ order of integration indicates, cf. Table 1, that it is uncertain whether the nominal wage is integrated of first or second order, whereas the other nominal variables, consumer and producer prices, are more unequivocally integrated of first order. The working hypothesis is that all nominal variables are integrated of first order. The real variables such as real wages, wedge, unemployment, working hours and payroll and income taxes are integrated of first order. In view of the test statistics productivity might appear to be stationary, but is assumed to be integrated of the same order as the other real variables.

The empirical analysis will be based on Johansen’s multivariate cointegration model. A $p$-dimensional VAR model, written in the error-correction form, is given as

$$\Delta X_t = \Pi \cdot X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \cdot \Delta X_{t-i} + \Phi \cdot D + \varepsilon_t, \quad t = 1, ..., T$$

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1) In concrete terms payroll taxes, i.e. business enterprises’ indirect wage costs, are determined using the formula $T_p = 1 + (\text{aud} + (\text{alba} \cdot (0.82 \cdot \text{qp} - 145) + \text{atpa} \cdot 0.82 \cdot \text{qp} + \text{invb}) / 1000000) / (\text{ywby} + \text{ywla})$, $\text{aud}$ is the AUD contribution (kr. billion) (abolished as from 1994), $\text{alba}$ is the employers’ contribution to unemployment insurance (kr.), $\text{atpa}$ is the employers’ contribution to ATP (kr.), $\text{qp}$ is employment in the private sector (1,000 persons), $\text{invb}$ is other social contributions (kr. billion), and $\text{ywby}$ and $\text{ywla}$ are total wage costs for respectively the private non-agricultural sector and the agricultural sector (kr. billion).

2) The average income-tax rate is determined using the formula $T_i = (1 - \text{bsda}) \cdot (1 - \text{arbsats})$, $\text{bsda}$ is the average income-tax rate and $\text{arbsats}$ is the gross tax (0 until the end of 1993).

3) In principle the unemployment rate, the income-tax rate and payroll taxes should be stationary since by their nature these variables can only vary within a certain range. In the concrete sample the variables nevertheless appear to be non-stationary and will be regarded as such in the analysis.

$k$ is the number of lags in the VAR model and $t$ is an index of time. $D$ signifies the deterministic terms. The error term $\varepsilon$ is assumed to be identically, independently and normally distributed with the covariance matrix $\Omega$, $\varepsilon_t \sim i.i.d. N_p(0, \Omega)$. Relevant variables in the long-term correlation are nominal wages, consumer prices, average hourly productivity, rate of unemployment, the wedge between enterprises' product real wages and the disposable consumption real wages, and the average replacement ratio, i.e. $X=\{w, p, q, UR, ww, r\}$.

The long-term multipliers of the model are contained in the $6 \times 6$ matrix $\Pi$. As mentioned above $X_t$ is integrated of first order, i.e. $X_t \sim I(1)$. The assumptions behind the VAR model imply that the above model describes a balanced system where all elements are stationary. Hence this means that $\Pi$ must be of reduced rank, rank $(\Pi)=p$, and can thereby be divided into two matrices, $\alpha$ and $\beta$, both $6 \times p$ matrices of full column rank, where $\Pi=\alpha\beta'$. In other words $p<6$, when $X$ is non-stationary. The situation $p=0$ corresponds to no cointegration and the model is reduced to a traditional VAR model in first differences, whereas in a situation where $0<p<6$, $p$ independent cointegrating relationship can be found between the $I(1)$ variables in $X$.

Table 1  Unit root tests (Augmented Dickey-Fuller test), 1975-1995

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>1st difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Det. terms</td>
<td>Augm.</td>
</tr>
<tr>
<td>Wages</td>
<td>$K, TR$</td>
<td>3</td>
</tr>
<tr>
<td>Consumer prices</td>
<td>$K, TR$</td>
<td>-</td>
</tr>
<tr>
<td>Producer prices</td>
<td>$K, TR$</td>
<td>1</td>
</tr>
<tr>
<td>Consumption real wage</td>
<td>$K, TR$</td>
<td>3</td>
</tr>
<tr>
<td>Product real wage</td>
<td>$K, TR$</td>
<td>1</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>$K$</td>
<td>1</td>
</tr>
<tr>
<td>Payroll taxes</td>
<td>$K$</td>
<td>3</td>
</tr>
<tr>
<td>Income tax</td>
<td>$K$</td>
<td>1, 2</td>
</tr>
<tr>
<td>Productivity</td>
<td>$K, TR$</td>
<td>1</td>
</tr>
<tr>
<td>Working hours</td>
<td>$K, TR$</td>
<td>1</td>
</tr>
<tr>
<td>Replacement ratio</td>
<td>$K$</td>
<td>-</td>
</tr>
<tr>
<td>Wedge</td>
<td>$K, TR$</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: ***, ** and * indicate significance at respectively 1, 5 and 10 per cent levels. The deterministic terms include a constant, $K$, and in certain cases a linear trend in time, $TR$. Critical values are taken from J.G. MacKinnon (1991), Critical Values for Cointegration Tests, in Engle og Granger (eds.), Long-Run Economic Relationships - Readings in Cointegration, Oxford University Press.
Each column in \( \beta \) describes a cointegration relationship, and \( \alpha \) the corresponding loadings, i.e. the coefficients of the cointegration relationships in the individual equations. If there is more than one cointegration relationship the coefficients in \( \alpha \) and \( \beta \) will not be identified and identifying restrictions must be imposed on the system in order to derive correlations which can be given an economic and structural interpretation.

**Estimation results**

Table 2 shows results from the cointegration analysis. On the basis of e.g. various information criteria a lag length of 2 has been chosen. The replacement ratio is assumed to be exogenous from the start with respect to the long-term parameters, and hence the system is partial in that only five out of six variables are perceived as endogenous. The trace test is generally favourable to a rank of 2\(^1\).

The misspecification tests indicate that overall the model is well-specified. The classical distributional assumptions can now be applied to the ongoing statistical analysis, since \( \Pi \) consists of 2 cointegrating, and thereby stationary, relations. The first test is for exogeneity with respect to the long-term parameters and for whether the variables can be removed individually from the cointegration space\(^2\). On the other hand, it does not make sense to apply tests to individual coefficients in \( \alpha \) and \( \beta \), since as stated they are not identified. A test on the rows in \( \alpha \) shows that productivity, unemployment and the wedge are exogenous, whereas no variables can be removed from the cointegration space.

The analysis now continues on the basis of a partial system with nominal wages and consumer prices as the endogenous variables, cf. Table 3. Overall the system appears to be well-specified and will be the basis for the ongoing analysis of the cointegrating relationships. The two cointegration vectors, \( \beta_1 \) and \( \beta_2 \), are normalized, but still not identified. The explanatory cointegrating relationships, which conform to the theory, may be the result of linear combinations of \( \beta_1 \) and \( \beta_2 \).

The following focuses on identification of the estimated cointegrating relations, against the background of the theoretical considerations outlined above. Table 4 shows the results of tests of identifying assumptions. A pre-

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\(^1\) The eigenvalues for the second and third eigenvectors may appear to be rather close to each other, so a rank of 1 or 3 respectively was also investigated. The analysis with \( rank=1 \) unequivocally supports the Phillips curve and therefore generally corresponds to the conclusions using \( rank=2 \), cf. below. On application of \( rank=3 \) the third cointegrating relation is included solely in the productivity equation, which would otherwise be exogenous. This analysis has not been pursued further.

\(^2\) In practice exogeneity with respect to the long-term parameters implies that the relevant rows in \( \alpha \), and thus in \( \Pi \), solely contain zeros, whereas a variable can be removed completely, i.e. will not be included in any cointegration relation, if the relevant column in \( \Pi \) consists solely of zeros.
The previous study based on quarterly data from Mona finds a relation for wage formation where the rate of wage increases, inter alia, is explained by two non-stationary variables, i.e. unemployment and the replacement ratio.

### Table 2  
**Cointegration analysis in a partial system, 1975-1995**

<table>
<thead>
<tr>
<th></th>
<th>Loading factors wrt.</th>
<th>Std. dev.</th>
<th>Misspecification tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta_1$</td>
<td>$\beta_2$</td>
<td>$\beta_3$</td>
</tr>
<tr>
<td>$\Delta w$ . $\alpha_1$</td>
<td>0.046</td>
<td>0.046</td>
<td>-0.039</td>
</tr>
<tr>
<td>$\Delta p_c$ . $\alpha_2$</td>
<td>0.056</td>
<td>-0.007</td>
<td>-0.033</td>
</tr>
<tr>
<td>$\Delta UR$ . $\alpha_3$</td>
<td>0.006</td>
<td>-0.009</td>
<td>-0.054</td>
</tr>
<tr>
<td>$\Delta q$ . $\alpha_4$</td>
<td>-0.032</td>
<td>0.034</td>
<td>0.791</td>
</tr>
<tr>
<td>$\Delta ww$ . $\alpha_5$</td>
<td>0.033</td>
<td>-0.046</td>
<td>0.269</td>
</tr>
</tbody>
</table>

2) No drift in the partial system ($c=0$). $c$ indicates the drift in the partial system relative to the drift in the marginal system standardized by means of the covariance in the respective systems, cf. I. Harboe, S. Johansen, B. Nielsen and A. Rahbek (1995), Test for Cointegration Rank in Partial Systems, Mimeo, Institute of Mathematical Statistics, University of Copenhagen.
3) $\psi$, **: Test statistics significant at 5 per cent and 1 per cent levels.
4) LM-test for autocorrelation of order 1-5, F-distributed.
5) LM-test for ARCH of 4th order, F-distributed.
7) Bera-Jarque test for normality, $\chi^2(2)$-distributed.

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Therefore these constitute a formal cointegrating relationship. In practice we are probably in a grey area since it is an open question whether the rate of wage increases is stationary or integrated of the first order. It is therefore likely that in the longer term the rate of wage increases is negatively correlated and cointegrated with the unemployment rate and positively correlated with the replacement ratio. Columns 1 and 2 show that it still cannot be ruled out that unemployment and the replacement ratio constitute a cointegrating relationship which might also be the only factor affecting the wage equation, with a correct sign.

It is also possible to compile an economically reasonable relationship to describe the real-wage curve, cf. columns 3 and 4. However, this relationship is included in the wage equation with an incorrect sign since the first element of $\alpha_t$ turns out to be positive in this case, equivalent to no error correction in wage formation. Furthermore, a statistical test shows that in this case the long-term relationship is not the only such term included in

<table>
<thead>
<tr>
<th>Equation</th>
<th>Loading factors wrt. $\beta_1$</th>
<th>Loading factors wrt. $\beta_2$</th>
<th>Std. dev. $\sigma$</th>
<th>AR$_1$, ARCH$_1$ $F(5,60)$, $F(4,57)$, Hetero., Norm. $\chi^2(2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta w$</td>
<td>$\alpha_1$</td>
<td>0.058 0.070</td>
<td>0.0066</td>
<td>1.83 1.24 1.00 1.14</td>
</tr>
<tr>
<td>$\Delta p$</td>
<td>$\alpha_2$</td>
<td>0.072 -0.049</td>
<td>0.0061</td>
<td>1.21 0.53 2.08 1.18</td>
</tr>
</tbody>
</table>

Note: See notes to Table 2.

Table 3  Cointegration analysis in a partial system, 1975-1995
the wage equation. It should be noted that certain coefficients in the real-wage equation, e.g. to the replacement ratio, have values impossible to interpret if they are estimated freely. This must of course be seen against the background of the fact that the coefficients for the unemployment rate and the replacement ratio are not identified in the real-wage equation in column 5, so interpreting these coefficients is not relevant. On this basis the real-wage curve cannot be rejected.

In the remaining columns the two types of relationship are identified simultaneously in the cointegration space. A Phillips curve equivalent to $\beta_2$ in column 7 also appears to dominate here, cf. a comparison of LR-tests of the overall set of overidentifying restrictions in columns 6 and 7.

The initial cointegration analysis appears to favour the Phillips curve specification rather than a real-wage equation. Nevertheless, the dynamic analysis continues to apply both hypotheses, cf. Table 5. This analysis is based on single-equation estimations and on the general-to-specific principle.

In principle, a real-wage equation with reasonable statistical properties can be estimated. However, conventional encompassing tests show clearly

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1) The unlagged consumer prices are clearly not significant. This also applies to productivity without lags, and both variables are therefore removed from the wage equation.
that the Phillips curve dominates the real-wage equation, since the equivalent coefficient to the wage share is not significant (columns 1 and 2). Furthermore, a test for hysteresis\(^1\) (columns 3 and 6) was made by studying in the traditional way whether changes in unemployment rather than levels determine the wages. This does not seem to be indicated. On the basis of the above analysis a Phillips curve (columns 4 and 5) is preferred.

The preferred equation (column 4) has satisfactory statistical properties. There are no signs of autocorrelation and it cannot be ruled out that the error

\(^1\) Hysteresis describes the empirical observation that in the 1970s and 1980s unemployment in many western-European countries showed only a very weak tendency to revert to the level from before the oil-price increases.
term is normally-distributed white noise. It should be noted that a standard deviation in the quarterly logarithmic changes of 0.0061, or approximately 0.6 per cent, converted into percentage year-on-year changes is equivalent to just over 1.2 per cent. This is of course a relatively large degree of uncertainty, but it should be viewed in the light of the relatively volatile quarterly rate of wage increases. In general, the model-determined wage development seems overall to give a satisfactory description of the actual development within the estimation period, cf. Chart 3, although it does not capture all fluctuations.

**Stability and forecast properties**

Outside the estimation period, i.e. from expiry of the estimation period at end-1995 to the 4th quarter of 1997, which is the latest statistics-based period, the estimated Phillips curve also performs relatively well, cf. Chart 3. The forecasts are not especially accurate all the way through, but the curve does come close to the "peaks" of the quarterly wage increases in 1993 and 1995, and not least the dampened wage development in the second half of 1996. It should furthermore be noted that even when the estimation period runs only to 1992 the Phillips curve gives a relatively good description of the wage increases throughout the 1990s.

On the basis of the recursive estimates in Chart 5 the stability properties of the estimated Phillips curve appear to be satisfactory. The various Chow tests do not indicate any significant problems of structural breaks in the estimation period\(^1\). The coincidence of low wage increases in recent years and a continuing decline in unemployment does not appear to give the model problems, although a small absolute drop in the coefficient for the unemployment rate after 1993 is observed. At present the unemployment rate is at the same level as the low in the mid-1980s, while the current price increases contribute to lower wage increases than previously. However, the fact that the model-determined rate of wage increases is not higher is due primarily to the absence of any contribution from reductions of working hours, as was the case in 1987-1991, cf. Chart 2.

Regarding the obvious stability of the Phillips curve in the period from 1975 until today it should be stated that the wage reaction to changes in the unemployment rate is more than trebled when the years 1972-1974 are included in the estimation period. This has no significant impact on the other

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\(^1\) A Chow test for constant parameters with one-period predictions is not as such a test of the model specification, but nevertheless provides a measure of whether the model parameters are constant.
Chart 5 Recursive parameter estimates and test for structural breaks

Note: In the uppermost charts the bold lines indicate recursive coefficient estimates, i.e. coefficient values from recursive re-estimation of the equation with a fixed starting point and variable end point, whereas the thin lines indicate plus/minus 1.96 times the standard deviation. The charts in the lowest row represent F-distributed test statistics for traditional Chow tests for parameter stability, standardized with critical values at a 5-per cent significance level. The left-hand chart indicates test for structural breaks at various times, while the right-hand chart indicates the test for constant parameters in the case of one-period predictions, cf. D.F. Hendry and J.A. Doornik (1996), Empirical Econometric Modelling Using PcGive 9.0 for Windows, International Thomson Business Press.
coefficients and the stability properties of the equation likewise seem
good. This indicates that during the first oil crisis the Danish labour mar-
et, like many other western European countries, experienced a change in
regime from an unemployment rate of around 2 per cent to a situation
where the unemployment rate more than trebled, simultaneously with a
strong upswing in the rate of wage increases. This may have led to a struc-
tural break in the Phillips curve, and hence favours the use of a sample
which starts in 1975.