

A list of Working Papers on
the last pages

No. 195, 1988

**CAUSES OF WAGE INCREASES IN SWEDISH
MANUFACTURING: A Remarkable Case of
Regular Behaviour**

by

Nils Henrik Schager

This is a preliminary paper.
Comments are welcome.

June, 1988

1988-07-01

Nils Henrik Schager

The Industrial Institute for Economic and Social
Research (IUI)

Box 5501

S-114 85 STOCKHOLM

Sweden

**Causes of Wage Increases in Swedish Manufacturing:
A Remarkable Case of Regular Behaviour***

Abstract

The present study is a theoretical and empirical investigation into the aggregate wage dynamics of Swedish manufacturing. It contains three essential results:

- a rigorous search theoretical model of the wage behaviour of firms is presented and adapted for application to aggregate data
- the implications of the model are confirmed by Swedish data for manufacturing industry and a stable wage drift equation is demonstrated to have existed since the mid-sixties
- the model is consistent with the findings of earlier postwar empirical research on wage drift in Sweden and provides them with a more satisfactory theoretical interpretation.

* Helpful comments by participants at the Research Seminar at the Department of Economics, Uppsala University, headed by Bertil Holmlund, as well as by Kurt Brännäs, University of Umeå, and by several of my colleagues at IUI are gratefully acknowledged. The nonlinear estimation procedures have been carried out by Benny Domeij, IUI. Erik Mellander, also at IUI, has helped me considerably in interpreting the estimation results.

Causes of Wage Increases in Swedish Manufacturing: a Remarkable Case of Regular Behaviour

The present study is a theoretical and empirical investigation into the aggregate wage dynamics of Swedish manufacturing. As far as the empirical part is concerned, my study fits well into a Swedish tradition, starting off with a contribution by Bent Hansen and Gösta Rehn in 1956.

The theoretical model of this study originates from my dissertation Schager (1987), in which I analyse the optimal wage behaviour of a firm, which recruits from a search labour market. On this basis I formulate a disequilibrium model of aggregate money wage dynamics, which is estimated on data for Swedish manufacturing.

The estimation results are very satisfactory. They show the existence of a stable wage increase relation in Swedish manufacturing since the mid-sixties. It is quite remarkable that the development of a few basic economic variables is sufficient to explain the rate of wage increases during this period of external shocks and structural changes.

The paper is organized as follows. The first section presents my model of optimal firm behaviour. The following section adapts the model for application to aggregate data. A third section presents the estimation results for wage drift in manufacturing. The fourth section compares my results with the findings of earlier empirical studies. In a final section estimation results are presented as to negotiated wage increases, indicating that these are determined by the same forces as wage drift.

The Firm Model

In Schager (1987) I analyse a model of a recruiting firm, which faces a stochastic (Markov process) flow of job applicants. The wage optimization problem of the firm is solved by dynamic programming. Two cases as to the feasible wage policy are distinguished and analysed: full wage flexibility and downward money wage rigidity. In this study we are going to apply the latter case as being in line with the pattern of Swedish wage formation.

The analysis in Schager (1987) refers to a specification of the hiring process such that the intensity of contacts between job applicants and the firm is unaffected by the number of vacancies announced by the firm. Aggregate data on the relation between stocks and flows of vacancies and unemployment in the Swedish labour market for workers in manufacturing point to a specification, in which vacancies influence positively the contact intensity [see Schager (1987), ch. I]. We will consequently build our further formal analysis on a specification, in which the contact intensity is linearly increasing in the number of vacancies.

The analysis of the decision problem, where the contact intensities are specified as above, is not published in Schager (1987), but it has been worked out [cf Schager (1987), pp 157-59]. The analysis establishes the following structure of the optimal wage policy: the firm should make a (possibly zero) wage increase at the initial decision instant and keep the wage level fixed during future employment expansion.

Moreover, the value function obtains in closed form. If the value productivity is constant with respect to all employment levels above the initial one, the expression for the value function, i.e. expected discounted total profits, becomes particularly simple; it reads

$$H(n) = \max_w \{H(n,w)\}$$

$$\alpha \cdot H(n,w) = (pa-w) \left[n + \frac{v \cdot \lambda(w)}{\lambda(w) + \alpha} \right], \quad (1)$$

where the notation is as follows:

- n = (initial) number of employees
- w = wage level
- α = instantaneous discount rate
- pa = value productivity
- v = (initial) number of announced vacancies
- $\lambda(\cdot)$ = $\gamma \cdot F(\cdot)$ = hiring intensity per vacancy
- γ = contact intensity of job applicants per vacancy
- $F(\cdot)$ = reservation wage distribution of job applicants

γ can be further decomposed as $S \cdot \theta$, where

- S = number of job applicants
- θ = individual contact intensity of an applicant to a vacancy at the firm

Differentiating (1) with respect to w yields

$$\alpha \cdot H'(n, w) = (pa - w) \cdot \frac{\alpha \cdot v \cdot \lambda'}{(\lambda + \alpha)^2} - n - \frac{v \cdot \lambda}{\lambda + \alpha} \quad (2)$$

$$\lambda' = \frac{d\lambda(w)}{dw}$$

[If someone is disturbed by the absence of quits in the specification (1), he may think of including an individual quit intensity μ and substitute $\mu + \alpha$ for α in (1) and (2). The decision problem of a stochastic recruitment-cum-quit model is not solved, however, although the solution can be conjectured (cf. Schager (1987), pp 132-136, 197-200). The results of such an extended model seem to add to but not to alter the results of the recruitment model.]

It is easily established that $H'(n, w)$ is increasing in pa and in v , so the optimal wage is increasing (non-decreasing) in these parameters. The corresponding results hold for the model presented in Schager (1987) as well.

The effect of changes in those parameters which compose λ is more complicated but at the same time very important. We recall $\lambda(w) = \gamma \cdot F(w) = S \cdot \theta \cdot F(w)$ and $\lambda'(w) = \gamma \cdot f(w) = S \cdot \theta \cdot f(w)$, where $f(w) = dF(w)/dw$. A change in γ reflects e.g. a proportional change of the same sign in the supply of job applicants S to the firm.

A change in γ increases or decreases $H'(n, w)$ depending on the value of w within its feasible interval. It is easily demonstrated, however, that $H'(n, w)$ must be decreasing in γ , if $\gamma \cdot F(w) > \alpha$. Such

a condition is easy to interpret: $[\gamma \cdot F(w)]^{-1}$ is the expected duration of the firm's vacancies and α^{-1} can be analogously interpreted as the expected horizon of the firm [cf. Schager (1987), p. 123]. Consequently, the condition $\gamma \cdot F(w) > \alpha$ is equivalent to the firm's expecting to fill its vacancies within a waiting time that is shorter than the expected time until the horizon. If this condition is fulfilled in the neighbourhood of the optimal wage w^* , the latter is decreasing in γ . [It can be shown that a similar result holds in the model specification given in Schager (1987); the condition is just slightly modified, reflecting the fact that the time it takes to fill all vacancies is now linearly increasing in their number.]

Generally speaking, it would be surprising if the firm expected to reach its horizon before having its vacancies filled. On the other hand, it does not seem possible to establish any simple relation between α and $\lambda(w^*)$ as a necessary consequence of the properties of the (interior) optimal solution. Hence the effect of a change in γ on the optimal wage is an empirical question, which we will address shortly.

The impact of $\gamma = S \cdot \theta$ on the optimal wage is of special importance, because the stock of job applicants S consists partly of the unemployed U (and S is sometimes identified with U , as on-the-job search is disregarded). Consequently, the effect of a change in U is the same as of a change in γ . A decrease in U increases the optimal wage, if vacancies are expected to be filled before the horizon is reached.

This is of course equivalent to establishing a Phillips-curve response at the level of the firm under the stated conditions. The possibility of such a result has not been discovered in earlier theoretical studies on the optimal behaviour of the firm in a search labour market. The reason for this is to be found in our assumptions that wages are downward rigid and that the number of vacancies are finite [see further Schager (1987)]. These assumptions seem to be a fairly sound basis for a realistic model.

Summarising our sensitivity results we conclude that the optimal wage of the firm is increasing in the value productivity and in the number of announced vacancies; it is also increasing in the interarrival times between job applicants per vacancy, if vacancies are (in expectation) filled before the horizon is reached.

The Aggregate Model

Our aggregate analysis will be based on the notion of the representative firm. Consequently, we ignore possible asymmetries between firms in the wage dynamics process. We allow firms to have different wages at the outset, reflecting different values added and expansion opportunities, but we must think of the firms as being subject to wage increasing parameter changes in such a way that they preserve roughly their relative position in the wage distribution. Thus the wage distribution over firms is assumed to remain unchanged with the exception of proportional shifts during the dynamic process.

On the symmetry assumption an increase in the average wage of the aggregate of firms reflects a shift in the wage distribution of the same magnitude. This shift has in turn repercussions on the reservation wage distribution of job applicants. The applicants can be partitioned into employed and unemployed job searchers. The reservation wage distribution of the former group should be a close reflection of the distribution of paid wages, so we are entitled to regard it as shifting *pari passu* with the latter distribution.

The effect on the distribution of the reservation wages of the unemployed is not so clear-cut. If the unemployed are 'voluntarily unemployed' job searchers, they should adjust their reservation wages in close correspondence to changes in the distribution of paid wages. If they are quantity constrained and 'involuntarily' unemployed, they might adjust their reservation wages to a less extent.

Any partitioning of the stock of job applicants into different groups introduces complications in the model, even at the level of the decision problem of the individual firm. Unless the reservation wage distributions are the same or the contact intensities are proportional for all groups, we cannot treat the overall wage distribution $F(\cdot)$ and the overall contact intensity γ as independent of each other. A taxonomic discussion on different cases will not be given here, as it is of no use for operationalising the model, given the information that available data contain; the reader can find a discussion on this subject in Schager (1987), ch. II, sec. 4.

Let us instead utilise the empirical evidence on the relation between the average duration of vacancies and the unemployment rate in order to find a suitable specification of the hiring process. As Schager (1987), ch. I, demonstrates, there exists a cyclically stable relation between these two variables for the aggregate of Swedish manufacturing. Let us now interpret this finding in terms of the following expression for the average hiring intensity per vacancy

$$\lambda(\bar{w}) = \gamma \cdot F(\bar{w}) = \gamma_E \cdot F_E(\bar{w}/\underline{s}_E - 1) + \gamma_U \cdot F_U(\bar{w}/\underline{s}_U - 1),$$

where \bar{w} denotes the average wage of the aggregate and γ_E and γ_U the contact intensities per vacancy of employed and unemployed job applicants, respectively, $\gamma = \gamma_E + \gamma_U$; $F_E(\cdot)$ and $F_U(\cdot)$ denote the reservation wage distributions of the respective groups; \underline{s}_E and \underline{s}_U are parameters characterising the distributions to be interpreted as the lower bound of their range.

$\lambda^{-1}(\bar{w})$ is the average duration of vacancies and γ_U is linearly increasing in the unemployment rate U_r . Consequently, the stability in the empirical relation between λ^{-1} and U_r indicates that \underline{s}_E and \underline{s}_U change approximately in proportion to \bar{w} , i.e. that shifts in the distribution of paid wages are in practice closely followed by shifts in the reservation wage distributions. Moreover, there seems to be little variation in the search behaviour of employed job applicants as reflected in γ_E .

The close correspondence between the different wage distributions implies that we are entitled to treat the argument of the reservation wage distribution(s) as constant during the process of wage dynamics.

The fact that changes in γ seem to be dominated by changes in γ_U does not change the formal structure of the model of the preceding section, as long as $F_U(\cdot) = F_E(\cdot) = F(\cdot)$. In the case where $F_E(\cdot) \neq F_U(\cdot)$, the analysis becomes more complex. If $F_U(\cdot) > F_E(\cdot)$, which seems likely, the qualitative result with respect to changes in γ_U holds a fortiori, however. The reader is referred to Schager (1987) ch. II, sec. 5 for a detailed discussion on this point. In the sequel we are going to keep to the simpler specification $\lambda(\cdot) = \gamma \cdot F(\cdot) = (\gamma_E + \gamma_U) \cdot F(\cdot)$, as being sufficient for the present purpose.

Let us now summarise the decision situation for any firm in the symmetric process of wage dynamics. The firm faces the value function

$$\alpha \cdot H(n, w) = (pa - w) \cdot \left(n + \frac{v \cdot \gamma \cdot F(w/\underline{s} - 1)}{\gamma \cdot F(w/\underline{s} - 1) + \alpha} \right), \quad \gamma = \gamma_E + \gamma_U$$

(We have preserved the notation $F(\cdot)$ from the preceding section, although the argument is now $w/\underline{s} - 1$, not just w).

We have

$$\alpha H'(n, w) = (pa - w) \cdot \frac{\alpha \cdot v \cdot \gamma \cdot f(w/\underline{s} - 1)}{\underline{s} \cdot [\gamma \cdot F(w/\underline{s} - 1) + \alpha]^2} - n - \frac{v \cdot \gamma \cdot F(w/\underline{s} - 1)}{\gamma \cdot F(w/\underline{s} - 1) + \alpha}$$

Given that an interior solution obtains, optimum is achieved by choosing such a w^* that $H'(n, w^*) = 0$.

All firms tend to respond in the same way in the symmetric aggregate process, however, so the initial optimum is eventually made inoptimal by an increase in \underline{s} , caused by an increased average wage \bar{w} . We can choose the firm, the wage of which is \bar{w} , as our representative firm. Its eventual optimal wage, which we denote \bar{w}^* , is determined by

$$\frac{pa-\bar{w}^*}{\bar{w}^*} \cdot \frac{\alpha \cdot v \cdot \gamma \cdot k^{-1} \cdot f(k^{-1}-1)}{[\gamma \cdot F(k^{-1}-1) + \alpha]^2} - n - \frac{v \cdot \gamma \cdot F(k^{-1}-1)}{\gamma \cdot F(k^{-1}-1) + \alpha} = 0 \quad (3)$$

where the constant k is obtained by the relation $\underline{s} = k \cdot \bar{w}$, as a result of all the wage distributions having shifted proportionally.

As we noted above $\lambda = \lambda(k) = \gamma \cdot F(k^{-1}-1)$ and $\lambda' = \lambda'(k) = \gamma \cdot k^{-1} \cdot f(k^{-1}-1)$ are now to be regarded as parameters of the aggregate process. They are of course subject to changes, when e.g. γ_U changes.

(3) determines directly an optimal distribution of functional income in terms of labour market parameters. Introducing the notation $\lambda'(k)/\lambda(k) = k^{-1} \cdot f(k^{-1}-1)/F(k^{-1}-1) = h$ and $v/n = v_r$, we have

$$\frac{pa-\bar{w}^*}{\bar{w}^*} = \frac{1 + \frac{v_r \cdot \lambda(k)}{\lambda(k) + \alpha}}{\frac{\alpha \cdot v_r \cdot h \cdot \lambda(k)}{(\lambda(k) + \alpha)^2}}$$

From (3) the eventual optimal wage is easily obtained as

$$\bar{w}^* = \frac{h \cdot pa \cdot v_r}{v_r (h+1) + \frac{v_r \cdot \lambda(k)}{\alpha} + \frac{\lambda(k)}{\alpha} \cdot [1 + \frac{\alpha}{\lambda(k)}]} \quad (4)$$

It is instructive to look at the transformation of (4), when α is small, i.e. when the expected horizon is far away. Provided that $\lambda(k)$ is not small, too, and that $\alpha \cdot h$ is large enough to make an interior solution possible, (4) becomes

$$\bar{w}^* = \frac{\alpha \cdot h \cdot pa \cdot v_r}{\alpha \cdot h \cdot v_r + v_r \cdot \lambda(k) + \lambda(k)} = \frac{\alpha \cdot h \cdot pa \cdot v_r \cdot \lambda^{-1}(k)}{\alpha \cdot h \cdot v_r \cdot \lambda^{-1}(k) + v_r + 1} \quad (4')$$

In (4') $\lambda^{-1}(k)$, which is the average duration of vacancies, appears in the combination $v_r \cdot \lambda^{-1}(k)$. Anyone who has worked with stock-flow relations in the labour market recognizes this product as the stock rate of unfilled vacancies. It is, strictly speaking, equal to the realized stock only in equilibrium, but $v_r \cdot \lambda^{-1}(k) = V_r$ can always be interpreted as the expected stock of unfilled vacancies as a ratio of employment. Hence (4') can be written in the simple form

$$\bar{w}^* = \frac{b \cdot p a \cdot V_r}{b \cdot V_r + v_r + 1} \quad , \quad b = \alpha \cdot h$$

We are now ready to specify a model of aggregate wage dynamics based on (4). We cannot assume, however, that the firms are in stable optimal wage positions at every point of time. Their wages increase to their new positions in the shifting wage distribution gradually as a result of decentralized wage setting in the search labour market. It is beyond the reach of the present state of science to derive rigorously such a disequilibrium process of wage adjustment. Within our framework of aggregate analysis the most natural approach is to postulate a simple partial adjustment mechanism such that

$$\frac{d\bar{w}}{dt} = \lambda \cdot (\bar{w}^* - \bar{w}) ,$$

λ being a constant adjustment coefficient.

Hence we get (substituting V_r for $v_r \cdot \lambda^{-1}(k)$ in (4))

$$\frac{d\bar{w}}{dt} / \bar{w} = \lambda \cdot \left[\frac{h \cdot p a / \bar{w} \cdot V_r}{V_r (h+1) + \frac{v_r}{\alpha} + \frac{1}{\alpha} \cdot (1 + \alpha \cdot \lambda^{-1}(k))^2} - 1 \right] \quad (5)$$

(5) constitutes the basis for the regression equations of the following section, where pa/\bar{w} , V_r , v_r and $\lambda(k)$ appear as explanatory variables and λ , h and α are parameters to be estimated.

We conclude this section with a caveat. As is extensively pointed out in Schager (1987), especially on pp 135-146, under a downward wage rigidity regime the firms may be in situations at some phases of the business cycle, where the optimal wage constitutes a corner solution, not an interior one, as we have taken for granted in the above analysis. This may affect the seeming impact of different parameters on the aggregate process of wage dynamics in a way that is not random. We will not extend the formal analysis of this study in that direction, though. It remains an interesting and probably important subject for further investigations.

A Test of the Aggregate Model on Wage Drift Data

In this section we are going to test our model of aggregate wage dynamics on data for Swedish manufacturing during the period 1964-86. The wage increase concept used is wage drift for blue-collar workers. The data are obtained from the comprehensive wage statistics of the Swedish Employers' Confederation (SAF) and the Swedish Trade Union Congress (LO). The wage is calculated on the basis of hourly time rates (tidlön) and piece rates (ackord). For a more detailed description of the wage concepts, see e.g. Schager (1981), pp. 417-419.

It is reasonable to confine the application of our model to wage drift as being the decentralized part

of wage increases in the Swedish labour market. The centrally negotiated increases cannot a priori be expected to be explained by the same model. In the present context their role is rather to be included as an explanatory part of the model. We will consider the centrally negotiated increases in the last section, in which some very interesting relations are revealed.

The labour market variables are obtained from the series on new announced vacancies and on remaining unfilled vacancies published by the Labour Market Board (AMS). We use the figures for manufacturing occupations (group 7-8 according to 'Nordisk Yrkesklassificering', NYK). There is a presentation and a discussion of the reliability of these series in Schager (1987), pp. 55-58, where it is also demonstrated how a measure of the average duration of vacancies can be calculated from the flow and stock figures. The conclusion is that the series on vacancy data for manufacturing occupations are sufficiently reliable to be used for research purposes.

Figures on value added in current prices as well as on the wage sum are obtained from the National Accounts (Nationalräkenskaperna), published by Statistics, Sweden (Statistiska Centralbyrån). The figures used apply to manufacturing industry (SNR-code 3).

There is a problem, however, in so far that the three sources calculate and present their data on different time bases. The vacancy data are gathered and presented on a monthly basis, so they are most easy to adapt to any observation period. The wage data are initially gathered on a quarterly basis, but special attention is paid to the second-quarter

data which have the best quality. The published wage drift figures are consequently presented on a second-quarter to second-quarter basis. By contrast, the data in current prices from the National Accounts are presented on a yearly basis. We let the observation period follow the published wage drift figures; the figures from the National Accounts, available on a yearly basis only, must be allowed to approximate the corresponding second-quarter figures.

We recall the equation (5) of wage dynamics

$$\frac{d\bar{w}}{dt} / \bar{w} = \lambda \cdot \left[\frac{h \cdot \frac{pa}{\bar{w}} \cdot v_r}{V_r (h+1) + \frac{v_r}{\alpha} + \frac{100}{\alpha} (1 + \alpha \cdot \lambda^{-1}(k))^2} - 1 \right], \quad V_r = v_r \cdot \lambda^{-1}$$

(Note: In the equations to be estimated in this section we measure the vacancy ratios v_r and V_r in percentage points, so $\frac{1}{\alpha}$ in (5) must be replaced by $\frac{100}{\alpha}$.)

Both λ^{-1} , v_r and hence $V_r = v_r \cdot \lambda^{-1}$ can be observed on a monthly basis, which means that a second-quarter to second-quarter average of monthly observations can be used to form a period average of these explanatory variables. An alternative procedure, which we are going to apply, is to observe the values during the first second quarter (measuring the disequilibrium at the start of the observation period) and their changes up to the next second quarter (measuring the change in disequilibrium during the period).

In principle the observations on the explanatory variable pa/\bar{w} can be formed in the same way. We must be careful, though, so that $(d\bar{w}/dt)/\bar{w}$ is not allowed to influence the value of \bar{w} during the

observation period, creating serious simultaneity problems. Consequently, \bar{w} must be evaluated at the beginning of the observation period (the first second quarter), while p_a is either calculated as an average for the whole period or, alternatively, evaluated at its level during the first second quarter and at its change up to the next second quarter. As we just noted, quarterly data on p_a/\bar{w} is not available, so we must be content to use the corresponding yearly figures.

We must at last take into account an institutional feature, that affects the timing of wage drift. Wage drift does not occur uniformly over the year, but is usually concentrated to certain periods, especially to those periods, when a central agreement is implemented. Because of delayed central negotiations there are no implementations occurring in some second-quarter periods, while in other ones there are two. We take care of this problem by adding a variable D as an additional explanatory variable, reflecting simply the number of implementation events during the observation period (see further Schager (1981), p. 430). Without adding such a variable we should expect negative serial correlation in the residuals of the estimate.

There are 22 second quarter to second quarter observations available, covering the period 1964/65 to 1985/86. Equation (5) with the variable D added (as well as an intercept) is at first estimated in its initial-level-plus-change form by means of a nonlinear least squares method (the Gauss-Newton algorithm in the SYSNLIN procedure of SAS).

The regression does not converge within the set limit of 50 iterations but yields an ultimate point estimate of $\alpha = 0.019$; the point estimate of $\alpha \cdot h$ is around 10. The correlation between the estimates of α and h is very high.

This result clearly indicates that we have encountered a situation, in which equation (4) degenerates into (4'). As a consequence the regression is unable to distinguish between the factors α and h making up b .

Although the estimated value of α is by necessity imprecise, it is nevertheless very interesting to note that its value is considerably less than that of the variable $\lambda(k)$. $\alpha=0.019$ implies an expected horizon of 54 months, while $\lambda^{-1}(k)$, the average duration of vacancies in manufacturing, does not exceed 6 weeks. It appears that the sufficient condition for the optimal wage of the firm to be decreasing in the supply of job applicants (and hence in the unemployment rate) is on average fulfilled within broad margins in Swedish manufacturing!

Consequently, we reformulate (5) on the basis of (4'), which yields

$$\frac{d\bar{w}}{dt} / \bar{w} = \lambda \cdot \left[\frac{b \cdot V_r \cdot pa / \bar{w}}{b \cdot V_r + v_r + 100} - 1 \right] \quad (5')$$

Equation (5'), again with D and an intercept added, is estimated in the same form and with the same technique as (5). The regression now converges rapidly, yielding an R-square of 0.73, a standard error of regression of 0.83 and a Durbin-Watson-statistic of 1.60. Unfortunately, the estimates of

b and l are highly correlated and consequently imprecise.

One obvious reason for this is not hard to detect. The term v_r+100 in the denominator in (5'), which reflects the cost effect of labour demand, is large in comparison with $b \cdot V_r$ (and in addition varies little). According to the imprecise point estimate of $b=6.4$, the term $b \cdot V_r$ varies between 2.4 and 22, while v_r+100 varies between 101 and 104. The impact of $b \cdot V_r$ does mainly show up in the numerator to the effect that the separate values of b and the adjustment coefficient l are hard to distinguish.

The results of the estimation of (5') point to the possibility of a respecification of the regression equation, which has the advantage of being linear in its parameters. Before we do that we will, however, reestimate (5'), allowing for different adjustment coefficients $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ to apply to the initial disequilibrium level and to the changes in it brought about by changes in p_a, V_r and v_r , respectively.

There are two reasons for allowing this higher degree of flexibility. One is theoretical and reflects the fact that changes in labour market conditions, i.e. in $V_r = v_r \cdot [\gamma \cdot F(\cdot)]^{-1}$, should be more slowly revealed to firms in a search labour market environment than changes in product prices or in productivity and hence in value added p_a . The other reason has to do with the mixed quality of the available data; the value added figures are not only calculated on a more vague time basis, as we noted, they are also typical average ex post calculations, which may inadequately reflect the relevant expected value added of marginal employment expansion at firms. The announced vacancy figures v_r have the advantage of reflecting the

actual recruitment efforts of firms, a property which does not seem to have been fully recognized, when the quality of these figures has been discussed in research contexts.

Running our regression on (5') with D and intercept added and the adjustment coefficient λ replaced by λ_i , $i=1...4$, as specified above improves the fit considerably. Convergence occurs rapidly, yielding an R-square of 0.86, a standard error of regression of 0.65 and a Durbin-Watson-statistic of 1.66. Again the estimated values of the parameters b , λ_1 , λ_2 , λ_3 and λ_4 are very imprecise. High degrees of collinearity exist not only between b and the λ_i 's but also between the λ_i 's themselves. At this stage, however, we must put some doubt on the accuracy of the applied non-linear estimation procedure to produce good asymptotic standard errors of the parameter estimates.

The reason for this doubt arises, when we approximate (5') on the premise that $b \cdot V_r$ is small compared to $v_r + 100$. This turns (5') into

$$\frac{d\bar{w}}{dt} / \bar{w} = \lambda \cdot \left[\frac{b \cdot V_r \cdot pa / \bar{w}}{v_r + 100} - 1 \right] \quad (5'')$$

Replacing v_r with the variable $L_r = v_r + 100$, i.e. labour demand as a ratio of actual employment, we get a regression equation that is non-linear in the variables V_r , L_r and pa/\bar{w} but linear in the parameter $\lambda \cdot b$ (or in $b \cdot \lambda_i$, $i=1...4$, allowing for different adjustment coefficients). Thus the ordinary least squares procedure can be applied. Such a regression yields the estimated equation

$$\frac{d\bar{w}}{dt} / \bar{w} = 1.08 + 55.86 \cdot \frac{V_r \cdot pa / \bar{w}}{L_r} + 444.58 \cdot \frac{V_r \cdot dpa / \bar{w}}{L_r} +$$

(2.80) (2.41) (2.55)

$$\begin{aligned}
 & + 65.02 \cdot \frac{dV_r \cdot pa/\bar{w}}{L_r} - 2\,447.9 \cdot \frac{V_r \cdot dL_r \cdot pa/\bar{w}}{L_r^2} + \\
 & + 0.89 \cdot D \tag{6} \\
 & (2.55) \qquad \qquad \qquad (0.99) \qquad \qquad \qquad (3.89)
 \end{aligned}$$

The coefficients before the explanatory variables are estimates of $b \cdot \lambda_1$, $b \cdot \lambda_2$, $b \cdot \lambda_3$, $b \cdot \lambda_4$, respectively, with absolute t-values given below in parenthesis.

R-square: 0.86; adjusted R-square: 0.82; standard error of regression: 0.63; Durbin-Watson-statistic: 1.68; F-statistic: 19.99.

The general fit of the OLS regression (6) is obviously very similar to that of the last non-linear one. Moreover, a closer inspection shows that their residual structures are almost identical. The only difference is that by applying (5") instead of (5') we accept that we cannot distinguish between the factors making up $b \cdot \lambda_i$, $i=1\dots 4$. This may explain some of the impreciseness in the non-linear estimate of the parameters b and λ_i with asymptotic t-values around 0.11, but the change to the t-values given by (6) is nevertheless surprisingly large.

Summarising our regression results up to this point we conclude that

- our model yields a satisfactory estimate of wage drift in terms of the theoretically relevant variables
- the structural coefficients of the model, α , h and λ_i cannot be determined with any precision by the non-linear estimation procedure; only the

products $\alpha \cdot h \cdot \lambda_i$ are possible to determine with a satisfactory degree of accuracy

- there is evidence from (6) that the adjustment coefficients λ_i , $i=1...4$, are not all equal; the strongest impact on wage drift seems to stem from the level of unfilled vacancies multiplied with the ex ante increase in value added, indicating that adjustment is faster with respect to changes in value added than to changes in labour market conditions as reflected by the stock of unfilled vacancies. The small (insignificant) effect from changes in (the marginal cost of) labour demand is as expected, given the small variation in this variable
- the point estimate of the intercept is around 1 in all regressions, although the precision has varied; with some caution we could interpret this result as one percent being the 'unavoidable' technical part of wage drift in Swedish manufacturing
- the implementation variable D is highly significant in (6); it is the only variable, the estimated coefficient of which has shown reasonable significance in all regressions, including the first, non-converging one, where it is estimated to 0.89 [as in (6)!] with asymptotic t-value 1.57.

As the variable L_r exhibits such small variations, it is obviously possible to exclude it from (5") and to produce a regression equation in the explanatory variables $V_r \cdot pa/\bar{w}$, $V_r \cdot dpa/\bar{w}$, $dV_r \cdot pa/\bar{w}$ and D only. Such an estimate yields the same picture as (6), but there is of course no reason to prefer it to (6).

We present at last a regression equation (7), which is simply linear in the basic variables V_R , dV_R , pa/\bar{w} , dpa/\bar{w} , L_R , dL_R and D . According to our theoretical analysis there is no need to pay special attention to such a specification, but it constitutes a natural bridge to the next section on earlier empirical studies, where linear specifications have regularly been estimated.

$$\begin{aligned} \frac{d\bar{w}}{dt} / \bar{w} = & - 7.73 + 1.56 V_R + 0.85 dV_R - 0.12L_R - 0.72 dL_R + \\ & (0.42) (5.98) (2.35) (0.63) (0.87) \\ & + 2.77 pa/\bar{w} + 8.75 dpa/\bar{w} + 0.89 D \qquad (7) \\ & (1.60) (3.20) (4.18) \end{aligned}$$

R-square: 0.88; adjusted R-square: 0.82; standard error of regression: 0.62; Durbin-Watson-statistic: 2.05; F-statistic: 15.06.

As can be seen, little new emerges from (7) compared to (6). The effects of V_R and dpa/\bar{w} stand out as especially important, L_R and dL_R are of little significance and the point estimate of the coefficient of D is even the same. It is interesting to note, however, that an ad-hoc linearisation of the influence of the relevant explanatory variables produces about the same goodness of fit as does a more careful functional specification of the regression equation.

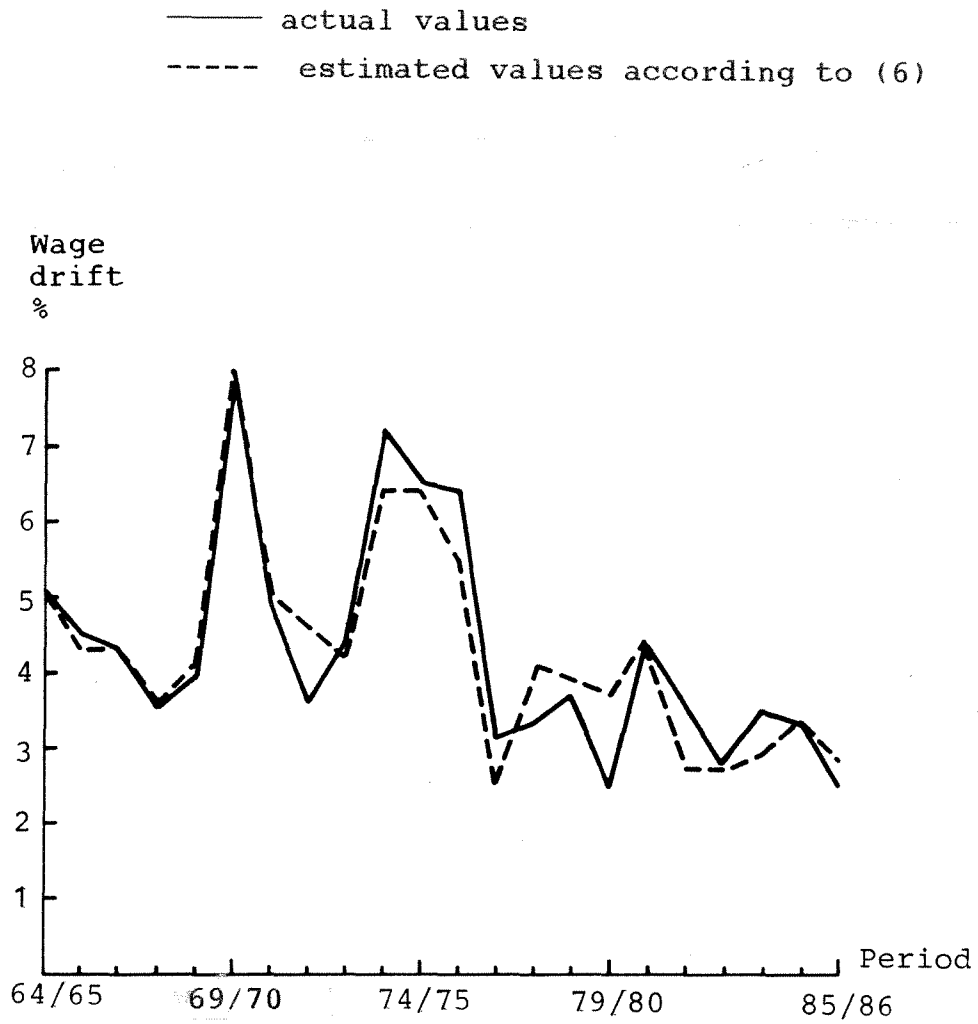
The Durbin-Watson-statistic may at first seem to speak in favour of (7). A closer inspection of the residuals reveals, however, that (6) has a stronger systematic tendency than (7) to underestimate wage drift in the period 73/74-75/76 and to overestimate it in the period 77/78-79/80 (see figure on page 23). This is not a troublesome feature of (6). The

overoptimistic attitude in Sweden in the mid-seventies, leading to the cost crisis, may clearly have been more pronounced than what is reflected in the ex post calculations on the profit share of value added. The cost crisis itself in the late seventies must clearly have caused an exceptional tendency for firms to be at disequilibrium wage levels. Such a situation should dampen the effect of otherwise wage increasing changes in the variables, a feature that is not formally incorporated in our model (cf. the last paragraph of the preceding section).

So far a consistent picture has emerged out of the confrontation between the model and the data. A puzzling fact remains, however, and that is the absence of any significant effect of the centrally negotiated wage increases on the amount of wage drift. As we noted in the beginning of this section, the negotiated increase should appear as an explanatory variable in the wage drift equation. More precisely, it should appear as a reduction in the variable dpa/\bar{w} . Such a transformation does not work well, however, nor does a simple inclusion of the negotiated increase as a separate regressor yield any significant coefficient. There is consequently no evidence of any substitution in the short run between wage drift and negotiated wage increases in Swedish manufacturing.

We will consider further the negotiated wage increases in the last section. At first, however, we turn to a comparison between our results and those of earlier studies on wage drift in Sweden.

Figure
Wage drift in Swedish manufacturing 1964/65-1985/86



A Comparison with Earlier Research on Wage Drift

Several studies on wage drift in Sweden were published already in the fifties and sixties [Hansen and Rehn (1956), Hansen and Marris (1964), Jacobsson and Lindbeck (1969, 1971)]. They all pointed to the same evidence: wage drift for workers in manufacturing was highly influenced by conditions in the labour market and as an indicator of those conditions the rate of unfilled vacancies seemed to perform better than the rate of unemployment. No other factor such as profits and/or productivity turned out to have any significant effect. [See further Schager (1981), pp. 396-401.]

Around 1969 the wage drift pattern in Sweden changed seemingly. This change was described and analysed in Calmfors and Lundberg (1974), Herin (1976), Isachsen (1977) and Holmlund (1976, 1978). Two important findings emerged from these contributions: the unemployment rate did not perform well as a labour market indicator (without the inclusion of dummy variables), whereas the vacancy rate continued to do so; a complementary price increase variable (in some studies interpreted as an expectation variable) turned out to be significant, especially if it was represented by a producer price increase, somewhat less so if represented by a consumer price increase.

In my own study Schager (1981), I found that wage drift for workers in the private sector (not just manufacturing) was well explained by the duration of vacancies, but it needed to be complemented by a profit variable. I could find no significant effect from increases in consumer prices.

There is consequently a striking correspondence between all empirical studies from the fifties up

to the present one that wage drift in Swedish manufacturing is very significantly influenced by the unfilled vacancy rate. The theoretical explanation in the earlier studies for such an influence is not that of our paper, however.

Instead of making inferences from a model of firm behaviour, as we do, earlier contributions have seen the wage dynamics as being governed by the excess of demand over supply in the labour market according to a traditional Walras-Samuelson equation of price dynamics. Net demand is identified with V_r , net supply with U_r . Hence the specification

$$\frac{d\bar{w}}{dt} = h(V_r - U_r); \quad h(0) = 0; \quad h' > 0,$$

or some similar version of it, often with a price (expectation) or profit variable added.

It has consequently been regarded as a puzzle why V_r has performed much better than $(V_r - U_r)$ or U_r in the estimates, especially after 1969. According to our model such a result is to be expected.

It is worth repeating how U_r enters indirectly in our wage drift equation. As we recall V_r already contains U_r via the relation $V_r = v_r \cdot \lambda^{-1} = v_r / U_r \cdot \theta_U \cdot F_U(\cdot)$ (we ignore the on-the-job search in this context). U_r can at most serve as a proxy for V_r as long as the demand for new workers v_r is constant (or strongly correlated with U_r) and as long as the 'hiring efficiency' factor $\theta_U \cdot F_U(\cdot)$ remains unchanged. It is noteworthy that there occurred a structural decline in $\theta_U \cdot F_U$ in the Swedish labour market during the years 1967-69 [see

Schager (1987), ch. I]. This change destroyed the ability of U_r to serve as a proxy for V_r . The candidate of Schager (1981) the duration of vacancies, λ^{-1} , takes care of this problem, but it is inadequate in so far as it does not reflect changes in v_r .

In our interpretation the significance of price variables in the wage drift equation reflects the influence of (the price component of) value added pa . The better performance of a producer price rather than a consumer price variable accords well with this view. An influence from profits is of course consistent with our model, although any ex post profit variable must be interpreted with care, taking into account possible simultaneity problems.

It is worth noting that the influence from the profit share variables pa/\bar{w} and dpa/\bar{w} in our model has nothing to do with the outcome of any bargaining situation between the firm and a union; it reflects solely the optimal behaviour of the firm in an atomistic search labour market. There have quite recently been some attempts to apply wage bargaining models to Swedish wage drift experiences [Calmfors and Forslund (1988), Holmlund and Skedinger (1988)]. It is too early to make an assessment of these contributions, but it seems that the power of this approach in explaining the time path of wage drift is not too strong.

Earlier studies did not find any influence from prices (or profits) until 1973. The data used in this study confirm that in a simple linear regression the unfilled vacancy variable suffices to 'explain' the observations on wage drift in the

period up to 1972/73 (as well as in the period since 1982/83). It is because of the violent swings in the changes of value added during the seventies that we are able to discern clearly the effect of this variable.

The main task of our contribution is now completed. We conclude by stating its three essential results:

- a rigorous search theoretical model of the wage behaviour of firms has been presented and adapted for estimation on aggregate data
- the implications of the model have been confirmed by Swedish data for manufacturing industry and a stable wage drift equation is demonstrated to have existed since the mid-sixties, a period of partly violent economic changes
- the model is consistent with the findings of earlier postwar empirical studies on wage drift in Sweden and provides them with a more satisfactory theoretical interpretation.

A Hypothesis-generating Regression on Negotiated Wage Increase Data

We observed earlier that no correlation exists between wage drift and centrally negotiated wage increases, when the two variables are measured on the same second quarter to second quarter basis. A closer inspection reveals, however, that there is a fairly strong correlation between wage drift in one observation period and the negotiated wage increase in the consecutive one.

This finding is to some extent expected, as there have existed 'earning development guarantees' in several recent central agreements, coupled to the amount of wage drift in the preceding period. What is astonishing, though, is the fact that the correlation is much stronger, if we regress the 13 observed values on negotiated increases since 1966 directly on the explanatory variables for wage drift in the preceding period according to our model. For the negotiated increase and the preceding wage drift the R-square is 0.41. When the negotiated increase is regressed on the values of the explanatory variables according to (6), lagged one period, it rises to 0.75. The lagged values of the regressors of the linear specification (7) yield an even better fit.

It is also noteworthy that the high correlation is brought about by (combinations of) the unfilled vacancy variables and the increase in the ex ante profit margin, while the realized profit margin appears as unimportant. This is the same pattern as we found for wage drift, but it is somewhat unexpected to find the outcome of the central bargaining process being unaffected by the level of the profit margin of firms.

Regression results such as these are of course not tests of independently formed hypotheses. They are a way of giving systematic structure to the available evidence. Nevertheless, they can be used to form a tentative hypothesis to be further explored. Such a hypothesis would state that the central negotiating parts react on the economic conditions in the market with a time lag. Put in other words, one may say that the relative strength of the positions of workers and firms in the labour market, determined by market forces, is slowly

revealed to the higher echelons in the bargaining organizations, and ultimately confirmed in the central agreement. The formulation of a bargaining model, in which the agents act on the basis of such delayed information, must clearly pay more careful attention to the reaction of firms than bargaining models usually do.

The observations on negotiated wage increases yield some further pieces of information. One seems to be useful. Given the economic conditions, the length of the central bargaining process appears to influence the amount of increases in an upward direction. A longer bargaining period means more threats and realizations of strikes and lockouts, so the period length may well serve as a proxy for union aggressiveness. The regression result supports the idea that this has an independent effect on the wage increases, which again seems to be a fruitful subject for more careful investigation.

The inclusion of a length of bargaining period variable (see Table 3) increases the fit of the regression equation on negotiated increases quite substantially. What makes one somewhat suspicious, though, is the fact that the coefficients of the variables containing the realized profit margin tend to become significantly negative. Any causal relation between the level of realized profits, the characteristics of the central bargaining process and the amount of negotiated wage increases needs consequently to be critically examined.

It is illustrative, either as an impressive or a deterrent example, to present the following regression equation for the amount of total wage increases in Swedish manufacturing, i.e. the sum of

wage drift and centrally negotiated increases. The explanatory variables are those of our equation (6), represented by current values (for wage drift) and by values lagged one period (for negotiated increases). The insignificant variables representing changes in total labour demand are dropped.

$$\begin{aligned} \frac{d\bar{w}_T}{dt} / \bar{w}_T = & 5.41 + 361.40 \cdot \frac{V_r \cdot pa/\bar{w}}{L_r} - 53.08 \cdot \frac{V_r \cdot dpa/\bar{w}}{L_r} + \\ & + 83.08 \cdot \frac{dV_r \cdot pa/\bar{w}}{L_r} - 398.69 \cdot \left[\frac{V_r \cdot pa/\bar{w}}{L_r} \right]_{-1} + \\ & + 2 \ 312.05 \cdot \left[\frac{V_r \cdot dpa/\bar{w}}{L_r} \right]_{-1} - 363.36 \cdot \left[\frac{dV_r \cdot pa/\bar{w}}{L_r} \right]_{-1} \quad (8) \end{aligned}$$

R-square: 0.96; adjusted R-square: 0.92; standard error of regression: 0.79; F-statistic: 25.28.

The corresponding procedure carried out on the linear regression equation (7) yields even more extreme statistics on the goodness of fit.

The presentation of (8) is at least useful insofar as it highlights the possibility of producing a seemingly good explanation of the amount of total wage increases. In Bosworth and Lawrence (1987), total wage increases for workers in Swedish manufacturing are regressed on current and lagged values of the duration of vacancies, on lagged values of increases in producer prices and on lagged values of the profit margin. The statistics are satisfactory.

At least one problem of interpretation is obvious, however. Envisaging their regression equation as a

unified explanatory model for total wage increases, one is led to the important conclusion that negotiated wage increases and wage drift are short run substitutes. The same interpretation, which is false, could be made of (8), if it is not realized that (8) is composed of two explanatory models, one related to wage drift, the other one to negotiated increases.

REFERENCES

- Bosworth, B. and Lawrence, R. (1987), 'Adjusting to Slower Economic Growth: The Domestic Economy', in Bosworth, B. and Rivlin, A. (eds.), The Swedish Economy, (Washington, D.C.: The Brookings Institution).
- Calmfors, L. and Forslund, A. (1988), 'Wage Setting in Sweden', preliminary paper for the conference on 'Nordic Wage Formation', Stockholm, April 11-13.
- Calmfors, L. and Lundberg, E. (1974), Inflation och arbetslöshet (Inflation and Unemployment), (Stockholm: Studieförbundet Näringsliv och Samhälle).
- Hansen, B. and Marris, S. (1964), 'Wage Determination in Sweden' in The Problem of Rising Prices (Paris: OECD).
- Hansen, B. and Rehn, G. (1956), 'On Wage-drift. A Problem of Money Wage Dynamics' in Twenty-five Economic Essays in Honour of Erik Lindahl (Stockholm: Ekonomisk Tidskrift).
- Herin, J. et al. (1976), "Den internationella bakgrunden" (The international background), Appendix 1 to SOU 1976:27, Långtidsutredningen 1975 (the Swedish Long-term Survey 1975), (Stockholm: Swedish Ministry of Finance).
- Holmlund, B. (1976), Arbetslöshet och lönebildning: Kvantitativa studier av svensk arbetsmarknad (Unemployment and Wage Formation: Quantitative Studies of the Swedish Labour Market), (Umeå: Dissertation, University of Umeå).
- Holmlund, B. (1978), "Arbetslöshet och lönebildning i ett regionalt perspektiv" (Unemployment and Wage Formation in Regional Perspective), in SOU 1978:60, Arbetsmarknadspolit i förändring (Labour Market Policy in Transition), (Stockholm: Swedish Ministry of Labour).

- Holmlund, B. and Skedinger, P. (1988), 'Wage Bargaining and Wage Drift: Evidence from the Swedish Wood Industry', preliminary Working Paper, FIEF, Stockholm.
- Isachsen, A.J. (1977), 'A Note on Wage Drift. The Case of Sweden', Scandinavian Journal of Economics, **79**, 366-374.
- Jacobsson, L. and Lindbeck, A. (1969), 'Labour Market Conditions, Wages and Inflation. Swedish Experiences 1955-67', Swedish Journal of Economics, **71**, 64-103.
- Jacobsson, L. and Lindbeck, A. (1971), 'On the Transmission Mechanism of Wage Change', Swedish Journal of Economics, **73**, 273-293.
- Mortensen, D.T. (1970), 'A Theory of Wage and Employment Dynamics', in E.S. Phelps (ed.) Microeconomic Foundations of Employment and Inflation Theory (London: Macmillan).
- Schager, N.H. (1981), 'The Duration of Vacancies as a Measure of the State of Demand in the Labour Market. The Swedish Wage Drift Equation Reconsidered' in Eliasson et al. (eds.) Studies of Labour Market Behaviour: Sweden and the United States, Conference Report 1981:2, (Stockholm: The Industrial Institute for Economic and Social Research).
- Schager, N.H. (1987), Unemployment, Vacancy Durations and Wage Increases: Applications of Markov Processes to Labour Market Dynamics. (Stockholm: The Industrial Institute for Economic and Social Research; dissertation, Uppsala University).

DATA TABLES

[Sources: Swedish Employers' Confederation (SAF);
Swedish Labour Market Board (AMS); Statistics,
Sweden (SCB)]

Table 1

Period, 2nd quarter -2nd quarter	Wage drift, percent	Unfilled vacancy rate, change (dV_r) in percentage points	Announced vacancy rate, change (dv_r) in percentage points	Ex ante value added/wage ratio, (year- ly) change (dpa/\bar{w})	No. of agreement implementa- tions (D)
1964/65	5.1	0.56	0.04	0.15	1
65/66	4.5	-0.54	-0.05	0.09	1
66/67	4.3	-0.87	-0.73	0.15	1
67/68	3.5	0.20	-0.27	0.13	1
68/69	3.9	1.66	0.38	0.14	0
69/70	7.8	0.55	-0.34	0.17	2
70/71	4.9	-2.01	-1.20	0.12	0
71/72	3.6	-0.16	0.17	0.14	2
72/73	4.4	0.17	-0.07	0.19	1
73/74	7.2	1.44	0.38	0.35	1
74/75	6.5	-0.46	-0.66	0.22	0
75/76	6.4	-0.38	-0.08	0.10	2
76/77	3.1	-0.80	-0.42	0.05	0
77/78	3.3	-0.39	0.13	0.14	2
78/79	3.7	0.95	0.24	0.19	1
79/80	2.5	0.18	-0.12	0.14	0
80/81	4.4	-1.34	-0.46	0.10	2
81/82	3.5	-0.27	-0.06	0.16	1
82/83	2.8	-0.02	0.10	0.26	1
83/84	3.5	0.40	0.50	0.18	1
84/85	3.3	0.28	-0.07	0.14	1
1985/86	2.5	0.04	-0.04	0.18	0

Table 2

Period, 2nd quarter	Unfilled vacancy rate, percent of employment (V_r)	Announced monthly vacancy rate, percent of employment (v_r)	Valued added/ wage ratio (pa/\bar{w}) (yearly basis)
1964	1.93	4.12	1.41
65	2.48	4.17	1.41
66	1.94	4.12	1.37
67	1.07	3.39	1.37
68	1.27	3.11	1.38
69	2.92	3.49	1.41
70	3.47	3.15	1.37
71	1.46	1.95	1.33
72	1.30	2.12	1.32
73	1.47	2.05	1.37
74	2.91	2.42	1.46
75	2.44	1.77	1.39
76	2.07	1.68	1.26
77	1.27	1.27	1.20
78	0.88	1.39	1.19
79	1.83	1.64	1.27
80	2.01	1.52	1.28
81	0.67	1.06	1.25
82	0.40	1.00	1.31
83	0.38	1.10	1.47
84	0.78	1.60	1.50
1985	1.06	1.52	1.47

Table 3

Period, year	Centrally negotiated wage increases, percent	No. of months of central negotiations
1966	4.7	3.0
1969	5.7	5.5
1971	7.3	5.5
1974	4.9	1.0
1975	10.0	4.0
1977	5.4	5.0
1978	2.8	2.0
1980	7.9	4.5
1981	4.5	1.0
1983	4.0	2.0
1984	5.4	3.0
1985	4.0	2.5
1986	4.2	5.5