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Real and nominal wage adjustment in open economies[*]

by

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Abstract

How are wages set in an open economy? What role is played by demand pressure, international competition, and structural factors in the labour market? How important is nominal wage rigidity and exchange rate policy for the medium term evolution of real wages and competitiveness? To answer these questions, we formulate a theoretical model of wage bargaining in an open economy and use it to derive a simple wage equation where all parameters have clear economic interpretations. We estimate the wage equation on data for aggregate manufacturing wages in Denmark, Finland, Norway, and Sweden from the mid 1960s to the mid 1990s.

JEL codes: E52, F33, F41, J31, J51, J63, J64

Keywords: Wage formation, efficiency wage, turnover, bargaining, rent sharing, nominal wage rigidity, exchange rate policy, competitiveness

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Innehållsförteckning

1 Introduction

Wage formation and competitiveness are important concerns in open economies and aggregate wage equations have been estimated for a long time in the Nordic countries. Most recent research on aggregate wage determination employs an error-correction approach, where a long run equilibrium condition is embedded in a statistical model of the dynamics.[1] In such models, the long run equilibrium condition is usually a relation between the *wage share* and unemployment. The basic idea is that when unemployment is high, workers can appropriate a smaller share of the cake.

Such a specification appears reasonable and has had empirical success, but its relation to wage bargaining theory is somewhat unclear. A close look reveals several inconsistencies between the standard theoretical bargaining model - as presented by e g Layard, Nickell & Jackman (1991) – and the typical empirical wage equation.[2] First, the *wage share is constant* and independent of unemployment in the standard theoretical model. This makes it hard to see how we can rationalize an empirical specification where there is a long run relation between the wage share and unemployment. Second, a standard theoretical result is that the *equilibrium wage is proportional to the unemployment benefit*, with a "mark up" that depends on the level of unemployment, implying a unit elasticity of the wage with respect to the unemployment benefit (see *Appendix 1*). In empirically estimated wage equations, benefits play a much more modest role. Third, the standard union bargaining model allows *only an indirect role for productivity* in the wage equation. For a given level of unemployment, productivity affects wages only if it affects unemployment benefits or the value of leisure and home production.[3] Empirical models typically allow productivity to have a direct effect on wages. The same argument applies to foreign prices and exchange rates.

[1] See Nymoen (1989), Calmfors & Nymoen (1990), Rodseth and Holden (1990), Johansen (1995), Forslund & Kolm (2004), Holden & Nymoen (2001), Nymoen & Rødseth (2003), Bårdsen, Eitrheim, Jansen & Nymoen (2005).

[2] In *Appendix 1* we present a model where the "threat point" of the workers is the expected utility if a worker leaves the firm without a job, the production function has constant returns to scale, and capital can be rented at a given cost in the world market. Under these conditions, the equilibrium wage is proportional to the unemployment benefit with a "mark up" that depends on the level of unemployment. The discussion below is closely related to Manning (1993).

[3] This is discussed by Manning (1993), Bean (1994),and Nymoen and Rodseth (2003).

Finally, most theoretical wage bargaining models are *real and static* models which say nothing about adjustment to shocks and leave no role for monetary (exchange rate) policy. Empirical error-correction models allow a general, data-based, dynamic structure, but with highly endogenous variables on the right hand side of the estimated equation, the economic interpretation of the adjustment coefficients is unclear.[4]

In this paper we try to improve the link between theory and empirical work in this area. We formulate a model of wage bargaining in an open economy and derive a simple wage equation where all parameters have clear economic interpretations. We estimate the wage equation on data for aggregate manufacturing wages in Denmark, Finland, Norway, and Sweden. The period is the mid 1960s to the mid 1990s when exchange rates were pegged but occasionally adjusted.

Our theoretical bargaining model differs in two ways from the standard union bargaining model (Layard, Nickell & Jackman (1991)). First, we assume that firms face product demand curves, which are *not constant-elastic*. Instead, the elasticity increases in absolute value with the firm's relative price.[5] When demand curves have this characteristic, we can derive a long run wage equation which resembles empirical error-correction models, and where foreign competitors' prices, exchange rates, and productivity affect wages directly. Second, we follow Gottfries & Westermark (1998) and Eriksson & Gottfries (2005) and assume that *to quit is not a credible threat* in the wage bargain. Therefore, unemployment benefits play a more indirect role compared to the Nash bargaining model where the utility if unemployed is taken as the threat point.

Our dynamic specification is based explicitly on nominal wage contracts and the dynamic adjustment coefficients can be interpreted in terms of the information available to wage setters. Most of the period, exchange rates in the Nordic countries were fixed to some currency (or basket of currencies) and occasionally adjusted (devalued). The exchange rate was the key monetary policy variable and the main monetary policy shocks were discrete changes in the ex-

[4] When, for example, the domestic inflation rate is included in the wage equation, it is hard to know whether a significant coefficient arises because wages adjust quickly to inflation or because shocks to wage costs are passed through quickly into prices.

[5] This assumption is consistent with evidence of less than full pass-through of exchange rate changes into export prices in foreign currency and pricing to market; see e. g. Gottfries (2002).

change rate.[6] By examining how nominal wages responded to exchange rate changes and other variables, we obtain measures of nominal wage rigidity.

The resulting wage equations have a good fit and most parameters are estimated with precision and reasonably similar across countries. Wages depend on unemployment, but also on the scope for wage increases in the tradable sector. Based on our theoretical model we interpret this as evidence that workers have bargaining power. Unemployment benefits are important, and rising replacement ratios have contributed to increasing unemployment. Still, the elasticity with respect to unemployment benefits is far below the unit value predicted by the standard Nash bargaining model. Shocks to exchange rates and productivity have large and persistent effects on competitiveness, indicating a high degree of nominal wage rigidity. Exchange rate policy and demand management have played a very important role in the medium term.

Our paper builds on a long tradition of modelling wage formation in the Nordic countries. According to the "Scandinavian model of inflation," wages in the tradable industry must adjust to the scope for wage increases, determined as the sum of productivity growth and price increases for tradable goods.[7] This model fitted Norwegian and Swedish data for the 1960's fairly well, but in the mid 1970's, wages rose far in excess of the scope, and this was followed by a series of devaluations in the late 1970's and early 1980's.[8] Searching for richer models, with better micro-foundations, Scandinavian economists turned to union bargaining models and several authors estimated real wage equations which were inspired by wage bargaining theory.[9] Starting with Nymoen (1989) and Calmfors & Nymoen (1990), subsequent research on aggregate wage

[6] With integrated financial markets, a fixed exchange rate implies complete loss of control over monetary aggregates and interest rates. Although financial markets were regulated until the early 1980's, the openness of the Nordic economies meant that firms had considerable opportunities to move their funds to other countries and hence the central banks had very limited scope to affect money supply and interest rates. The central banks had to set the interest rate that was required in order to maintain the fixed exchange rate.

[7] See Aukrust, Holte & Stoltz (1967), Edengren, Faxen & Ohdner (1970), Aukrust (1977), Lindbeck (1979).

[8] Observing wage increases far in excess of what was predicted by the Scandinavian model, economists considered the scope as - at most - a long run determinant of wages. Calmfors (1979) combined a Phillips curve with a long run zero profit condition to a model of fluctuations around the long run course determined by foreign prices and productivity.

[9] Examples are Hersoug, Kjaer & Rødseth (1986), the country studies in Calmfors (1990), and Holm, Honkapohja, & Koskela (1994). This work was inspired by union bargaining theory (e g Calmfors (1982), Oswald (1985)) and the empirical application to the UK by Layard & Nickell (1986).

determination has been heavily influenced by the error-correction approach, where a long run equilibrium condition is embedded in a statistical model of the dynamics. Our theoretical model combines elements from the Scandinavian model of inflation, union bargaining theory, and efficiency wage theory, and we derive a wage equation which has similarities with the error-correction equations estimated in recent work by e. g. Nymoen & Rødseth (2003) and Bårdsen et. al (2005).

In Section 2 we derive a long run wage equation relating the wage to the scope for wage increases, unemployment, and unemployment benefits. In Section 3 we introduce nominal wage rigidity and derive a short run wage equation where unexpected shocks cause temporary deviations from the long run equilibrium condition. In Section 4 we present data and test for cointegration. Empirical results are presented in Section 5 and alternative specifications are considered in Section 6. We end by summarising our results and comparing with other studies.

2 The long run wage equation

Let the production function of an individual firm be $Y = K^{\alpha}\left(ZN\right)^{1-\alpha}$ where Z is an exogenously given technology factor, K is capital and N is the number of workers. Capital is rented at a price R and there are no adjustment costs for capital. Turnover among workers is $S\left(W/\bar{W}\right)AN$ and depends on the firm's own wage, W, the average wage, $\bar{W}$, and the probability A that a worker searching on the job does get a new job. The function S is decreasing and convex in the relevant region.[10] Turnover is associated with a cost $c\bar{W}$ per quitting worker so the profit of the firm is:

$$\Pi = PY - \left(W + c\bar{W}S\left(W/\bar{W}\right)A\right)N - RK \ , \qquad (1)$$

[10] See Eriksson & Gottfries (2005) for a simple derivation. W denotes the wage paid by the producer, including the tax on labour paid by employers. The latter is assumed to be proportional, so it does not affect the relative wage paid to the worker.

where P is the price set by the firm. Given factor prices, a cost minimizing choice of input quantities implies the cost function:

$$C\left(W,\bar{W},A,R,Y,Z\right)=\kappa\left(W+c\bar{W}S\left(W/\bar{W}\right)A\right)^{1-\alpha}R^{\alpha}Y/Z^{1-\alpha},(2)$$

where $\kappa=\alpha^{-\alpha}\left(1-\alpha\right)^{\alpha-1}$. The demand facing an individual firm is $D\left(P/\bar{P}\right)$ where $\bar{P}$ is the average price in the market. After wages have been set, the firm sets the price and hires capital and labour so as to maximise profits. Without loss of generality we may think of the firm as choosing its *relative* price to maximise real profit, and define maximised real profit as:

$$\Pi\left(\frac{W}{\bar{W}},\frac{\Theta}{\bar{W}},A\right)\equiv\max_{P/\bar{P}}\left(\frac{P}{\bar{P}}-\kappa\left(\frac{W/\bar{W}+cS\left(W/\bar{W}\right)A}{\Theta_i/\bar{W}}\right)^{1-\alpha}\right)D\left(\frac{P}{\bar{P}}\right),\qquad(3)$$

where $\Theta=Z\left(P/R^{\alpha}\right)^{\frac{1}{1-\alpha}}$. The first order condition with respect to price

$$\frac{P}{\bar{P}}=\left(1+\frac{D\left(P/\bar{P}\right)\bar{P}}{D'\left(P/\bar{P}\right)P}\right)^{-1}\kappa\left(\frac{W+c\bar{W}S\left(W/\bar{W}\right)A}{\Theta}\right)^{1-\alpha},\qquad(4)$$

implies a price equation of the form:

$$\frac{P}{\bar{P}}=\Omega\left(\frac{W}{\Theta},\frac{\bar{W}}{W},A\right).\qquad(5)$$

Before we turn to bargaining, let us consider what wage the firm would set if it was free to set the wage. This is the "efficiency wage," W^e, which minimizes cost per unit:

$$1+cS'(W^e/\bar{W})A=0.\qquad(6)$$

3 Nominal wage rigidity

A very large fraction of the labour force in the Nordic countries is covered by union contracts and the length of union wage contracts is typically between one and three years. Much of the time, union contracts have been relatively well coordinated and wage contracts covering several years always specify wage increases to take place during the contract period. These observations suggest that non-overlapping Fischer contracts, rather than Taylor fixed-wage contracts, best characterise the Nordic labour markets.[21] To derive a dynamic wage equation, we think of wages for period t as being *predetermined,* set at some *earlier point in time t-j*, based on expectations that wage bargainers had at that time.[22] We use E_{t-j} to denote the *expectation conditional on information available to wage-setters* when they set wages for period t.

Letting W_t be the wage cost per hour, including a proportional wage tax, we have $W_t = (1+\overline{\tau})W_t^c$, where W_t^c is the contracted wage paid to the worker (before personal income tax) and $\overline{\tau}_t$ is the tax on labour, or in logs: $w_t = w_t^c + \tau_t$ where $\tau_t = \ln(1+\overline{\tau})$.[23] It is W_t^c that is written into the labour contract, but wage setters do not know what the labour tax will be, so their expectation of total wage cost per hour is:

$$E_{t-j}(w_t) = w_t^c + E_{t-j}(\tau_t) = w_t - (\tau_t - E_{t-j}(\tau_t)) \quad (21)$$

Assume that w_t^c is set to fulfil the long run wage equation (18), but with expected values replacing actual values which are not yet known:

$$E_{t-j}(w_t) = E_{t-j}(s_t) - \gamma E_{t-j}(u_t) + \beta E_{t-j}(rr_t) + \mu_t \quad (22)$$

[21] The recent paper by Mankiw & Reis (2002) formulates a model with infrequent updating of information that has similar dynamics to the Fischer contract model.
[22] See Gottfries (1992) for an explanation of nominal wage contracts.
[23] A proportional wage tax does not affect the relative wage which determines search on the job in our theoretical model. Progressive income taxation has different effects, but we disregard this.

Here we have added a shock μ_t which represents unobserved factors that temporarily affect wages. Further we take unemployment to be determined by (20) with an autoregressive demand shock $\varphi_t = \rho\varphi_{t-1} + \xi_t$ where ξ_t is unpredictable and $\rho \le 1$. Assuming that wage setters observe variables dated *t-j* we can derive the expected value of u_t as:

$$E_{t-j}(u_t) = \eta\left(E_{t-j}(w_t) - s_t\right) - \rho^j \varphi_{t-j} = \eta\left(E_{t-j}(w_t) - s_t\right) - \rho^j \left[\eta\left(w_{t-j} - s_{t-j}\right) - u_{t-j}\right]. \quad (23)$$

Substituting into (22), solving for the expected wage, and using (21) we get:

$$w_t = E_{t-j}(s_t) + \frac{\gamma\rho^j}{1+\gamma\eta}\left[\eta\left(w_{t-j} - s_{t-j}\right) - u_{t-j}\right] + \frac{\beta}{1+\gamma\eta} E_{t-j}(rr_t) + \tau_t - E_{t-j}(\tau_t) + \frac{\mu_t}{1+\gamma\eta}. \quad (24)$$

Lagged wages and labour market conditions enter the wage equation, not because wage setters have irrational backward-looking expectations, but because past wages and labour market conditions are indicators of unobserved and persistent demand shocks. Expected changes in the labour tax are born by the workers but unexpected changes are born by firms.

3.1 A measure of nominal wage rigidity

$E_{t-j}(.)$ is defined as the expectation conditional on information available to wage-setters in period t-j. We do not know exactly when wages were set and even if we did, we do not know what information wage-setters had, so it is hard to say what $E_{t-j}(.)$ really is. We therefore use an approach suggested by Gottfries & Persson (1988), that allows us to decompose wage-setters' expectations into a predictable and an unpredictable part relative to pre-specified information set.

Consider wage setters expectations about the foreign price, p_t^*, and consider an information set Ψ_{t-j} containing lagged variables which are observed by the econometrician.[24] Assume that all wage-setters know *at least* Ψ_{t-j} when they set wages for period t, but perhaps more than that. Now we can think of two extreme possibilities. One is that they have no more relevant information

[24] In our empirical implementation, j= 2 and Ψ_{t-2} includes p_{t-2}^* and p_{t-3}^*.

than Ψ_{t-j} so their expectation is $E_{t-j}\left(p_t^*\right)=E\left(p_t^*\middle|\Psi_{t-j}\right)$. Another extreme possibility is that they have enough information to perfectly predict the outcome: $E_{t-j}\left(p_t^*\right)=p_t^*$. Gottfries & Persson (1988) show that when agents' information contains at least Ψ_{t-j} we can write agents' expectations as a weighted average between these two extremes plus a noise term:

$$E_{t-j}(p_t^*)=g_pE\left(p_t^*\middle|\Psi_{t-j}\right)+\left(1-g_p\right)p_t^*+\eta_t^p=p_t^*-g_pp_t^{*u}+\eta_t^p \qquad (25)$$

where $p_t^{*u}=p_t^*-E\left(p_t^*\middle|\Psi_{t-j}\right)$ is the innovation relative to the pre-specified information set.[25] The coefficient g_p is between zero and one and reflects the information that agents have. If they make perfect forecasts about p_t^* when they set wages, g_p equals zero; if they know no more than Ψ_{t-j}, g_p equals unity. Thus, the parameter g_p measures the extent to which agents *do not foresee* innovations in p_t^*. The same decomposition can be made for the other right hand side variables. Substituting (25) into (24), and similarly for other variables, and subtracting $w_{t-j}-s_{t-j}$ on both sides we get our basic wage equation:

$$\begin{aligned}w_t-s_t-\left(w_{t-j}-s_{t-j}\right)&=-b_w\left(w_{t-j}-s_{t-j}\right)-b_uu_{t-j}+b_r\left(rr_t-g_rrr_t^u\right)\\&-g_ee_t^u-g_pp_t^{*u}-g_zz_t^u+g_\tau\tau_t^u+\varepsilon_t\end{aligned} \qquad (26)$$

where $b_w=1-\dfrac{\gamma\rho^j\eta}{1+\gamma\eta}$, $b_u=\dfrac{\gamma\rho^j}{1+\gamma\eta}$, and $b_r=\dfrac{\beta}{1+\gamma\eta}$. In the long run, the wage is proportional to the "scope" for wage increases. Because of nominal wage rigidity, unexpected variations in the nominal exchange rate, foreign prices, and productivity cause deviations from the long run solution. Variations in the labour tax affect the wage cost (which includes the labour tax) only if they are unexpected. The g-coefficients measure wage rigidity because they tell us how

[25] η_t^p is by construction orthogonal to Ψ_{t-j} and p_t^*; see Gottfries & Persson (1988) or Gottfries (2002).

much information wage setters have when they set wages. A positive value of g_e, for example, implies that wages respond slowly to exchange rate shocks because agents have less than perfect information about exchange rates when they set wages. This may be because wages are set earlier or because data is available with delays.[26] The error term ε_t contains unobserved shocks and the noise in our expectations measures.

4 Data, trends and cointegration

Most of the data is the same as in Nymoen & Rødseth (2003) and documented in Evjen & Langseth (1997). Data for wages and productivity refer to industry, which we take to be the tradable sector of the economy. The wage is measured as the wage sum, including social security contributions, divided by the number of hours worked. Productivity is measured as value added in fixed prices divided by the number of hours worked. The foreign price is a trade-weighted index of foreign export prices of major trading partners, and the exchange rate is a trade-weighted index of nominal exchange rates. More precise definitions are given in *Appendix 2*.

In most of our analysis we consider a *baseline model* where we disregard capital $(\alpha = 0)$.[27] In this case, the scope is $s_t = e_t + p_t^* + z_t$, where z_t is labour productivity in the traded goods sector. *Figure 1* shows unemployment and wage relative to scope. Unemployment has increased in all four countries, but it started to increase earlier and reached much higher levels in Denmark and Finland compared to Norway and Sweden. Peaks in unemployment are followed by decreases in the wage relative to scope, but there is no evident long correlation. The positive trend in unemployment does not produce a negative trend in wage relative to scope, except possibly for Sweden. Some other variable must enter into the wage setting relation and one candidate is the replacement ratio.

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[26]Obviously, the estimates will depend on how the information set is specified. For g to be identified, the information set must be specified so that $E\left(p_t^* \middle| \Psi_{t-j}\right)$ is sufficiently different from p_t^*

[27] We reintroduce the required return on capital in the sensitivity analysis.

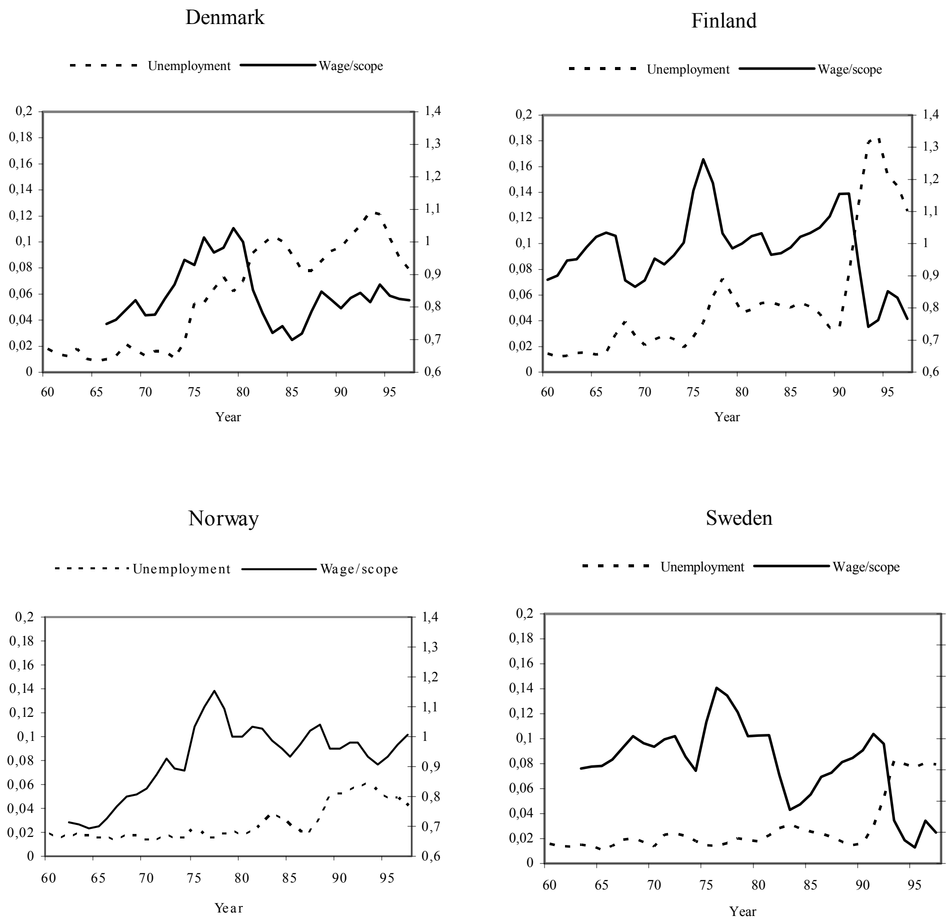

Figure 1 Wage relative to scope and unemployment

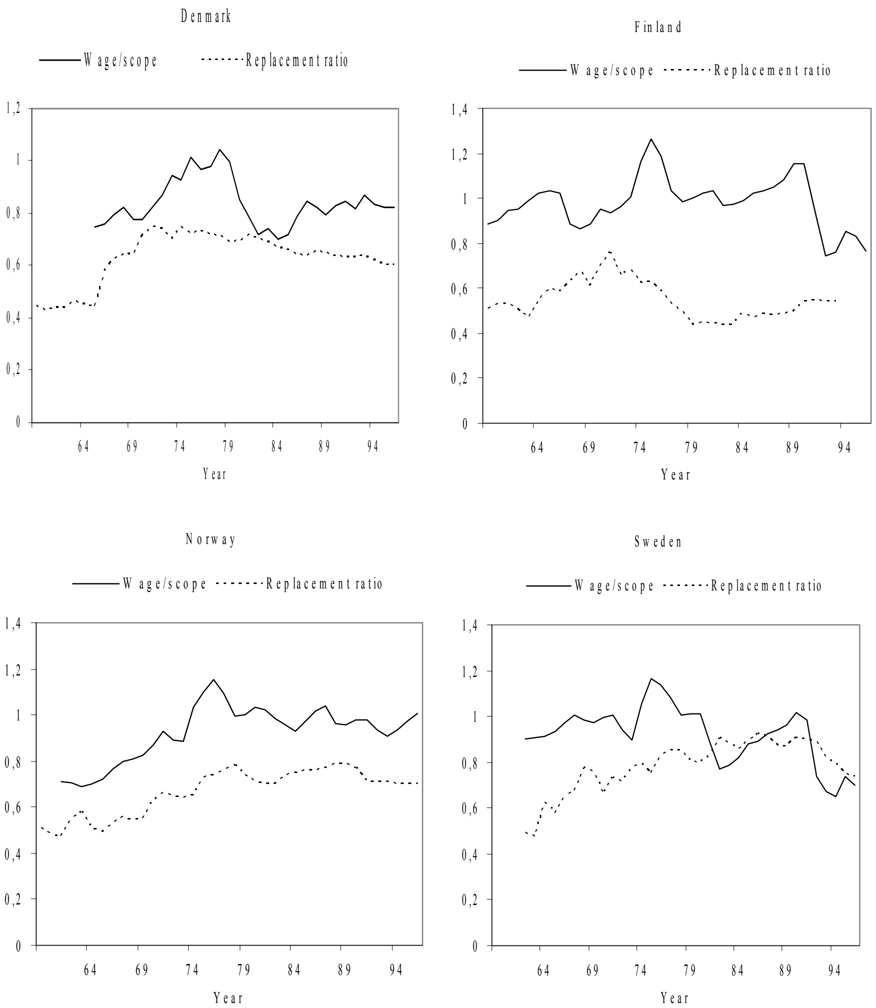

Figure 2 Wage relative to scope (W/S) and replacement ratio (RR)

Figure 2 shows the replacement ratio and wage relative to scope. In all four countries, there was a general increase in benefits in the late 1960's and early 1970's. This is long before the rise in unemployment, but the benefit hike may have contributed to high nominal wage increases in the early 1970's. This period saw a dramatic deterioration of competitiveness in all four countries. Since then, benefits have developed quite differently. The trend in benefits could potentially explain some of the secular increase in unemployment in Denmark, Norway and Sweden.

Figure 3 shows that there is a clear negative relation between changes in the nominal exchange rate (the price of foreign currency) and changes in the wage relative to the scope. Devaluations bring about an improvement in competitiveness, at least in the short run.

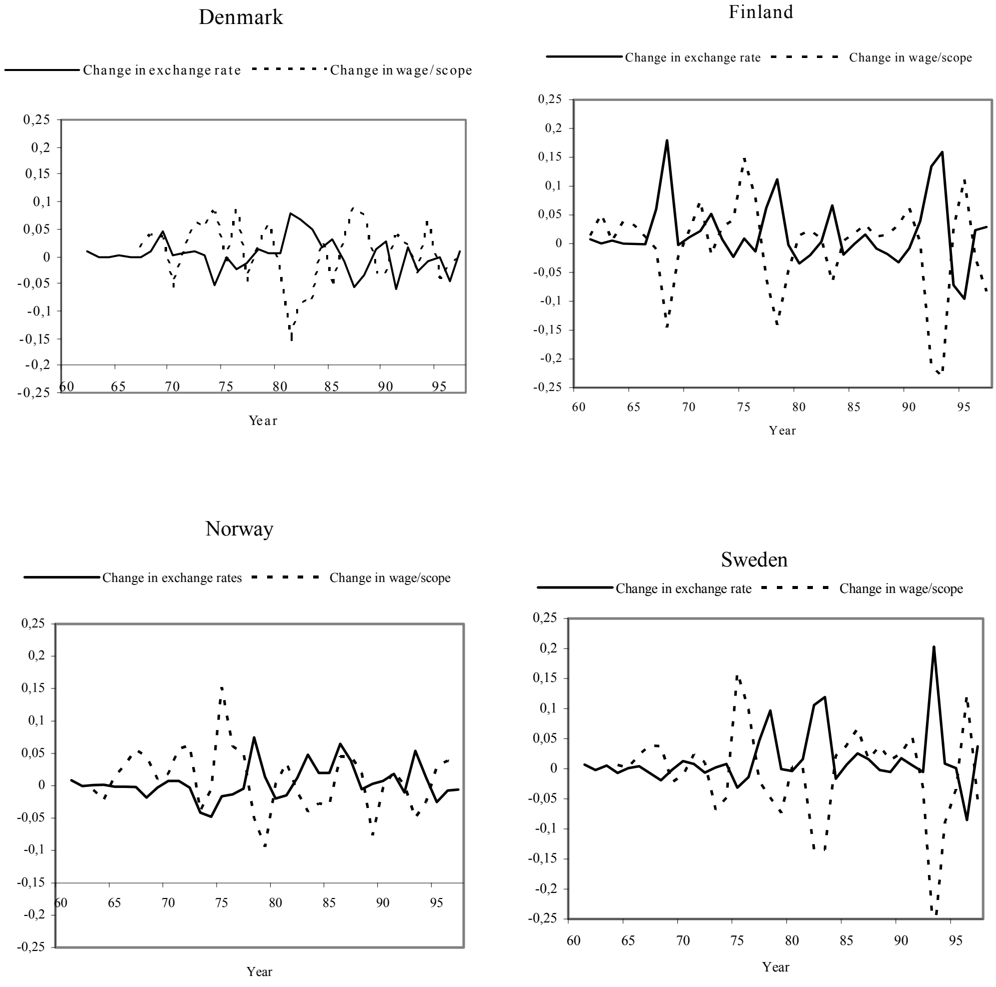

Figure 3 Changes in exchange rate and wage/scope (logs)

Before estimating the structural model, we first examine trends and cointegration relations between the key variables *w-s, rr* and *u*. A priori, one may argue that neither *w-s,* nor *u* or *rr* could really be nonstationary. But there appear to be trends in several of the variables, and in most cases, unit roots cannot be rejected (see *Appendix 3*). To avoid estimating spurious correlations it may be cautious to treat the variables as I (1).

When variables are trending we may think of (18) and (20) as potential cointegration relationships. If γ is finite and variables are I (1), the long run *wage setting curve* (18) implies cointegration between *w-s, b*, and *u*. In the special case when workers have no bargaining power so that the wage setting schedule is vertical, β goes to infinity but β / γ takes a finite value, and *w-s* drops out of the wage setting relationship.

If $\rho < 1$ there is a stable long run *labour demand function* (20) implying cointegration between u and w-s.[28] But if shocks to labour demand are permanent $\left(\rho = 1\right)$ there is no stable long run labour demand relation between *w-s* and *u*. One reason may be that our measure of competitors' prices, *p**, is imperfect and does not fully capture the world price developments which are relevant for the export industry in a particular country. The potential cointegration relationships are summarized in *Table 1*.

To test for cointegration we considered models with and without a trend in the cointegrating relationship. Using the Johansen method to examine the *number* of cointegrating relations, we found evidence for one cointegrating relationship for Denmark and Sweden in both models using both the trace and λ max test statistic. For Norway, we found indications of one cointegrating relationship in the model with trend. For Finland there is no evidence of cointegration relationship in any of the models.

The Engle-Granger method produced very different results. Now we found evidence of cointegration for Sweden and for Finland in the model without a trend. For Norway there is no significant evidence of cointegration in any of the models, but the test statistics are fairly close to the critical values. For Denmark there is no evidence of cointegration relationship in any of the models. Since different tests for cointegration give very different results we cannot draw any definite conclusions.

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[28] A special case is that there is a long run zero profit condition that makes labour demand horizontal and *w-s* stationary. In almost all cases, ADF tests support nonstationarity of *w-s*, so this case does not appear to be relevant.

Table 1 Special cases of the model

	1	2	3	4
	Sloping WS Stable LD	**Sloping WS Unstable LD**	**Vertical WS Stable LD**	**Vertical WS Unstable LD**
	γ finite $\rho<1$	γ finite $\rho=1$	$\gamma\to\infty$, $\beta/\gamma\to\hat{\beta}$ $\rho<1$	$\gamma\to\infty$ $\beta/\gamma\to\hat{\beta}$ $\rho=1$
Cointegration if *rr* nonstationary	*WS: (w-s,u,rr)* *LD: (u,w-s)*	*WS: (w-s,u,rr)* *LD: -*	*WS:(u,rr)* *LD: (u,w-s)*	*WS: (u,rr)* *LD: -*
Cointegration if *rr* stationary	*WS: (w-s,u)* *LD: (u,w-s)*	*WS: (w-s,u)* *LD: -*	*WS: (u)* *LD: (u,w-s)*	*WS:* (u) *LD: -*
b_w	$1-\frac{\gamma\rho^j\eta}{1+\gamma\eta}$	$1-\frac{\gamma\eta}{1+\gamma\eta}$	$1-\rho^j$	0
b_u	$\frac{\gamma\rho^j}{1+\gamma\eta}$	$\frac{\gamma}{1+\gamma\eta}$	$\frac{\rho^j}{\eta}$	$\frac{1}{\eta}$
b_r	$\frac{\beta}{1+\gamma\eta}$	$\frac{\beta}{1+\gamma\eta}$	$\frac{\hat{\beta}}{\eta}$	$\frac{\hat{\beta}}{\eta}$
$\frac{b_u}{b_w}$	$\frac{\gamma\rho^j}{1+\gamma\eta\left(1-\rho^j\right)}\leq\gamma$	γ	$\frac{\rho^j}{\eta\left(1-\rho^j\right)}$	∞
$\frac{b_r}{b_w}$	$\frac{\beta}{1+\gamma\eta\left(1-\rho^j\right)}\leq\beta$	β	$\frac{\hat{\beta}}{\eta\left(1-\rho^j\right)}$	∞
$\frac{1-b_w}{b_u}$	η	η	η	η

Note: The wage setting equation is $w-s=-\gamma u+\beta rr$. The slope of the labour demand curve η is assumed to be finite. If η is infinite, a stable labour demand relation implies that *w-s* is stationary.

Assuming that there is one cointegration vector, we estimated the cointegration relationship using two alternative methods: the Johansen method and Dynamic OLS. As above, we considered models with and without a deterministic trend in the cointegration relationship. Unemployment was significant with the expected negative sign in many of the specifications. The coefficient for benefits was more unstable, but had the expected positive sign in some cases. Overall, these results suggest that there is at most one cointegration relationship between these variables, and if there is one, it is a negative relation between unemployment and wages - a wage setting curve rather than a labour demand equation.

5 Estimation of the dynamic wage equation

To allow for unobserved trending factors, which affect the functioning of the labour market, a deterministic trend is included. Because of missing data for Denmark we omit unexpected variations in the labour tax in our baseline estimation, i. e. we set $g_\tau = 0$. All explanatory variables except the exchange rate are taken to be exogenous or predetermined.[29] The contractual structure suggests that the error should be a low order moving average. To allow for this, we estimated the wage equations by GMM allowing for first order MA errors.

Measures of e_t^u, p_t^{*u}, z_t^u, rr_t^u and τ_t^u were constructed using forecasting (projection) equations for each variable including a constant and the variable itself lagged 2 and 3 years. The residuals (projection errors) were constructed as $x_t^u = x_t - P\left(x_t \middle| x_{t-2}, x_{t-3}\right) = x_t - h_0 - h_1 x_{t-2} - h_2 x_{t-3}$. If we first estimate the projection equations and then use the calculated projection errors in the wage equation we will have a problem with generated regressors. For this reason we estimate the wage equation and the projection equations jointly.[30]

5.1 Simultaneity of the exchange rate

As always, a major empirical problem is that monetary policy is endogenous. In this period, the exchange rates were pegged and the Nordic countries went

[29] Manning (1993) has argued that wage equations are typically unidentified because all variables which affect unemployment will also affect the wage bargain. Here, lagged unemployment is treated as predetermined.

[30] With respect to the exchange rate, an alternative would have been to use the forward exchange rate as a measure of the expected exchange rate. Doing this would be complicated by the fact that countries pegged to different currencies, and baskets of currencies, in different periods. Also, we know that forward rates predict changes in exchange rates very poorly and this is the case also for our projection equation. Most of the variation in the exchange goes into e^u. Hence the results should not be much affected.

through several "devaluation cycles" where the official policy was to maintain a fixed exchange rate, but periods of high inflation lead to loss of competitiveness and subsequent devaluation. The decision to devalue a currency is clearly not random and the question is whether this will lead to biased estimates. To answer this question, we must think of what causes devaluations.

The political costs of maintaining the fixed exchange rate rise in a recession, so devaluation should be more likely when unemployment is high.[31] This implies some correlation between two right hand side variables in the wage equation, but such a correlation does not pose a problem unless the correlation is so high that multicolinearity becomes a problem, which is clearly not the case.

If wage setters anticipate devaluation they will raise wages and this will in itself make devaluation more likely. Without some commitment device for monetary policy, we may end up in a bad equilibrium with continuous high wage increases and devaluations (Horn & Persson (1988)). This possibility does not contradict the approach taken here because it would just mean that most changes in the nominal exchange rate would be anticipated by wage setters and hence they would have small effects on competitiveness $\left(g_e = 0\right)$.[32]

A more difficult problem arises if there is some state variable which affects both the wage and the exchange rate, but is omitted from the estimated equation. Such a variable may be expected future output or employment. A pessimistic outlook may lead to lower wage increases and, at the same time, make devaluation more likely. This will lead us to attribute too much of the improvement in competitiveness to the nominal depreciation of the currency. Our estimate of g_e will be biased upwards.

But we could also imagine the simultaneity going the other way. If unions become more aggressive and demand higher wages (μ_t increases) policy makers may try to bring temporary relief by devaluing the currency.[33] Such monetary accommodation of unexplained wage shocks will lead us to *underestimate* the effects on wage/scope of truly exogenous changes in the nominal exchange rate. Our estimate of g_e will be biased downwards.

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[31] Edin & Vredin (1993) found that devaluations in the Nordic countries were more likely when the economy was in a recession. The currency crisis model by Ozkan & Sutherland (1998) illustrates the political mechanism.

[32] In fact, this is the opposite to what we find below.

[33] During the period with pegged exchange rates, decisions to devalue were effectively taken by the government.

To sum up, there are risks that the estimates are biased due to simultaneity, but it is not clear which way the bias goes. To construct a measure of exogenous policy shocks, we estimate a "reaction function" for the exchange rate where we regress the change in the nominal exchange rate on lags of unemployment, wage relative to scope, and current and lagged real value added in manufacturing, (all in logs).[34] We take the residuals from this equation as truly exogenous policy shocks and use these policy shocks dated t and t-1 as instruments for e_t^u.[35]

5.2 Results

Table 2 shows the results for the baseline dynamic wage equation (26).[36] The equations have a good fit and all behavioural coefficients are significant at the 5 percent level with the expected (positive) sign.[37] The coefficient for unemployment, b_u, is very similar across countries. The coefficient for the replacement ratio, b_r, is similar for Denmark, Finland and Sweden, but higher for Norway. The significant coefficient for the lagged wage, b_w, is consistent with the existence of a long run equilibrium wage setting relation between *w-s, u* and *rr*. Note, however, that according to our theoretical model, b_w should not be interpreted as an adjustment speed. Rather it reflects the slopes of the labour demand and wage setting curves.[38] This illustrates the dangers of jumping to economic interpretations without an explicit economic model.[39]

[34] For all countries, Δe_t was positively related to u_{t-1} and $w_{t-1}–s_{t-1}$ and negatively related to value added in the previous period, but only some of the coefficients were significantly different from zero.

[35] This is analogous to the structural VAR approach where one effectively estimates a policy rule for the monetary policy variable and interprets the residuals from this regression as truly exogenous policy shocks; see Blanchard (1989), Christiano, Eichenbaum & Evans (1999).

[36] The simultaneously estimated forecasting equations are reported in *Appendix 3* Table A6.

[37] The standard t-distribution is used which is correct provided that there is cointegration, so that each coefficient can be written as a coefficient on a stationary combination of variables; see e. g. Stock & Watson (1988). tests for cointegration were performed in the previous section.

[38] b_w reflects the amount of wage adjustment needed to restore equilibrium.

[39] If the equation had been derived from another theoretical model, e g with quadratic adjustment costs, it is possible that b_w could have been interpreted as an adjustment speed.

Table 2 Baseline wage equation

Parameter	Denmark	Finland	Norway	Sweden	Panel
b_u	0.0303** (0.00370)	0.0319** (0.0147)	0.0444** (0.0158)	0.0440** (0.0115)	0.0415** (0.00953)
b_r	0.161** (0.0350)	0.150** (0.0257)	0.395** (0.0781)	0.158** (0.0273)	0.109** (0.0367)
b_w	0.136** (0.0376)	0.199** (0.0331)	0.542** (0.115)	0.143** (0.0539)	0.283** (0.0512)
g_e	1.385** (0.0402)	1.071** (0.0716)	0.802** (0.121)	1.347** (0.0602)	1.170** (0.0465)
g_p	0.152** (0.0592)	0.220** (0.0560)	0.466** (0.107)	0.674** (0.0543)	0.343** (0.0566)
g_z	1.121** (0.0587)	1.168** (0.103)	0.908** (0.180)	1.057** (0.0729)	0.990** (0.0711)
g_r	0	0	0	0	0.645* (0.346)
Trend De	0.00328** (0.000602)				0.00532** (0.00151)
Trend Fi		-0.000396 (0.00112)			0.00002 (0.00200)
Trend No			0.00289** (0.00134)		0.00287 (0.00222)
Trend Sw				0.000928 (0.00133)	-0.00109 (0.00265)
s. e.	0.013	0.018	0.029	0.020	0.016, 0.015, 0.049, 0.028
R^2	0.98	0.98	0.86	0.98	0.97, 0.99, 0.66, 0.96
Autocorrelation 1 Lag	0.100 0.186	0.315 0.196	0.404** 0.174	0.457** 0.177	
Autocorrelation 2 Lag	-0.380** 0.188	-0.064 0.215	-0.0836 0.200	0.00531 0.210	
Autocorrelation 3 Lag	-0.126 0.212	-0.0214 0.215	-0.149 0.202	-0.129 0.210	
Period	1968-1997	1963-1994	1965-1997	1966-1997	1968-1994
$\gamma \; if \;\; \rho = 1$	0.223** 0.0569	0.161* 0.0827	0.0819** 0.0274	0.307** 0.0737	0.147** 0.0344
$\beta \; if \;\; \rho = 1$	1.183** 0.447	0.756** 0.222	0.729** 0.0821	1.105** 0.530	0.386** 0.163
$\eta = \dfrac{1-b_w}{b_u}$	28.5** 4.12	25.1** 11.4	10.32* 5.26	19.49** 6.09	17.30** 4.58

Notes: The estimated equation is (26) with $\alpha \equiv 0$ and $g_\tau \equiv 0$. Because of convergence problems, g_b is set to zero in the country regressions. The equation was estimated with GMM allowing for first order moving average errors. Numbers in parenthesis are standard errors. ** and * denote significance on the 5 and 10 percent level.

The adjustment coefficient with respect to the benefit ratio is poorly identified and because of convergence problems we set this coefficient to zero in the country regressions. All other g-coefficients are significantly different from zero indicating less than full adjustment of wages to unexpected changes in the explanatory variables. The coefficients g_e and g_z are both close to unity, indicating considerable nominal wage rigidity. Within a two-year period, nominal wages hardly respond to shocks to exchange rates and productivity. Foreign price inflation is to a much greater extent incorporated into wage increases, possibly because it is more predictable than exchange rates and productivity.

Significant trend terms for Denmark and Norway indicate deterioration of labour market performance which cannot be explained within our model. This may reflect either omitted variables or persistence mechanisms which have not been explicitly included in our model.[40]

Since the parameter estimates are reasonably similar across countries it is interesting to summarize the evidence from the Nordic countries in the form of a panel estimate. The last column shows panel estimates with country-specific constants and trends. All behavioural coefficients are significant at the 5 percent level. In the panel estimation, g_r is well identified and takes a value which is similar to the other adjustment coefficients.

5.3 Long run implications

There are three regression coefficients in the dynamic wage equation and four underlying parameters, so in general we cannot infer all the long run coefficients from our dynamic regression. But provided that $\rho \leq 1$, b_u / b_w and b_r / b_w are lower bounds on γ and β, with equality if $\rho = 1$ (see Table 1). The cointegration tests did not show any indication of a stable long run labour demand relation between *w-s* and *u*. If, in line with these results, we assume that $\rho = 1$, we can calculate the long run parameters γ, β, η from the estimated coefficients (see lower part of *Table 2*). Furthermore, η can be calculated as $\eta = \left(1 - b_w\right) / b_u$ independent of the value of ρ.

[40] One indication of a less well functioning labour market is increased duration of unemployment; see e. g. Holmlund (2003). Persistence of unemployment is discussed by e. g. Blanchard (1991), Bean (1994), Eriksson (2001,2002), Eriksson & Gottfries (2005).

According to the panel estimates $\gamma = 0.15$, not far from the Blanchflower & Oswald (1994) benchmark of 0.1. An increase in unemployment from 5 to 5.5 percentage units will reduce the wage 1.5 percent.

The panel estimate of β is 0.39, so an increase in the replacement *ratio* from 60 to 66 percent will raise the wage 3.9 percent for a given level of unemployment. The elasticity of the wage with respect to the benefit *level* is 0.28 $\left(\beta/(1+\beta)\right)$ which is far below the unit elasticity implied by the standard Nash bargaining model with unemployment benefits as threat point. This is consistent with our theory, which suggests a more indirect role for benefits in wage formation. Still, benefits have a substantial effect.

On the demand side, $\eta = 17$ implies that a 1 percent increase in the wage will raise unemployment by 17 percent, e. g. from 5 to 5.85 percentage units. This corresponds to an aggregate labour demand elasticity with respect to *w-s* equal to 0.9.[41]

These long run coefficients measure the direct effects on wage setting (18) and labour demand (20), but an increase in the replacement ratio will set off indirect adjustment as the increase in unemployment moderates the wage increase. The total effect of a 10 percent increase in the benefit ratio is a 1.1 percent increase in the wage $\left(\beta/(1+\gamma\eta) = 0.11\right)$ and a 19 percent increase in unemployment $\left(\eta\beta/(1+\gamma\eta) = 1.9\right)$. Because of the high demand elasticity, much of the incidence falls on unemployment. Starting from a 60 percent replacement ratio and 5 percent unemployment, an increase of the replacement ratio to 66 percent will increase the unemployment rate to 6 percent. This is a substantial effect and similar to what Layard, Nickell & Jackman (1991) and others have found in cross country regressions, though large relative to Nickell and Layard (1999).[42]

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41 $\frac{\Delta N}{N} = -\frac{\Delta(L-N)}{L-N}\frac{(L-N)/L}{N/L} = -17\frac{5}{95} = -0.89$. According to Gottfries (2002) a 10 percent increase in wage costs will raise Swedish export prices about 4 percent, leading to a decrease in exports of about 12 percent. The total effect on employments depends also on how domestic demand responds to wage increases.

42 See Cahuc and Zylberberg (2004) chapter 11 for review and references.

Comparing our long run effects to Nymoen & Rødseth (2003) we find that the results are qualitatively similar, but our wage curve parameters are larger.[43] Note, however, that the dependent variable in Nymoen & Rødseth (2003) is the product real wage in terms of the domestic producer price while our equation determines the real wage in terms of foreign prices. Because of nontraded goods and partial pass through of wage costs to tradable prices, we should expect the product real wage in terms of own prices to respond less to shocks.

Nymoen & Rødseth (2003) include productivity *growth* on the right hand side of their error correction model without making any distinction between expected and unexpected changes. According to their results (page 15) higher productivity growth will reduce the wage share and unemployment in the long run. According to our structural model, only *unexpected* productivity growth should affect wage relative to scope, and we have imposed this in our econometric specification.[44] We find that productivity shocks have large and persistent effects on competitiveness,[45] but permanent changes in productivity growth should not affect wage relative to scope.

5.4 Country differences

With a relatively small number of observations for each country we should be cautious in interpreting differences between countries. Still, it is noteworthy that Norway sticks out with a flatter wage setting curve and a steeper labour demand curve In terms of our theory, a flat wage setting curve means that bargaining and rent sharing is important relative to labour market conditions. A steep labour demand curve may reflect the greater reliance on raw materials, making exports are relatively insensitive to wage costs. *Figure 4* shows the estimated wage setting and labour demand curves and illustrates the effect of a 10 percent increase in the replacement ratio.

[43] Nymoen & Rødseth (2003) find an average elasticity of the wage with respect to unemployment of 0.13 (calculated from Table 3 using the "Finland-A" specification). The average elasticity of the wage with respect to the benefit ratio is 0.18. Also, our coefficients are larger than those obtained by Bårdsen, Eitrheim, Jansen & Nymoen (2004, ch. 5.5) for Norwegian data.

[44] Similarly, we do not allowed taxes to affect *w-s* in the long run. Proportional taxes are born by the workers in our model and we do not consider the effects of progressive taxation; see e. g. Holmlund & Kolm (1995).

[45] Aside from nominal wage rigidity, lack of wage adjustment to productivity shocks may occur because some fluctuations in measured productivity reflect variations in factor utilization (see Carlsson 2003).

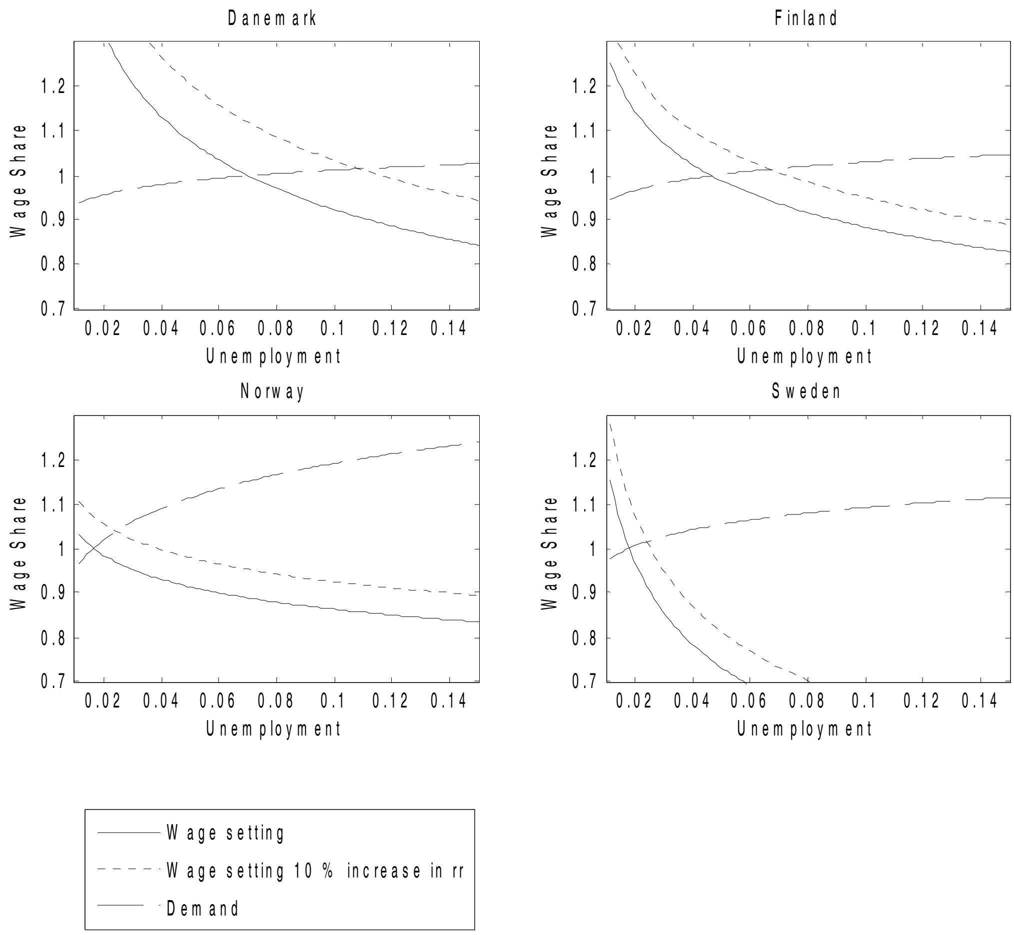

Figure 4 Estimated wage setting and labour demand curves

6 Alternative specifications

In this section we consider several variations of our baseline model. These include unexpected changes in the labour tax, inclusion of capital costs, alternative measures of the chance to get a job, and labour market policy.

6.1 Unexpected changes in the labour tax

With the wage before labour tax set in a contract, unexpected increases in the labour tax should raise *w-s* temporarily. In Sweden, it is often argued that the drastic increase in labour taxes in 1974-1976 contributed to the first Swedish "cost crisis". *Table 3* shows estimates where we include unexpected changes in the labour tax. Labour taxes raised labour costs in Sweden, but not in Finland or Norway.[46]. Danish labour taxes have been low and there is no consistent and reliable series for Denmark.

6.2 Capital costs

A higher required return on capital should reduce the scope for wage increases. So far we have disregarded this by setting $\alpha = 0$. When $\alpha \neq 0$ we have $s_t = \hat{s}_t - \frac{\alpha}{1-\alpha}\hat{r}_t$ where $\hat{s} \equiv e + p^* + z$ and we can then write the wage equation:

$$\begin{aligned} & w_t^T - \hat{s}_t - \left(w_{t-j}^T - \hat{s}_{t-j}\right) = -b_w\left(w_{t-j}^T - \hat{s}_{t-j}\right) - b_u u_{t-j} + b_r\left(rr_t - g_r rr_t^u\right) \\ & -b_c\left[\hat{r}_t - \left(1-b_w\right)\hat{r}_{t-j}\right] - g_e e_t^u - g_p p_t^{*u} - g_z z_t^{Tu} + g_\tau \tau_t^u + \varepsilon_t \end{aligned} \tag{27}$$

where b_c should be equal to $\alpha/\left(1-\alpha\right)$. To construct the required return $\hat{r}_t = \ln\left(i_t + \delta - \Delta e_{t+h}^e - \Delta p_{t+h}^{*e}\right)$ we measure i_t by the government bond rate and set δ equal to 0.10 to reflect depreciation and risk premium. We regressed changes in the exchange rate and the foreign price level (from t to *t+2*) on their own lags (*t-2*,*t-3*) and use the fitted values as proxies for the expectations. In this case, Z_t should ideally be a measure of factor productivity. Since we do not have data on capital input that allows us to measure factor productivity, we use

[46] This finding is consistent with the results in a number of previous studies of Swedish wage setting, where it is typically found that labour taxes influence labour costs in the short run, see the survey in Forslund (1997).

Table 3 Wage equation with unexpected changes in labour taxes

Parameter	Finland	Norway	Sweden	Panel
b_u	0.0230 (0.0211)	0.0413 (0.0270)	0.0567** (0.0161)	0.0584** (0.0130)
b_r	0.133** (0.0401)	0.532** (0.154)	0.171** (0.0474)	0.103** (0.0463)
b_w	0.270** (0.0743)	0.632** (0.172)	0.296** (0.0816)	0.308** (0.0633)
g_e	0.995** (0.0822)	0.597** (0.247)	1.256** (0.0765)	1.147** (0.0550)
g_p	0.217* (0.0860)	0.317 (0.224)	0.621** (0.0832)	0.512** (0.0856)
g_z	1.285** (0.168)	1.184** (0.183)	0.720** (0.119)	0.874** (0.100)
g_r	0	0	0	0.884** (0.365)
g_τ	-0.00598 (0.333)	-0.450 (0.612)	1.122** (0.293)	0.737** (0.215)
Trend Fi	-0.000666 (0.00195)			-0.000378 (0.00189)
Trend No		0.00101 (0.00219)		0.00474** (0.00212)
Trend Sw			-0.000104 (0.00226)	-0.00105 (0.00210)
s. e.	0.018	0.027	0.015	0.021, 0.041, 0.019
Adjusted R^2	0.98	0.88	0.99	0.98, 0.74, 0.98
Period	1963-1994	1965-1997	1966-1997	1966-1994

Notes: The estimated equation is (26) with $\alpha \equiv 0$ .Because of convergence problems, g_b is set to zero in the country regressions. Denmark was omitted because of lack of data. The equation is estimated with GMM allowing for first order moving average errors. Numbers in parenthesis are standard errors. ** and * denote significance on the 5 and 10 percent level.

labour productivity as proxy for Z and include linear and quadratic trends in the equation.[47]

Our measure on the required return $\hat{r}_t$ was low in the 1970s because high inflation was not matched by correspondingly higher nominal interest rates. In all four countries, the required return increased from about 10% at the start of the

[47] The production function can be written $Z^{1-\alpha} = (Y/K)^{\alpha} (Y/N)^{1-\alpha}$. On a steady state growth path where *K/Y* is constant, *Z* is proportional to *Y/N*.

sample to about 15 percent at the end. In *Table 4* we see no evidence that wage setters took account of the required return on capital when setting wages. Either wage setters disregard capital costs or we have a poor measure of capital costs.[48]

Table 4 Wage equation with the required return on capital

Parameter	Denmark	Finland	Norway	Sweden	Panel
b_u	0.0202* (0.0117)	0.0322 (0.0239)	0.0388** (0.0156)	0.0483** (0.0138)	0.0413** (0.00936)
b_r	0.154* (0.0786)	0.0842* (0.0472)	0.388** (0.0845)	0.163** (0.0259)	0.0984** (0.0365)
b_w	0.210** (0.0817)	0.311** (0.0902)	0.496** (0.127)	0.194** (0.0671)	0.280** (0.0527)
b_c	0.0322 (0.0411)	0.0107 (0.0367)	-0.0309 (0.0249)	-0.00512 (0.0300)	0.0295 (0.0217)
g_e	1.325** (0.0640)	0.963** (0.0877)	0.930** (0.154)	1.306** (0.0570)	1.160** (0.0458)
g_p	0.157** (0.0615)	0.195** (0.0921)	0.531** (0.120)	0.657** (0.0741)	0.328** (0.0576)
g_z	1.112** (0.0120)	1.295** (0.177)	0.908** (0.188)	0.987** (0.101)	0.990** (0.0717)
g_r	0	0	0	0	0.724* (0.371)
Trend De	0.00368* (0.00187)				0.00526** (0.00150)
Trend Fi		-0.000600 (0.00215)			0.00054 (0.00203)
Trend No			0.00214 (0.00146)		0.00303 (0.00221)
Trend Sw				0.000606 (0.00123)	-0.00076 (0.00265)
s. e.	0.012	0.018	0.029	0.019	0.016,0.015 0.049,0.028
R^2	0.98	0.98	0.86	0.98	0.97, 0.99, 0.65, 0.96
Period	1969-1997	1965-1994	1965-1997	1966-1997	1969-1994

Notes: The estimated equation is (27) with $g_\tau \equiv 0$. Because of convergence problems, g_b is set to zero in the country regressions. The equation is estimated with GMM allowing for first order moving average errors. Numbers in parenthesis are standard errors. ** and * denote significance on the 5 and 10 percent level.

[48] The low calculated capital cost in the 1970s was partly due to regulation of credit markets, so firms may have been rationed implying that the true cost of funds was in fact higher in the 1970s.

6.3 Using vacancies to measure the state of the labour market

What is relevant for wage setting in our bargaining model is the probability that an *employed* job seeker finds a job. The easier it is to get a job, the weaker is employers' resistance to wage increases. In our baseline estimation we used minus the unemployment rate as a measure of this probability. A more direct measure of the probability to get a job is the number of vacancies relative to the number of people looking for jobs:

$$A = \frac{V}{L - N + SN} = \frac{V/N}{U/(1-U) + S} \ , \qquad (28)$$

where V is the number of vacancies, L is the labour force, N is aggregate employment, and S is the fraction of workers searching on the job, and $U = (L - N)/L$ is the rate of unemployment. We use this formula to construct an alternative measure of the chance to get a job.[49] Since we do not have time series data on search on the job, we treat S as a constant and set it to 0.05.[50] Since vacancies are more volatile than unemployment and the constant S is added in the denominator, the short run variation in A_t is driven mostly by vacancies.

Figure 5 shows vacancies and unemployment. There is a negative short run relation between vacancies and unemployment in all countries, but the long run relation is less clear. Although unemployment has increased substantially in Norway and Finland, vacancies show no clear trend.[51] In the case of Denmark there is a large drop in vacancies in connection with the large increase in unemployment in 1975, but no clear trend thereafter although unemployment continued to increase.

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[49] In previous studies of wage formation, the ratio of vacancies to unemployment has sometimes been used as a measure of labour market pressure (see e. g. Jacobsson & Lindbeck 1971). Our model motivates the use of these two variables, and also yields a specific functional form.

[50] For some references concerning on the job search, see Eriksson & Gottfries (2005). . If unemployed workers are at a disadvantage in the competition for jobs, the unemployment rate may have a weak effect on wages and vacancies may be a better indicator of the chance for employed workers to find a job; see Eriksson & Gottfries (2005) and Eriksson (2001, 2002).

[51] Such a pattern has been observed for many European countries and is often interpreted as an indication of a less well functioning labour market.

Does our alternative measure of the chance to get a job work better than unemployment as an indicator of labour market conditions in the wage equation? *Table 5* shows that this is not the case. Our new measure of a_t is significant for only two of the countries.[52] The other coefficients are essentially unchanged. One reason may be poor quality of vacancy data.

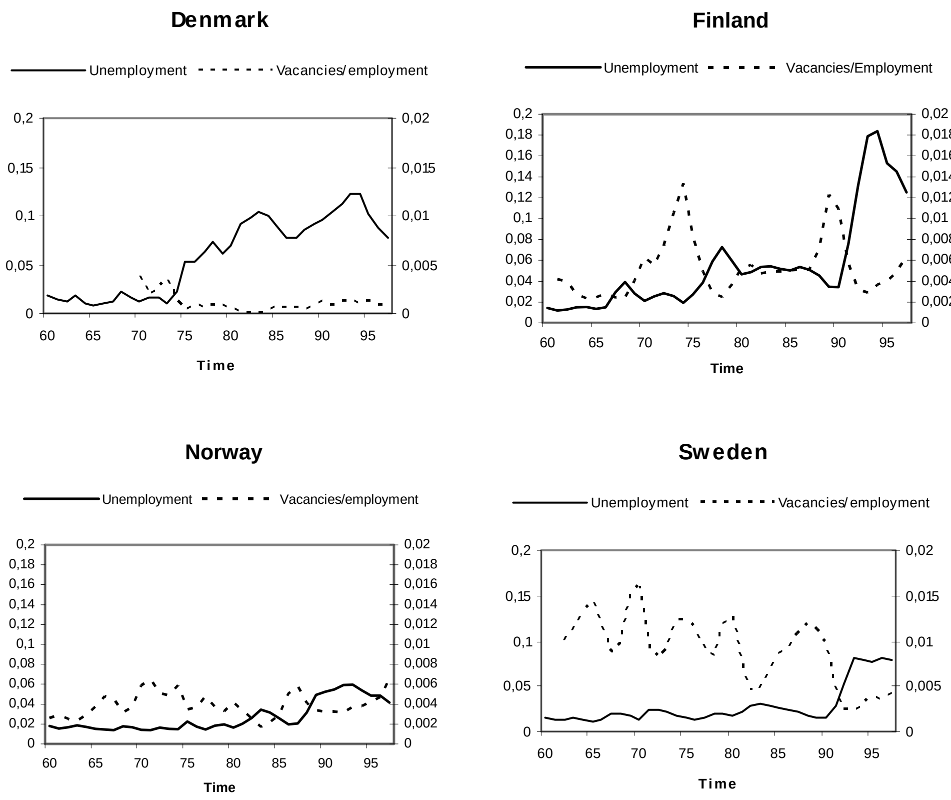

Figure 5 Vacancies and unemployment

[52] In principle, vacancy data should improve our measure of the chance to get a job, but on the other hand vacancy data is known to be unreliable. For a long time period data may not be comparable because of changes in search methods and registration.

Table 5 Wage equation with probability to get a job calculated from vacancies and unemployment

Parameter	Denmark	Finland	Norway	Sweden	Panel
b_a	0.0160** (0.00438)	0.0160 (0.00995)	0.00774 (0.0106)	0.0346** (0.00917)	0.0200** (0.00496)
b_r	0.407** (0.165)	0.155** (0.0273)	0.368** (0.0751)	0.172** (0.0250)	0.219** (0.0572)
b_w	0.362** (0.0806)	0.182** (0.0433)	0.417** (0.124)	0.140** (0.0566)	0.329** (0.0534)
g_e	1.354** (0.0641)	1.110** (0.0603)	0.842** (0.157)	1.317** (0.0646)	1.174** (0.0421)
g_p	0.0723 (0.0757)	0.285** (0.0607)	0.507** (0.129)	0.736** (0.0527)	0.439** (0.0650)
g_z	1.097** (0.110)	1.143** (0.142)	0.981** (0.194)	0.997** (0.0860)	0.902** (0.0666)
g_r	0	0	0	0	0.974** (0.205)
Trend De	0.00676** (0.00223)				0.00442** (0.00163)
Trend Fi		-0.000118 (0.00102)			-0.00187 (0.00231)
Trend No			0.000181 (0.00143)		-0.00065 (0.00250)
Trend Sw				0.00055 (0.00155)	-0.00198 (0.00350)
s. e.	0.011	0.018	0.030	0.021	0.015, 0.014, 0.054, 0.030
R^2	0.99	0.98	0.85	0.97	0.98, 0.99, 0.65, 0.96
Period	1972-1997	1963-1994	1965-1997	1966-1997	1972-1994

Notes: The estimated equation is (26) where u is replaced by the log of A where A is calculated from (28). $\alpha \equiv 0$ and $g_\tau \equiv 0$. Because of convergence problems, g_r was set to zero in the country regressions. The equations were estimated with GMM allowing for first order moving average errors. Numbers in parenthesis are standard errors. ** and * denote significance on the 5 and 10 percent level.

6.4 Active labour market policy

So far, we assumed that only open unemployment contributes to downward wage pressure. But workers in active labour market programs may also contribute to downward wage pressure if they look for jobs while in programs or because they become more competitive when they leave the programs. To see if this is the case, we specify the probability to get a job as

$$A = \frac{sN + SAN}{L - N + \nu M + SN} . \tag{29}$$

The numerator is the number of vacancies, occurring because of exogenous separations, s, and because the fraction searching on the job, S, find jobs with probability *A*. The job searchers consist of workers in open unemployment, *L-N*, workers in labour market programs, *M*, and workers searching on the job, *SN*. The coefficient ν measures the extent to which workers in programs compete for jobs.[53] This equation can be solved for *A*. In order to avoid highly nonlinear estimation we take a linear approximation of the log of *A* at the point where *M=0*:

$$a = \ln(A) = \ln\left(\frac{s}{\frac{L-N}{N} + \nu \frac{M}{N}}\right) \approx \ln(s) - \ln\left(\frac{L-N}{N}\right) - \nu \frac{M}{L-N} . \tag{30}$$

Thus we add *M/(L-N)* in our wage equation with a coefficient $-b_{lmp} = -\gamma\nu$. If workers in labour market programs exert the same downward pressure on wages as openly unemployed workers b_{lmp} should be equal b_u. As we can see in *Table 6,* b_{lmp} is positive for two countries, negative for two countries, and the panel estimate is zero. Thus we see no clear evidence that workers in labour market programs contribute to wage restraint.

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[53] There is turnover in programs so a positive *m* may reflect either workers looking for jobs while they are in programs, or workers competing better for jobs when they leave them.

Table 6 Wage equation with labour market programs

Parameter	Denmark	Finland	Norway	Sweden	Panel
b_u	0.0295** (0.00949)	0.0512** (0.0173)	0.0333** (0.0116)	0.0497** (0.0102)	0.0398** (0.00921)
b_r	0.111 (0.0782)	0.101** (0.0256)	0.399** (0.0725)	0.158** (0.0301)	0.0988** (0.0369)
b_w	0.250** (0.0780)	0.262** (0.0377)	0.365** (0.0992)	0.160** (0.0516)	0.287** (0.0510)
b_{lmp}	0.161* (0.0906)	0.134** (0.0591)	-0.207** (0.0333)	-0.00645* (0.00323)	0.00851 (0.00811)
g_e	1.307** (0.0584)	1.046** (0.0678)	0.747** (0.136)	1.337** (0.0599)	1.160** (0.0460)
g_p	0.175** (0.0593)	0.203** (0.0520)	0.550** (0.113)	0.625** (0.0513)	0.345** (0.0571)
g_z	1.046** (0.119)	1.291** (0.113)	0.862** (0.117)	1.054** (0.0751)	0.995** (0.0704)
g_r	0	0	0	0	0.717* (0.381)
Trend De	0.00586** (0.00187)				0.00541** (0.00152)
Trend Fi		-0.00306 (0.00201)			-0.00008 (0.00201)
Trend No			-0.00007 (0.00153)		0.00282 (0.00221)
Trend Sw				0.00071 (0.00134)	-0.00046 (0.00270)
s. e.	0.012	0.018	0.025	0.020	0.016,0.0150 .049,0.028
R^2	0.98	0.98	0.90	0.98	0.97, 0.99, 0.66, 0.96
Period	1969-1997	1963-1994	1965-1997	1966-1997	1969-1994

Notes: The estimated equation is (26) with the addition of M/(L-N) where M is the number of workers in labour market programs. $\alpha \equiv 0$ and $g_\tau \equiv 0$. Because of convergence problems, g_r was set to zero in the country regressions. The equations were estimated with GMM allowing for first order moving average errors. Numbers in parenthesis are standard errors. ** and * denote significance on the 5 and 10 percent level.

7 Concluding remarks

Our theoretical model rationalizes an econometric wage equation with wage relative to scope as the dependent variable and unemployment, replacement ratio, and lagged wage relative to scope on the right hand side. Such an equation has a good fit and produces similar results for all the Nordic countries. In the long run, wages adjust to the scope, determined by foreign prices and productivity. Based on our theoretical model, we interpret this as evidence that bargaining (rent sharing) is important in wage determination.[54]

Blanchard & Katz (1999) noted a difference in wage setting between the US and several European countries. While a Phillips curve fits the US data quite well - and can be interpreted as a vertical long run wage-setting curve - there is evidence of a sloping wage curve – a relation between the *levels* of wages and unemployment in European countries.[55] Similarly, Bårdsen, Eitrheim, Jansen & Nymoen (2005, ch. 4.6) find that a Phillips curve fits Norwegian wage data quite poorly. Our model provides a straightforward explanation of such a difference. The wage-setting curve becomes vertical if one of the following conditions hold: i) workers have no bargaining power, or ii) the economy is completely closed.[56] Both assumptions appear more relevant for the US than for a typical European country.

According to our estimates, unemployment benefits play a significant role. In all four countries, benefit ratios increased around 1970. Initially, unemployment remained low, but the increase in benefits helps to explain high nominal wage increases in the mid 1970’s which eventually lead to rising unemployment. Of course, benefits may be correlated with other forms of labour market regulation which occurred at the same time, e. g. job security legislation which increased the protection of insiders. From this point of view, benefits may act as a proxy for labour market regulation generally.

[54] This is consistent with survey evidence that the ability to pay is an important determinant of wages; see references in Manning (1993).

[55] See also Cahuc and Zylberberg (2004) chapter 8.

[56] If workers have no bargaining power $W=W^e$ and the efficiency wage condition (6) pins down A. If the economy is closed the price equation (5) and the wage equation (12) imply a vertical WS curve.

We find pervasive nominal rigidity, contrary to the findings of e g Layard, Nickell & Jackman (1991, ch. 9) and Cahuc & Zylberberg (2004, ch. 8). They test for nominal rigidity by including the acceleration of inflation on the left hand side of a real wage equation; if an increase in the inflation rate reduces the real wage, this is taken as evidence of nominal wage rigidity. Applying this approach, they find large differences between countries and for many countries, there is no evidence of nominal wage rigidity. This test may be unreliable, however, because inflation is endogenous. If a wage shock is quickly, but partially, passed on into prices, wage shocks will generate a positive correlation between real wage changes and inflation, and lead researchers to falsely conclude that there is little nominal wage rigidity.

Our approach is similar but tests for nominal rigidity by examining how quickly wages respond to more exogenous variables. We found that nominal wages adjust very slowly after shocks to exchange rates and productivity in all four countries. Such a high degree of nominal wage rigidity may appear implausible. We should note, however, that union coverage is high, and union contracts have often been two or three years long. Also, a high degree of nominal wage rigidity is consistent with evidence from structural VAR models, which show very slow response of wages and prices to monetary shocks even in the US.[57]

High nominal wage rigidity means that changes in exchange rates have large and persistent effects on competitiveness. From other studies we know that competitiveness has substantial effects on demand and production.[58] More generally, nominal wage rigidity means that demand management is important. Thus we confirm the views expressed by Lindbeck (1997), Rødseth (1997), Nymoen- Rødseth (2003), and Holmlund (2003) that demand side factors have been important determinants of unemployment in the medium term. It seems likely, for example, that expansionary fiscal and monetary policy in the 1970's and 1980's delayed an increase in Swedish unemployment, which would have occurred if demand management had been less expansionary.

Let us finally note that downward nominal wage rigidity, coordination of wage bargaining, and progressive taxes are potentially important factors, which

[57] See e. g. Blanchard (1989), Christiano, Eichenbaum & Evans (1999).
[58] Gottfries (2002) documents large but sluggish effects of competitiveness on Swedish exports.

have been omitted in the present study.[59] To incorporate these aspects in the model developed here is an interesting topic for future research.

[59] These aspects have been analysed by e. g. Holden (1994, 2004), Agell & Lundborg (2003), Calmfors & Driffill (1988), Lockwood and Manning (1993), Holmlund & Kolm (1995).

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Appendix 1. Additional derivations

A standard model of union bargaining.

With perfect competition in goods and capital markets, constant returns to scale, and labour-augmenting technical progress Z_i, we have maximzed profit in firm *i*:

$$\Pi(W_i, Z) = \max_{K_i, N_i} Pf\left(K_i / (Z_i N_i)\right) Z_i N_i - W_i N_i - RK_i \ .$$

Let k be capital per effective worker: $k \equiv K/(ZN)$. Profit maximization implies that k is determined by $f'(k) = R/P$ and the labour share of income is $LS = 1 - f'(k)k / f(k)$. If *R/P* is determined in the world market the labour share is independent of wage setting. Let the wage W_i be determined by Nash bargaining:

$$\max_{W_i} \left(U\left(W_i / P^c\right) - U^a\right)^{\beta} \Pi(W_i, Z)^{1-\beta} ,$$

where U is the utility function of the worker, P^c is the consumer price, and β represents the bargaining power of the workers. The “threat point” of the worker is taken to be the expected utility if you leave the firm without a job:

$$U^a = (1 - \rho(u)) U\left(W / P^c\right) + \rho(u) U\left(B / P^c\right)$$

where W is the wage prevailing elsewhere, B is unemployment benefit, and $\rho(u)$ is the risk of remaining unemployed, taken to be an increasing function of unemployment, u. Maximizing and considering a symmetric equilibrium where $W_i = W$, we get

$$\beta \frac{U'(W/P) W / P^c}{\rho(u)\left(U\left(W/P^c\right) - U\left(B/P^c\right)\right)} = (1-\beta)\frac{LS}{1-LS} \ .$$

In the derivation we use the fact that the derivative of the profit function with respect to the wage equals minus employment. In the case of constant relative risk aversion $U\left(W/P^c\right)=\left(W/P^c\right)^{1-\sigma}/(1-\sigma)$ the solution for the wage is

$$W=\left(1+\frac{(\sigma-1)(1-LS)\alpha\beta}{LS(1-\beta)\rho(u)}\right)^{\frac{1}{\sigma-1}}B$$

where σ is the coefficient of relative risk aversion. The wage is proportional to the unemployment benefit with a "mark up" that depends on the state of the labour market. If we allow for monopolistic competition with constant-elastic demand this will not change the qualitative conclusion.

Proof of Proposition 1

Note first that equations (7) and (8) imply $W^w > W^f \geq W^e$.[60] Assume now that $W^f > W^e$.[61] To find the effect of Θ on the wage we differentiate (9):

$$\frac{dW_i}{d\Theta}=-\frac{\Pi_\Theta\left(W^w,\Theta\right)-\delta(1-\phi)\Pi_\Theta\left(W^f,\Theta\right)-\delta\phi\Pi_\Theta\left(W^e,\Theta\right)}{\Pi_w\left(W^w,\Theta\right)-(1-\phi)^2\delta^2\Pi_w\left(W^f,\Theta\right)}.$$

To simplify notation we have set $\bar{W}=1$ and left out *A*. As $W^w > W^f$ the denominator is negative, provided the second order condition is fulfilled. Thus the sign of the numerator determines the sign. Dividing the numerator by Π and using (9) we find that $dW_i/d\Theta$ is positive if and only if

[60] To show this, consider first the case when $W^f = \delta\left((1-\phi)W^w + \phi W^e\right) > W^e$. Since $\delta < 1$, this immediately implies that $W^w > W^f$ and hence $W^w > W^f > W^e$. If, instead $W^f = W^e > \delta\left((1-\phi)W^w + \phi W^e\right)$ equation (7) implies that that $W^w > W^e$ since profits fall when the wage increases.

[61] For the case when $W^f = W^e$ the argument is analogous.

$$\frac{\Pi_{\Theta}\left(W^{w},\Theta\right)}{\Pi\left(W^{w},\Theta\right)}\Theta \geq \frac{(1-\phi)\frac{\Pi_{\Theta}\left(W^{f},\Theta\right)\Theta}{\Pi\left(W^{f},\Theta\right)}+\phi\frac{\Pi\left(W^{e},\Theta\right)}{\Pi\left(W^{f},\Theta\right)}\frac{\Pi_{\Theta}\left(W^{e},\Theta\right)\Theta}{\Pi\left(W^{e},\Theta\right)}}{(1-\phi)+\phi\frac{\Pi\left(W^{e},\Theta\right)}{\Pi\left(W^{f},\Theta\right)}}.$$

Since W^{w} is larger than W^{f} and W^{e}, this holds if $\Pi_{\Theta}\left(W\right)\Theta/\Pi\left(W\right)$ is an increasing function of the wage. Using the profit function and the first order condition with respect to the price we can write this elasticity as:

$$\frac{\Pi_{\Theta}\left(W_{i}\right)}{\Pi\left(W_{i}\right)}\Theta = \frac{W_{i}+C}{\Theta\left(\frac{P_{i}}{P}-\frac{W_{i}+C}{\Theta}\right)} = -\frac{\frac{P_{i}}{P}+\frac{D}{D'}}{D/D'} = -\frac{D'\left(P_{i}/P\right)P_{i}}{D\left(P_{i}/P\right)P}-1 = E\left(\Psi(W_{i})\right)-1$$

where $E\left(P_{i}/P\right)$ is the elasticity of the demand equation and $\Psi(W_{i})$ is the optimal relative price as a function of the wage, holding other variables constant. It is straightforward to show that Ψ is an increasing function. *End of proof.*

Labour turnover and the chance to get a job

Assume that workers have log utility functions. In a short period of length Δ an unemployed workers can search or not search and the period-specific cost associated with search is ζ which is drawn from a distribution $H\left(\zeta\right)$. Let ν be an index for whether the worker is searching. The value of unemployment is given by

$$V^{u} = \max_{\nu\in\{1,0\}}\left[\Delta\left(b-p\right)+\frac{1}{1+\Delta r}\left[\nu\Delta A V^{j}+\left(1-\nu\Delta A\right)V^{u}\right]-\nu\Delta\zeta\right]$$

V^{j} is the value of a job which is given by

$$V^{j} = \Delta\left(w-p\right)+\frac{1}{1+\Delta r}\left[\left(1-\Delta s\right)V^{j}+\Delta s V^{u}\right].$$

An unemployed worker will search if $\zeta \leq A\left(V^{j}-V^{u}\right)/\left(1+\Delta r\right)$. Letting the period length Δ go to zero we get $V^{j}-V^{U} = \left(w-b\right)/\left(r+s+A\right)$ and hence the fraction of unemployed workers searching at a particular point in time is $H\left(A(w-b)/(r+s+A)\right)$. The probability to get a job, *A*, is given by the flow of job openings divided by the number of workers looking for jobs. Job openings occur because of quits and turnover between jobs and job applicants consist of unemployed workers and those searching on the job:

$$A=\frac{sN+S(1)AN}{(L-N)H\left(A(w-b)/(r+s+A)\right)+S(1)N}$$

where *L* is the labour force and *N* is employment. This can be rewritten as

$$AH\left(A(w-b)/(r+s+A)\right)=s\frac{1-U}{U}$$

where *U=(L-N)/L*. This equation determines the chance to get a job implicitly as a function of the replacement rate and unemployment.

Appendix 2. Data

Most series come from Nymoen and Rodseth (2003) and is documented in Evjen and Langset (1997).

w_t: log of nominal wage cost per hour in industry. Source: Nymoen et al database.

p_t^*: competition-weighted foreign export price calculated as $p_t^* = \sum_i v_i \left(\sum_j w_{ij} p_{jt} \right)$ where p_{jt} is log of export price index for of country j, w_{ij} is share of imports to country i coming from country j in and v_i is share of Swedish exports going to country i. Weights are from 1980. Sources: prices from OECD, Main Economic Indicators, export values and import values from IMF, Direction of Trade Statistics.

e_t: exchange rate index calculated using the same weights. Source: OECD.

z_t: log of hourly labour productivity computed as value added in fixed prices divided by hours worked in industry. Source: Nymoen et al database.

i_t: 5 year government yearly bond yield. Source: Ecowin database.

u_t: log of open unemployment. Source: Nymoen et al database.

n_t: log of labour force. Source: Nymoen et al database.

l_t: log of employment. Source: Nymoen et al database.

$\overline{\tau}_t$: labour tax computed as total wage costs divided by wage costs excluding labour tax minus one. Source: Nymoen et al database.

rr_t: log of replacement ratio. Source: Nymoen et al database.

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