Prices, Productivity, and Wage Bargaining in Open Economies*

Anders Forslund^a, Nils Gottfries^b, Andreas Westermark^c

26 February 2007

Standard union bargaining models predict that product market prices and productivity should not directly affect the wage bargain, but unemployment benefits should play an important role. We formulate an alternative bargaining model, where wages depend on all these factors. We derive a wage equation which is estimated on aggregate data for the Nordic countries. Wages are found to depend on domestic labour market conditions (unemployment and unemployment benefits) as well as productivity, international prices and exchange rates. There is evidence of considerable nominal wage rigidity and nominal exchange rate changes have very persistent effects on competitiveness.

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

Keywords: efficiency wage, turnover, bargaining, rent sharing, wage rigidity, open economy, exchange rate policy, competitiveness

* We have received very helpful comments from Louis Christofides, Steinar Holden, Bertil Holmlund, Ann-Sofie Kolm, Ragnar Nymoen, Asbjørn Rødseth, the editor and referees, and seminar participants at Institute of Labour Market Policy Evaluation, CESifo, and the Universities of Oslo, Umeå, Uppsala, and Zurich. We thank the Institute of Labour Market Policy Evaluation (IFAU) for financial support and Ragnar Nymoen and Asbjørn Rødseth for access to their data.

a) Institute for Labour Market Policy Evaluation and Department of Economics, Uppsala University.

b) Department of Economics, Uppsala University, CESifo and IZA. Address: Box 513, 751 20 Uppsala, Sweden. <u>nils.gottfries@nek.uu.se</u>.

c) Department of Economics, Uppsala University.

1. Introduction

The theory of collective bargaining was developed in order to understand how various factors affect the wage bargain. A commonly used model is the Nash bargaining model where the "threat point" of the workers is the expected utility if a worker leaves the firm, demand is constant-elastic, and there is constant returns to scale in production (see e. g. Layard, Nickell, and Jackman (1991), Chapter 2).

A close look at this standard model reveals some counterintuitive results, however. The bargaining solution yields a wage that is proportional to the unemployment benefit, with a "mark up" that depends on the level of unemployment. This implies an implausibly large role for unemployment benefits in the wage bargain; in empirically estimated wage equations, benefits play a more modest role. At the same time, product prices and productivity do not directly affect the wage. For a given level of unemployment, an increase in productivity will affect the wage only if it leads to an increase in unemployment benefits or the value of leisure or home production (c. f. Manning (1993), Bean (1994)).

That productivity and product market prices would not directly affect the wage bargain appears counterintuitive and empirical models typically allow direct effects of productivity on wages. According to the "Scandinavian model of inflation" foreign prices and productivity should be the main determinants of wages (Aukrust, Holte & Stoltz (1967)). Much recent research on aggregate wage determination employs an error-correction approach, where the long run equilibrium condition is a relation between the wage share and unemployment; such a specification implies a direct role for productivity and prices in wage determination.

In this paper, we present a theoretical wage bargaining model, where wages depend on productivity and product market prices as well as on unemployment benefits and labor market conditions. We derive a dynamic wage equation, where all parameters have clear economic interpretations, and this equation is estimated on data for aggregate manufacturing wages in Denmark, Finland, Norway, and Sweden.

Our theoretical bargaining model differs in two ways from the standard union bargaining model, which is presented in Layard, Nickell & Jackman (1991). First, we assume that firms face product demand curves, which are not constant-elastic but that elasticity increases in absolute value with the firm's relative price. This assumption is consistent with evidence of less than full pass-through of exchange rate changes into export prices. We show that when demand curves have this characteristic, wages will depend positively on

2

productivity and product market prices. 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 standard application of the Nash bargaining model, where the utility if unemployed is taken as threat point.

The model has interesting implications for wage curves in closed and open economies. In a closed economy, product prices depend only on domestic conditions, wage increases are fully passed on into prices, and the wage curve is vertical. In the open economy, wage increases are not fully passed on to price increases. The wage depends on unemployment and a weighted average of foreign prices, productivity, and unemployment benefits. Since workers get a smaller share of the surplus when unemployment is high, there is a sloping wage curve. This difference between wage curves in closed and open economies is consistent with the empirical findings of Blanchard and Katz (1999) who found evidence of a wage curves in European countries while a vertical Phillips curve fits better to US data.

The dynamic specification is derived assuming that nominal wages are set at an earlier point in time. The dynamic adjustment coefficients can be interpreted in terms of the information available to wage setters and our specification allows us to measure the degree of nominal wage rigidity.

We estimate the wage equation on data from Nymoen and Rödseth (2003) for aggregate manufacturing wages in Denmark, Finland, Norway, and Sweden. The period is the mid 1960s to the mid 1990s. Most of this period, exchange rates in the Nordic countries were pegged 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 exchange rate. We examine how nominal wages responded to exchange rates, foreign prices, productivity, unemployment benefits, and unemployment in the short and the long run.

The equation has a good fit and parameters estimates are reasonably similar across countries. Wages depend on the labour market situation, but also on international prices and productivity. Unemployment benefits are important, but the elasticity with respect to unemployment benefits is far below the unit value predicted by the standard Nash bargaining model. We find a high degree of nominal wage rigidity; shocks to exchange rates and productivity have large and persistent effects on competitiveness. Hence exchange rate policy plays an important role in the medium term.

3

Our paper builds on a long tradition of modelling wage formation in open economies. According to the "Scandinavian model of inflation," wages in the tradable industry must adjust to the "scope" or "main course" for wage increases, determined as the sum of productivity growth and price increases for tradable goods (Aukrust, Holte & Stoltz (1967), Edengren, Faxen & Ohdner (1970), Aukrust (1977), Lindbeck (1979), Calmfors (1979)). The Scandinavian 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. Searching for better micro-foundations, Scandinavian economists turned to union bargaining models and estimated real wage equations which were inspired by bargaining theory (Hersoug, Kjaer & Rødseth (1986), Calmfors (1990), Holm, Honkapohja, & Koskela (1994)). Subsequent research on aggregate wage 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 (Nymoen (1989), Calmfors & Nymoen (1990), Johansen (1995), Holden & Nymoen (2001), Nymoen & Rødseth (2003), Forslund & Kolm (2004), Bårdsen et. al (2005)). Our model combines elements from the Scandinavian model of inflation, union bargaining theory, and efficiency wage theory, and we derive a wage equation which is similar to the error-correction equation specification, which has been used in recent empirical work on aggregate wage formation. A difference, though, is that we model the dynamics. Distinction is made between expected and unexpected changes in the explanatory variables and all coefficients have clear economic interpretations.

In Section 2 we derive a static wage equation relating the wage to productivity, product market prices, unemployment, and unemployment benefits. In Section 3 we make the equation dynamic by adding nominal wage rigidity. Sections 4 and 5 present data and empirical results. 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 *i* be $Y_i = K_i^{\alpha} (Z_i N_i)^{1-\alpha}$ where Z_i is an exogenously given technology factor, K_i is capital, N_i is the number of workers, and $0 < \alpha < 1$. Capital is rented at a price *R*. Following Eriksson and Gottfries (2005), we assume that turnover among workers is $S(W_i/W)AN_i$; it depends on the firm's own wage W_i relative to the average wage *W* and the probability *A* that a worker searching on the job does

find a new job. The function S is decreasing and convex in the relevant region. Turnover is associated with a cost cW per quitting worker and the profit of the firm is

$$\Pi_{i} = P_{i}Y_{i} - \left(W_{i} + cWS\left(W_{i}/W\right)A\right)N_{i} - RK_{i}, \qquad (1)$$

where P_i is the price set by firm *i*. A cost minimizing choice of input quantities implies the cost function

$$C(W_i, W, A, R, Y_i, Z_i) = \kappa (W_i + cWS(W_i / W)A)^{1-\alpha} R^{\alpha} Y_i / Z_i^{1-\alpha}, \qquad (2)$$

where $\kappa = \alpha^{-\alpha} (1 - \alpha)^{\alpha^{-1}}$. The demand facing an individual firm is $D(P_i/P)$ where *P* is the average market price. 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

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

where $\Theta_i = PZ_i (R/P)^{\alpha/(\alpha-1)}$. Θ_i determines the surplus to be shared between the firm and the workers. In the following, Θ_i is called the "scope" for wage increases. The first-order condition with respect to price

$$\frac{P_i}{P} = \left(1 + \frac{D(P_i/P)P}{D'(P_i/P)P_i}\right)^{-1} \kappa \left(\frac{W_i + cWS(W_i/W)A}{\Theta_i}\right)^{1-\alpha},\tag{4}$$

implies a price equation of the form

$$\frac{P_i}{P} = \Omega\left(\frac{W_i}{\Theta_i}, \frac{W}{W_i}, A\right).$$
(5)

A Conventional Bargaining Model

Before we turn to our bargaining model, we consider a common specification. We disregard turnover costs and let demand be constant-elastic, with elasticity of absolute value $\eta > 1$. In this case, maximized profits are $\Pi = (\eta - 1)^{\eta - 1} \eta^{-\eta} \kappa^{(1-\eta)} (W_i / \Theta_i)^{(1-\alpha)(1-\eta)}$. Let the wage be set so as to maximize the Nash product $(W_i - \overline{W})^{\beta} \Pi^{1-\beta}$. The threat point of the firm is zero and the threat point of the worker is the expected utility if the worker leaves the firm: $\overline{W} = (1 - \rho(u))W + \rho(u)B$, where *B* is unemployment benefit, and where $\rho(u)$ is the risk that the worker remains unemployed. In a symmetric equilibrium where $W_i = W$ we get

$$W = \left(1 - \frac{\beta/(1-\beta)}{(1-\alpha)(\eta-1)\rho(u)}\right)^{-1} B.$$
(6)

The wage is proportional to the benefit level, with a mark-up that depends on unemployment. For a given benefit level, productivity and product market prices play no *direct* role in the wage bargain. The size of the cake, Θ , does not matter.¹

An Alternative Bargaining Model

We now return to our original specification with turnover costs. Note first that the wage that is preferred by the firm is the "efficiency wage" W^e which minimizes cost per unit of labour input, determined by

$$1 + cS'(W^{e}/W)A = 0.$$
⁽⁷⁾

Now assume that bargaining occurs in an individual firm, or a group of identical firms. The firm/group is small, so it takes aggregate labour market conditions as given. To model bargaining, we follow Gottfries & Westermark (1998). If there is a conflict, there is no production, no wages are paid, and the two parties make alternating bids. When a bid has been rejected, it may turn out that the workers are unable to continue the strike, in which case the firm can set the wage that it prefers, W^e . Let δ be the discount factor relevant to the period

¹ Productivity and product market prices may play an *indirect* role if benefits are indexed to the wage or the price level. Also, a general productivity or price increase may affect the value of home production, which should be included in *B*. For discussions of this, see e. g. Manning (1993), Bean (1994), Nymoen and Rodseth (2003).

between bids and let ϕ be the probability that workers cannot continue the strike. The worker's optimal bid W^w is such that the firm is indifferent between taking the bid and continuing the conflict:

$$\Pi\left(\frac{W^{w}}{W}, \frac{\Theta_{i}}{W}, A\right) = \delta\left[\left(1 - \phi\right)\Pi\left(\frac{W^{f}}{W}, \frac{\Theta_{i}}{W}, A\right) + \phi\Pi\left(\frac{W^{e}}{W}, \frac{\Theta_{i}}{W}, A\right)\right],\tag{8}$$

where the function Π is defined in (3). Analogously, the firm's optimal bid W^f is such that the worker is indifferent between taking the offer and continuing the conflict:

$$\frac{W^{f}}{P^{c}} = \delta \left(\left(1 - \phi \right) \frac{W^{w}}{P^{c}} + \phi \frac{W^{e}}{P^{c}} \right).$$
(9)

The utility of the worker is simply the real wage, P^c being the consumer price. In equilibrium the first bid is accepted.² Assuming that the worker makes the first bid, so that $W_i = W^w$, we can substitute (9) into (8) to get an equation that determines W_i/W :

$$\Pi\left(\frac{W_i}{W}, \frac{\Theta_i}{W}, A\right) = \delta\left[\left(1-\phi\right)\Pi\left(\delta\left(1-\phi\right)\frac{W_i}{W} + \delta\phi\frac{W^e}{W}, \frac{\Theta_i}{W}, A\right) + \phi\Pi\left(\frac{W^e}{W}, \frac{\Theta_i}{W}, A\right)\right].$$
(10)

From (7) we know that W^e/W is a function of A and thus (7) and (10) implicitly determine W_i/W as a function of Θ_i/W and A

$$\frac{W_i}{W} = F\left(\frac{\Theta_i}{W}, A\right). \tag{11}$$

The wage increases with A, but the derivative with respect to Θ_i depends on the form of the demand function:

 $^{^{2}}$ Thus the wage depends on who makes the first bid but if we let the time between bids go to zero, the strategic advantage of the first bidder disappears.

Proposition 1: The bargained wage increases with Θ_i if and only if workers have bargaining power and demand becomes more elastic as the relative price increases. *Proof: See Appendix 1.*

To get some intuition for this result, consider an increase in the market price P. At an unchanged price P_i this implies a decrease in the firm's relative price P_i/P . If demand becomes less elastic it becomes easier to pass on wage increases to product prices, so wages increase.

If demand is constant-elastic the wage is independent of Θ_i . Constant-elastic demand is often assumed in theoretical models, but evidence on pricing behaviour suggests that the price elasticity is increasing (in absolute value) in the relative price. Less than full pass-through and "pricing to market" in international markets can be explained when demand functions have this characteristic (see e. g. Gottfries (2002)).

Our theory predicts that, when workers have bargaining power, the wage depends on the product market price, but not on the consumer price. To consider the macroeconomic implications of this theory, assume that the required real return on capital is constant and productivity is the same for all firms, $\Theta_i = \Theta = PZ$, and log linearize the wage equation (11):

$$w_i - w = \lambda (p + z - w) + \phi a.$$
⁽¹²⁾

where $\lambda \ge 0$, $\phi > 0$, lower case letters denote logs, and the constant is omitted. The probability *a* that an employed job-seeker can get a job affects the wage bargain, not because workers threaten to quit, but because a strong labour market decreases employers' resistance to wage increases. The firm's preferred wage increases when the labour market is tight (Holden (1990), Gottfries & Westermark (1998)). Unemployment benefits do not affect wage bargaining via the threat point, but if benefits affect the search intensity and choosiness of the unemployed workers it will affect the effective competition that employed workers face when they look for a new job. In *Appendix 1* we present a simple model where unemployed workers face random search costs and show that the chance to get a job for an employed job searcher depends on unemployment and the relation between benefits and wages. Thus we assume that *a* is a function of two variables: the log of the replacement ratio χ and the log of the unemployment rate *u*:

$$a = \hat{\beta} \chi - \hat{\gamma} u \,. \tag{13}$$

Wage curves in closed and open economies

We now consider the implications of our model for wage curves. Consider first the case when workers have *no bargaining power* and hence $\lambda = 0$ (c. f. (7) and *Proposition 1*). Then, in a symmetric equilibrium where all firms (sectors) set the same wage, (12) and (13) imply a vertical wage setting curve:

$$u = \left(\hat{\beta} / \hat{\gamma}\right) \chi \,. \tag{14}$$

If workers have some bargaining power $(\lambda > 0)$ we also need to consider price determination. Consider first a *closed economy*. Log-linearizing the price equation (5) we get in a symmetric equilibrium where $w_i = w$ and $p_i = p$:

$$p = w - z + ha \,, \tag{15}$$

where h>0 because high turnover raises the marginal cost. Using (12) and (13) we again get a vertical wage setting curve (14) and a constant wage share w - p - z.

Now consider an *open economy* where workers have bargaining power. Assume, for simplicity, that firms compete only with foreign firms so that $p = e + p^*$ where *e* is the exchange rate (price of foreign currency) and p^* is the competitors' price in foreign currency.³ In a symmetric equilibrium where $w_i = w$, (12) and (13) imply

$$w = e + p^* + z + \beta \chi - \gamma u , \qquad (16)$$

where $\beta = \phi \hat{\beta} / \lambda$ and $\gamma = \phi \hat{\gamma} / \lambda$. This is our main equation and the basis for our empirical application. When wages are bargained over in a fixed exchange rate regime, the wage level is "anchored" to the scope, which is determined by foreign prices and productivity. The role of monetary policy is to peg the nominal exchange rate. Of course, this is the key insight in the "Scandinavian model of inflation" but there are some differences. In the original model,

exporting firms were assumed to be price-takers and the exchange rate was fixed, so that wage growth was determined by price and productivity increases in the tradable sector: $\Delta w = \Delta p^* + \Delta z$. Our model is more general in that it allows for variations in the relative prices of domestic and foreign goods, and for labour market conditions to affect wages. In periods of high unemployment, wages will be low relative to foreign market prices and productivity.

Blanchard & Katz (1999) noted a difference in wage setting between the US and European countries. While an expectations augmented Phillips curve - a vertical long run wage-setting curve - fits the US data quite well, there is evidence of a sloping wage curve – a relation between the *levels* of wages and unemployment - in European countries.⁴ Similarly, Bårdsen, Eitrheim, Jansen & Nymoen (2005, ch. 4.6) find that a Phillips curve fits Norwegian wage data poorly. Our analysis provides a straightforward explanation of this difference. The wage-setting curve becomes vertical if one of two conditions hold: i) workers have no bargaining power ($\lambda = 0$), or ii) the economy is completely closed ($p = p_i$). Both assumptions appear more relevant for the US than for European countries.

Letting *b* be the (log of) nominal unemployment benefit, so the replacement ratio is $\chi = b - w$, we may also write

$$w = \frac{e + p^* + z + \beta b}{1 + \beta} - \frac{\gamma}{1 + \beta} u .$$
 (17)

The wage depends on a weighted average of the scope $e + p^* + z$ and the unemployment benefit, and the elasticity with respect to benefits is $\beta/(1+\beta)$ rather than unity as in the standard model (6).

On the demand side, the model implies that for a given number of firms, there is a positive relationship between W / Θ and unemployment.⁵ In order to derive an empirical wage equation in the next section, we specify a log linear demand relation

$$u = \eta (w - e - p^* - z) - \delta, \tag{18}$$

where δ represents unobserved factors affecting labour demand and labour supply.

³ In a working paper version of this paper we included nontradable goods; this does not change the qualitative results (see Forslund-Gottfries-Westermark (2005)).

⁴ See also Cahuc and Zylberberg (2004) chapter 8.

3. Nominal Wage Rigidity and Short Run Dynamics

A 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. Union contracts have been relatively well coordinated and wage contracts covering several years always specify wage increases to take place during the contract period. To derive a simple dynamic wage equation, we think of wages for period t as being *predetermined*, set on average two years before, based on expectations that wage bargainers had at that time. We use E_{t-2} to denote the expectation conditional on information that wage-setters have when they set wages for period t. Assume that wages are set to fulfil the wage equation (16), but with expected values replacing actual values which are not yet known

$$w_{t} = E_{t-2}(\theta_{t}) + \beta E_{t-2}(\chi_{t}) - \gamma E_{t-2}(u_{t}) + \mu_{t}, \qquad (19)$$

where $\theta_t = e_t + p_t^* + z_t$. We have added a shock μ_t which represents unobserved factors that temporarily affect wages. The outcome for unemployment u_t depends on the wage w_t . We take unemployment to be determined by (18) with an autoregressive demand shock $\delta_t = \rho \delta_{t-1} + \xi_t$ and $\rho \le 1$. Assuming that wage setters observe variables at t-2 we can derive the expected value of u_t as

$$E_{t-2}(u_{t}) = \eta(w_{t} - E_{t-2}(\theta_{t})) - \rho^{2}\delta_{t-2} = \eta(w_{t} - E_{t-2}(\theta_{t})) - \rho^{2}[\eta(w_{t-2} - \theta_{t-2}) - u_{t-2}].$$
(20)

Substituting into (19) and solving for the wage we get

$$w_{t} = E_{t-2}\left(\theta_{t}\right) + \frac{\gamma\rho^{2}}{1+\gamma\eta} \left[\eta\left(w_{t-2} - \theta_{t-2}\right) - u_{t-2}\right] + \frac{\beta}{1+\gamma\eta} E_{t-2}\left(\chi_{t}\right) + \frac{\mu_{t}}{1+\gamma\eta}.$$
 (21)

Lagged wages and labour market conditions enter the wage equation because past wages and labour market conditions are indicators of unobserved and persistent demand shocks.

 $[\]frac{1}{5}$ In the working paper version we show this more explicitly - see Forslund-Gottfries-Westermark (2005).

A measure of nominal wage rigidity

We also need to construct measures of expected exchange rates, prices, productivity and replacement ratios. To do this, we 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 assume that wage-setters know *at least* p_{t-2}^*, p_{t-3}^* when they set wages for period t, but perhaps they know more than that. Now we can think of two extreme possibilities. One is that they have no more relevant information than p_{t-2}^*, p_{t-3}^* so their expectation is $E_{t-2}(p_t^*) = E(p_t^* | p_{t-2}^*, p_{t-3}^*)$. Another possibility is that they have enough information to perfectly predict the outcome: $E_{t-2}(p_t^*) = p_t^*$. Gottfries & Persson (1988) show that when agents' information contains at least p_{t-2}^*, p_{t-3}^* we can write agents' expectations as a weighted average of these two extremes plus a noise term:

$$E_{t-2}(p_t^*) = g_p E\left(p_t^* \middle| p_{t-2}^*, p_{t-3}^*\right) + \left(1 - g_p\right) p_t^* + \eta_t^p = p_t^* - g_p p_t^{*u} + \eta_t^p$$
(22)

where $p_t^{*u} = p_t^* - E(p_t^* | p_{t-2}^*, p_{t-3}^*)$ is the innovation relative to the pre-specified information set and where η_t^p is by construction orthogonal to p_{t-2}^*, p_{t-3}^* and p_t^* . The coefficient g_p is between zero and one and measures the extent to which agents *do not foresee* innovations in p_t^* . If wage setters make perfect forecasts about $p_t^*, g_p = 0$; if they know no more than $p_{t-2}^*, p_{t-3}^*, g_p = 1$. The same decomposition can be made for the other right hand side variables. Substituting into (21) and subtracting $w_{t-2} - \theta_{t-2}$ on both sides we get our basic wage equation

$$w_{t} - \theta_{t} - \left(w_{t-2} - \theta_{t-2}\right) = -b_{w}\left(w_{t-2} - \theta_{t-2}\right) - b_{u}u_{t-2} + b_{\chi}\left(\chi_{t} - g_{\chi}\chi_{t}^{u}\right) - g_{e}e_{t}^{u} - g_{p}p_{t}^{*u} - g_{z}z_{t}^{u} + \varepsilon_{t}$$
(23)

where $b_w = 1 - \frac{\gamma \rho^2 \eta}{1 + \gamma \eta}$, $b_u = \frac{\gamma \rho^2}{1 + \gamma \eta}$, and $b_{\chi} = \frac{\beta}{1 + \gamma \eta}$. Because of nominal wage rigidity,

unexpected variations in the nominal exchange rate, foreign prices, and productivity cause deviations from the long run solution. The g-coefficients measure wage rigidity because they

tell us how much information wage setters have when they set wages. A positive value of g_p , for example, implies that wages respond slowly to price shocks. The "adjustment speed" b_w reflects the slopes of demand and supply, and the persistence of the shocks, which together determine the necessary wage adjustment. The error term ε_t contains unobserved shocks and the noise in our expectations measures.

4. Data

Most of the data comes from Nymoen & Rødseth (2003). 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 and the exchange rate are trade-weighted indexes of foreign export prices and nominal exchange rates of major trading partners. More precise definitions are given in *Appendix 2*.

Figure 1 shows unemployment and wage relative to scope. Unemployment has increased in all four countries, but it started to increase earlier and reached 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 run 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.

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 wage increases in the mid 1970's. In this period, there was a marked deterioration of competitiveness in all four countries. Since then, benefits have developed quite differently. High benefits could potentially explain 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 improvements in competitiveness, at least in the short run.

Are the variables stationary? From an economic point of view, one may argue that $w - \theta$, *u* and χ must be stationary. In the very long run, one would expect exit and entry of firms to shift demand so as to restore some normal profit level. In practice, there are trends in

13

several of the variables, and in most cases, unit roots cannot be rejected. When variables are trending we may think of the wage equation (16) as a potential cointegration relationship. Cointegration tests for $w - \theta$, u and χ using Johansen and Engel-Granger methods suggested that there is at most one cointegration relationship between these variables, and if there is one, it is a negative relation between u and $w - \theta$ – consistent with the existence of a long run wage setting curve. (These tests are reported in Forslund-Gottfries-Westermark (2005).)

5. Estimation

To allow for unobserved trending factors, which affect the functioning of the labour market, a deterministic trend is included. All explanatory variables except the exchange rate are taken to be exogenous or predetermined. The contractual structure suggests that the error may 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 , χ_t^u were constructed using forecasting (projection) equations for each variable including a constant and the variable itself lagged 2 and 3 years. For example, we estimate $e_t = h_0 + h_1 e_{t-2} + h_2 e_{t-3}$, and form the projection error as $e_t^u = e_t - P(e_t | e_{t-2}, e_{t-3}) = e_t - h_0 - h_1 e_{t-2} - h_2 e_{t-3}$. 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 substitute for e_t^u in (23) and estimate the wage equation and projection equations jointly.⁶

Simultaneity of the exchange rate

A major empirical problem is that monetary policy is endogenous. Most of this period, the exchange rates were pegged and the Nordic countries went through several "devaluation cycles" where 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.

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 an equilibrium with continuous high wage increases and devaluations (Horn & Persson

⁶ The econometric issues are thoroughly discussed by Gottfries-Persson (1988) and Gottfries (2002).

(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 have small effects on competitiveness ($g_e = 0$). In fact, this is the opposite of what we find below.

Edin & Vredin (1993) found that devaluations in the Nordic countries were more likely when the economy was in a recession, presumably because the political costs of maintaining a fixed exchange rate rise in a recession. Thus, exchange rate changes may be correlated with unemployment, but a correlation between two right hand side variables is in itself not a problem. 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 may 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 $(\mu_t > 0)$ policy makers may try to bring temporary relief by devaluing the currency. 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.

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). 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 .⁷ The estimated reaction functions, which are reported in Appendix 3, show that high unemployment and low growth lead to depreciation of the Swedish and Finnish currencies.

⁷ 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).

Results

As can be seen in *Table 1* the equations have a good fit and all behavioural coefficients are significant at the 5 percent level with the expected (positive) sign. A significant coefficient for the lagged wage, b_w , indicates the existence of a wage setting curve. When wages are too high relative to the scope, they will adjust. The coefficient for unemployment, b_u , is fairly similar across countries. The coefficient for the replacement ratio, b_{χ} , is similar for Denmark, Finland and Sweden, but higher for Norway.

High values of g_e indicate considerable nominal wage rigidity; wages react very slowly to changes in nominal exchange rates. For Denmark and Sweden, g_e is significantly higher than unity, which is not consistent with our theory. As discussed above, the estimate of g_e may be biased upwards because bad times lead to reduced nominal wage growth and also make devaluation likely. This seems to be the situation in the early 1980s when both countries devalued their currencies and nominal wages decelerated (see Figure 3). Similarly, the Swedish crisis in 1993-1994 was associated with a depreciating currency and low nominal wage increases. In any case, our results strongly contradict the view that the improved competitiveness after devaluation is quickly eliminated by high nominal wage increases.

Estimates of g_p well below unity show that foreign price inflation is to a much greater extent incorporated into wage increases – possibly because inflation is more predictable than exchange rate and productivity changes.

The adjustment coefficients with respect to productivity, g_z , are high in most cases, again indicating a high degree of nominal wage rigidity.⁸ The adjustment coefficient with respect to the benefit ratio g_{χ} is poorly identified and because of convergence problems we set this coefficient to zero in the country regressions.

The significant trend term for Denmark indicates deterioration of labour market performance. This may reflect either omitted variables or persistence mechanisms which have not been included in our model. For the other countries, the trend is not significant.

Since parameter estimates are reasonably similar across countries it is interesting to summarize the evidence in the form of a panel estimate. The last column in *Table 1* shows panel estimates with country-specific constants and trends. All behavioural coefficients are significant at the 5 percent level. In the panel estimation, g_{χ} is well identified and takes a reasonable value.

⁸ There may also be a problem of measurement errors: some fluctuations in measured productivity may reflect variations in factor utilization rather than true productivity shocks (Carlsson 2003).

Long run implications

effect of similar magnitude.

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 $\rho \le 1$, $\underline{\gamma} = b_u / b_w$ and $\underline{\beta} = b_{\chi} / b_w$ are lower bounds on γ and β , with equality if $\rho = 1$ (c. f. (23)).

According to the panel estimates the long run elasticity with respect to unemployment, γ is at least 0.12. A 10 % increase in unemployment, e. g. from 5 to 5.5 percentage units, will reduce the wage 1.2 percent or more. Blanchflower-Oswald (1994, p. 361) summarize wage curve estimates, based on regional data, for a large number of countries saying that the unemployment elasticity of pay is approximately 0.1. Our estimate is very close to this number.

The panel estimate of $\underline{\beta}$ is 0.38, so an increase in the replacement *ratio* from 60 to 66 percent will raise the wage at least 3.8 percent for a given level of unemployment. The elasticity of the wage with respect to the benefit *level* is $\beta/(1+\beta) = 0.28$ (c. f. equation (17)). This is a substantial effect, but far below the unit elasticity implied by the standard bargaining model (6).

The demand elasticity η can be calculated as $\eta = (1 - b_w)/b_u$ independent of the value of ρ .⁹ The panel estimate $\eta = 20$ implies that a 1 percent increase in the wage will raise unemployment by 20 percent, e. g. from 5 to 6 percentage units. This corresponds to an aggregate labour demand elasticity with respect to $w - \theta$ equal to 1.05.¹⁰

These coefficients measure the direct effects on wage setting and labour demand, but an increase in the replacement ratio will set off indirect adjustment as increasing unemployment moderates the wage increase. While the coefficients in the wage setting curve depend on ρ the equilibrium effect of an increase in the replacement ratio is independent of ρ and hence fully identified. The total effect of a 10 percent increase in the benefit ratio is a 1.1 percent wage increase $(\beta/(1+\gamma\eta)=b_{\chi}=0.11)$ and a 22 percent increase in unemployment

⁹ The demand elasticity is identified from the reduced form wage equation because $\eta \left(w_{t-2} - \theta_{t-2} \right) - u_{t-2}$ measures the demand shock, which determines the necessary wage adjustment (c. f. equation (20)). ¹⁰ $\frac{\Delta N}{N} = -\frac{\Delta (L-N)}{L-N} \frac{(L-N)/L}{N/L} = -20 \frac{5}{95} = -1.05$. 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 – an $(\eta\beta/(1+\gamma\eta)=\eta b_{\chi}=2.2)$. 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 6.1 percent. Because of the high demand elasticity, much of the incidence falls on unemployment. This is a substantial effect, similar to what Layard, Nickell & Jackman (1991) found in cross country regressions, but large relative to Nickell and Layard (1999).¹¹

Comparing our long run effects to Nymoen & Rødseth (2003) we find that the results are qualitatively similar, but some of our wage curve parameters are larger.¹² 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 partial pass through of wage costs to domestic prices, we should expect the product real wage in terms of domestic prices to respond less to shocks.¹³

Nymoen & Rødseth (2003) include productivity growth on the right hand side of their error correction model and find that higher productivity growth will reduce the wage share in the long run. They make no distinction between expected and unexpected changes, however. According to our structural model, only *unexpected* productivity growth should affect $w-\theta$, and this is reflected in our econometric specification.

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, either because 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, let the probability to get a job be

$$A = \frac{sN + SAN}{L - N + vM + SN} \,. \tag{24}$$

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

¹² 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.

¹³ When $W_i = W$ the price equation (5) is $P_i / (EP^*) = \Omega(W / (ZEP^*), 1, A)$. The derivative with respect to the first argument is positive, so when $W / (EP^*)$ increases $P_i / (EP^*)$ will increase, so W_i / P_i increases less than $W / (EP^*)$.

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 v measures the extent to which workers in programs compete for jobs. 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*:

$$a = \ln(A) = \ln\left(\frac{s}{\frac{L-N}{N} + v\frac{M}{N}}\right) \approx \ln(s) - \ln\left(\frac{L-N}{N}\right) - v\frac{M}{L-N}.$$
 (25)

Based on this reasoning we add the ratio of program participants to open unemployment (in year t-2) in our wage equation, with a coefficient $-b_{lmp}$. 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 2*, b_{lmp} is positive for two countries, negative for two countries, and the panel estimate is zero. We see no clear evidence that workers in labour market programs contribute to wage restraint.¹⁴

6. Concluding Remarks

In this paper we have investigated how domestic and international factors affect wage formation in small open economies. Using bargaining theory and assuming nominal wages to be set in medium term contracts, we derived an econometric wage equation with wage relative to scope as the dependent variable and unemployment, replacement ratio, and lagged wage relative to scope as independent variables. Such an equation has a good fit and produces similar results for all the Nordic countries. Given labour market conditions, wages adjust to the scope, which is determined by the exchange rate, foreign prices and productivity. Based on our theoretical model, we interpret this as evidence that bargaining (rent sharing) is important in wage determination.

Unemployment benefits play a significant role, though not as large as suggested by the standard bargaining model. When replacement ratios increased around 1970, unemployment

¹⁴ In the working paper version, we considered several variations of our baseline model. We allowed for unexpected changes in the labour tax, included a measure of the required return on capital, and alternative measures of the chance to get a job based on vacancy data. These variations did not change our conclusions.

first 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.

We find evidence of pervasive nominal wage rigidity. This results is contrary to the findings of Layard, Nickell & Jackman (1991, ch. 9) and Cahuc & Zylberberg (2004, ch. 8). Those authors test for nominal rigidity by including the acceleration of inflation in a real wage equation: if an increase in the inflation rate reduces the real wage, this is taken as evidence of nominal wage rigidity. Their test is based on the assumption that inflation is a random walk, so expected inflation equals the previous level of inflation. In our view, their test has serious weaknesses. First, inflation need not be a random walk but could follow some other stochastic process. Second, price inflation depends on wage inflation. Wage shocks, which are partially passed on into prices, will generate a positive correlation between real wage changes and changes in inflation, and lead to the false conclusion that there is little nominal wage rigidity.

Our approach differs in two respects. First, we decompose right hand side variables into expected and unexpected components using projection equations. Second, we tests for nominal rigidity by examining how quickly wages respond to more exogenous shocks such as foreign price and exchange rate changes. We found that nominal wages adjust very slowly to shocks to exchange rates and productivity. Such a high degree of nominal wage rigidity may appear implausible. We should note, however, that union contracts are often 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 U. S. (Blanchard (1989), Christiano, Eichenbaum & Evans (1999)).

Substantial nominal wage rigidity means that changes in nominal exchange rates have large and persistent effects on competitiveness. From other studies we know that competitiveness affect demand and production (Gottfries (2002)). 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 (2006) that, in the medium term, demand side factors are important determinants of unemployment. 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 earlier if demand management had been less expansionary.

20

REFERENCES

- Aukrust, O., F. Holte, & G. Stoltz, 1967, Instilling II fra utredningsutvalget for inntektsoppgjörene 1966, Oslo.
- Aukrust, Odd, 1977, "Inflation in the Open Economy: A Norwegian Model, in L. Krause andW. Salant (eds), *Worldwide Inflation*, Brookings Institution, Washington DC.

Bårdsen, Gunnar, Öyvind Eitrheim, Eilev S. Jansen & Ragnar Nymoen, 2005, *The Eocnometrics of Macroeconomic Modelling*, Oxford University Press.

- Bean, Charles R., 1994, European Unemployment: A Survey, *Journal of Economic Literature* 32, 573-619.
- Blanchard Olivier J., 1989, A Traditional Interpretation of Macroeconomic Fluctuations, *American Economic Review* 79, 1146-1164.
- Blanchard, Olivier & Lawrence F. Katz, 1999, Wage Dynamics: Reconciling Theory and Evidence, *American Economic Review* 89, Papers and Proceedings 69-74.
- Blanchflower, David & Andrew Oswald, 1994, *The Wage Curve*, MIT Press, Cambridge, Massachusetts.
- Cahuc, Pierre, and André Zylberberg, 2004, Labor Economics, MIT Press, Cambridge MA.
- Calmfors, Lars, 1979, Real Wages, Inflation and Unemployment in the Open Economy, in Assar Lindbeck (ed.) *Inflation and Employment in Open Economies*, North-Holland, Amsterdam.
- Calmfors, Lars, ed., 1990, Wage Formation in the Nordic Countries, Oxford University Press.
- Calmfors, Lars & Ragnar Nymoen, 1990, Real Wage Adjustment and Employment Policies in the Nordic Countries, *Economic Policy* 5, 397-448.
- Calmfors, Lars & Anders Forslund, 1991, Real Wage Determination and Labour Market Policies: the Swedish Experience, *Economic Journal* 101, 1130-1148.
- Carlsson, Mikael, 2003, Measures of Technology and the Short-run Response to Technology Shocks, *Scandinavian Journal of Economics* 105, 555-579.
- Christiano, Lawrence J., Eichenbaum, Martin, & Evans, Charles L., 1999, Monetary policy shocks: What have we learned and to what end? In M. Woodford & J. B. Taylor, editors, *Handbook of Macroeconomics*, Elsevier Science North-Holland, Amsterdam.
- Edgren, Gösta, Karl-Olof Faxén & Carl-Erik Odhner, 1970, *Lönbebildning och Samhällsekonomi* (Wage Formation and the Economy, in Swedish), Rabén & Sjögren, Stockholm.
- Edin, Per-Anders & Anders Vredin, 1993, Devaluation Risk in Target Zones Evidence from the Nordic Countries, *Economic Journal* 103, 161-175.

- Eriksson, Stefan, & Nils Gottfries, 2005, Ranking of Job Applicants, On-the-job Search and Persistent Unemployment, *Labour Economics* 12, 407-428.
- Forslund, Anders, 1997, "Lönebildningen och arbetsmarknadens funktionssätt" (Wage formation and the functioning of the labour market, in Swedish), Appendix 1 to SOU 1997:4, Ministry of Labour, Stockholm.
- Forslund, Anders, Nils Gottfries and Andreas Westermark, 2005, Real and Nominal Wage Adjustment in Open Economies, Uppsala Univ. Econ., working paper 2005:18.
- Forslund, Anders, & Ann-Sofie Kolm, 2004, Active labour market policies and real-wage determination - Swedish Evidence, in S. Polachek (ed): Accounting for Worker Well-Being - Research in Labor Economics vol 23.
- Gottfries, Nils, 2002, Market Shares, Finance Constraints, and Pricing Behaviour in the Export Industry, *Economica* 69, 583-607.
- Gottfries, N. & T. Persson, 1988, Empirical examinations of the information sets of economic agents, *Quarterly Journal of Economics* 103, 251-259.
- Gottfries, Nils, & Andreas Westermark, 1998, Nominal Wage Contracts and the Persistent Effects of Monetary Policy, *European Economic Review*, 42 (207-223.
- Hersoug, T, Knut Kjaer & Asbjorn Rodseth, 1986, Wages, Taxes and the Utility-Maximizing Trade Union – a Confrontation with Norwegian data, *Oxford Economic Papers* 38, 403-423.
- Holden, Steinar, 1990, Wage Bargaining and Efficiency Wages: Some Implications for Tests of Trade Union Models, in *Wage Bargaining: Theory and Some Norwegian Evidence*, PhD Thesis, Oslo University.
- Holden, Steinar, & Ragnar Nymoen, 2002, Measuring structural unemployment: NAWRUestimates in the Nordic countries, *Scandinavian Journal of Economics* 104, 87-104.
- Holm, P., Honkapohja, Seppo. & Erkki Koskela, 1994, A Monopoly Union model of Wage Determination with Capital and Taxes - an Application to Finnish Manufacturing, *European Economic Review* 38, 285-303.
- Holmlund, Bertil, The Rise and Fall of Swedish Unemployment, in Martin Werding (ed.), *Structural Unemployment in Western Europe*, CESifo Seminar Series, MIT Press 2006.
- Horn, Henrik & Torsten Persson, 1988, Exchange Rate Policy, Wage formation and Credibility, *European Economic Review* 32, 1621-1636.
- Johansen, Kåre, 1995, Norwegian Wage Curves, Oxford Bulletin of Economics and Statistics, 57, 229-247.

Layard, Richard, Stephen Nickell, & Richard Jackman, 1991, *Unemployment -Macroeconomic Performance and the Labour Market*, Oxford University Press, Oxford.

- Lindbeck, Assar, 1979, Imported and Structural Inflation and Aggregate Demand the Scandinavian Model, in Assar Lindbeck (ed.), *Inflation and Employment in Open Economies*, North-Holland, Amsterdam.
- Lindbeck, Assar, 1997, The Swedish Experiment, *Journal of Economic Literature 35, 1273-1319*.
- Manning, Alan, 1993, Wage Bargaining and the Phillips Curve: Identification and Specification of Aggregate Wage Equations, *Economic Journal* 103, 98-118.
- Nymoen, Ragnar, 1989, Modelling Wages in the Small Open Economy: an Error-Correction model of Norwegian Manufacturing Wages, *Oxford Bulletin of Economics and Statistics* 51, 239-258.
- Nymoen, Ragnar & Asbjørn Rødseth, 2003, Explaining Unemployment: Some Lessons from Nordic Wage Formation, *Labour Economics* 10, 1-29.
- Nickell, Stephen and Richard Layard, 1999, *Labour Market Institutions and Economic Performance*, Handbook of Labor Economics, 3, 3029-3084.
- Rødseth, Asbjørn, 1997, Why has Unemployment been so Low in Norway? On the Potential of Macroeconomic Implications, in Dölvik, J. E., A. H. Steen, eds., *Making Solidarity Work?*, Scandinavian University Press, Oslo.

Parameter	Denmark	Finland	Norway	Sweden	Panel
b_w	0.136**	0.199**	0.519**	0.295**	0.287**
	(0.0376)	(0.0331)	(0.130)	(0.0580)	(0.0509)
b_u	0.0303**	0.0319**	0.0543**	0.0418**	0.0353**
-	(0.00370)	(0.0147)	(0.0231)	(0.0148)	(0.00956)
b _x	0.161**	0.150**	0.425**	0.217**	0.109**
~	(0.0350)	(0.0257)	(0.0884)	(0.0227)	(0.0342)
ge.	1.385**	1.071**	0.935**	1.304**	1.200**
01	(0.0402)	(0.0716)	(0.215)	(0.0758)	(0.0451)
g _n	0.152**	0.220**	0.630**	0.580**	0.322**
0 _F	(0.0592)	(0.0560)	(0.176)	(0.0848)	(0.0555)
g ₇	1.121**	1.168**	0.454**	0.894**	0.921**
	(0.0587)	(0.103)	(0.0772)	(0.0965)	(0.0688)
g y	0	0	0	0	0.493
- ~					(0.328)
Trend De	0.00328**				0.00497**
	(0.000602)				(0.00153)
Trend Fi		-0.000396			0.000148
		(0.00112)			(0.00199)
Trend No			0.00294		0.00287
			(0.00193)		(0.00220)
Trend Sw				0.000656	-0.00080
				(0.00135)	(0.00249)
s. e.	0.013	0.018	0.041	0.023	0.016, 0.016,
					0.055, 0.031
\mathbf{R}^2	0.98	0.98	0.73	0.97	0.98, 0.99,
					0.57, 0.95
DW	1.79	1.41	1.20	1.60	1.40, 1.08,
					1.13, 1.23
Autocorrelation1	0.100	0.315	0.347**	0.188	
Lag	(0.186)	(0.196)	(0.174)	(0.177)	
Autocorrelation2	-0.380**	-0.064	-0.0931	-0.0525	
Lag	(0.188)	(0.215)	(0.194)	(0.183)	
Autocorrelation3	-0.126	-0.0214	-0.0172	0.0335	
Lag	(0.212)	(0.215)	(0.195)	(0.183)	
Period	1968-1997	1963-1994	1965-1997	1966-1997	1968-1994
$\gamma = b_{\mu} / b_{w}$	0.223**	0.161*	0.104**	0.142**	0.123**
<u> </u>	(0.0569)	(0.0827)	(0.0370)	(0.0314)	(0.0316)
$\beta = b_{x} / b_{w}$	1.183**	0.756**	0.819**	0.737**	0.381**
· ^ w	(0.447)	(0.222)	(0.166)	(0.187)	(0.153)
1-h	28.5**	25.1**	8.86*	16.87**	20.21**
$\eta = \frac{1 \sigma_w}{1}$	(4.12)	(11.4)	(5.49)	(7.14)	(6.20)
b_{μ}					

Table 1. Baseline wage equation.

Notes: Equation (23) is jointly estimated with projection equations. Estimator is GMM allowing for first order moving average errors. Because of convergence problems, g_{χ} is set to zero in the country regressions. Numbers in parenthesis are standard errors. ** and * denote significance on the 5 and 10 percent level.

¹⁷ To show this, consider first the case when $W^f = \delta((1-\phi)W^w + \phi W^e) > W^e$. Since $\delta < 1$, this immediately implies that $W^w > W^f$ and hence $W^w > W^f > W^e$. If, instead $W^f = W^e > \delta((1-\phi)W^w + \phi W^e)$ equation (8) implies that that $W^w > W^e$ since profits fall when the wage increases.

Parameter	Denmark	Finland	Norway	Sweden	Panel
b _w	0.250**	0.262**	0.157	0.360**	0.301**
	(0.0780)	(0.0377)	(0.144)	(0.0666)	(0.0491)
b _u	0.0295**	0.0512**	0.0222	0.0639**	0.0352**
	(0.00949)	(0.0173)	(0.0194)	(0.0191)	(0.00917)
b _{\chi}	0.111	0.101**	0.336**	0.263**	0.115**
	(0.0782)	(0.0256)	(0.0858)	(0.0281)	(0.0340)
b _{lmp}	0.161*	0.134**	-0.293**	-0.0184**	-0.00662
-	(0.0906)	(0.0591)	(0.0558)	(0.00288)	(0.00680)
ge	1.307**	1.046**	1.343**	1.241**	1.185**
	(0.0584)	(0.0678)	(0.184)	(0.0728)	(0.0444)
$\mathbf{g}_{\mathbf{p}}$	0.175**	0.203**	0.985**	0.490**	0.326**
_	(0.0593)	(0.0520)	(0.147)	(0.0897)	(0.0561)
gz	1.046**	1.291**	0.452**	0.793**	0.933**
	(0.119)	(0.113)	(0.0729)	(0.108)	(0.0682)
g _x	0	0	0	0	0.534*
					(0.306)
Trend De	0.00586**				0.00514**
	(0.00187)				(0.00152)
Trend Fi		-0.00306			-0.00033
		(0.00201)			(0.00199)
Trend No			-0.00089		0.00298
			(0.00234)		(0.00217)
Trend Sw				0.00149	-0.00194
				(0.00121)	(0.00264)
s. e.	0.012	0.018	0.032	0.022	0.016, 0.016,
					0.054, 0.031
\mathbf{R}^2	0.98	0.98	0.84	0.97	0.97, 0.99,
					0.58, 0.95
DW	1.70	1.30	1.65	1.39	1.34, 1.15,
					1.11, 1.18
Period	1969-1997	1963-1994	1965-1997	1966-1997	1969-1994

 Table 2. Wage equation with labour market programs.

Notes: See note to Table 1. \mathbf{b}_{imp} is the coefficient for M/(L-N) where M is the number of workers in labour market programs.



Figure 1. Wage relative to scope and unemployment



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



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

Denmark





Finland

Appendix 1. Additional Derivations

Proof of Proposition 1

Note first that equations (8) and (9) imply $W^w > W^f \ge W^e$.¹⁷ Assume now that $W^f > W^e$.¹⁸ To find the effect of Θ on the wage we differentiate (10):

$$\frac{dW_i}{d\Theta} = -\frac{\Pi_{\Theta} (W^w, \Theta) - \delta(1 - \phi) \Pi_{\Theta} (W^f, \Theta) - \delta \phi \Pi_{\Theta} (W^e, \Theta)}{\Pi_w (W^w, \Theta) - (1 - \phi)^2 \delta^2 \Pi_w (W^f, \Theta)}.$$
 (A1)

To simplify notation we have set W = 1 and left out *A*. Provided δ is close to one $\Pi_w (W^w, \Theta) \approx \Pi_w (W^f, \Theta)$ and hence the denominator is negative. Thus the sign of the numerator determines the sign. Dividing the numerator by Π and using (10) we find that $dW_i / d\Theta$ is positive if and only if

$$\frac{\Pi_{\Theta}(W^{w},\Theta)}{\Pi(W^{w},\Theta)} \Theta \geq \frac{(1-\phi)\frac{\Pi_{\Theta}(W^{f},\Theta)\Theta}{\Pi(W^{f},\Theta)} + \phi\frac{\Pi(W^{e},\Theta)}{\Pi(W^{f},\Theta)}\frac{\Pi_{\Theta}(W^{e},\Theta)\Theta}{\Pi(W^{e},\Theta)}}{(1-\phi) + \phi\frac{\Pi(W^{e},\Theta)}{\Pi(W^{f},\Theta)}}.$$
(A2)

Since W^w is larger than W^f and W^e , this holds if $\Pi_{\Theta}(W,\Theta)\Theta/\Pi(W,\Theta)$ 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:

$$\frac{\Pi_{\Theta}(W_{i},\Theta)}{\Pi(W_{i},\Theta)}\Theta = \frac{(1-\alpha)MC}{P_{i}/P-MC} = -(1-\alpha)\frac{P_{i}/P+D/D'}{D/D'} = (1-\alpha)\left[\left|\frac{D'(P_{i}/P)P_{i}}{D(P_{i}/P)P}\right| - 1\right],$$
(A3)

where $MC = \kappa (W + sSA)^{1-\alpha} \Theta^{\alpha-1}$. Since the optimal relative price is an increasing function of the wage, the result follows. *End of proof.*

Labour turnover and the chance to get a job

Assume that in a short period of length Δ an unemployed worker can search or not search and a period-specific cost associated with search, ζ , is drawn from a distribution $H(\zeta)$. Let x be an index for whether the worker is searching. The value of unemployment is given by

$$V^{u} = \max_{x \in \{1,0\}} \left[\Delta B + \frac{1}{1 + \Delta r} \left[x \Delta A V^{j} + (1 - x \Delta A) V^{u} \right] - x \Delta \zeta \right].$$
(A4)

To simplify notation, we set P=1. V^{j} is the value of a job which is given by

$$V^{j} = \Delta W + \frac{1}{1 + \Delta r} \Big[(1 - \Delta s) V^{j} + \Delta s V^{u} \Big].$$
(A5)

An unemployed worker will search if $\zeta \leq A(V^j - V^u)/(1 + \Delta r)$. From (A5) we get

$$(1+\Delta r)\left(V^{j}-V^{u}\right) = (1+\Delta r)\Delta W + (1-\Delta s)\left(V^{j}-V^{u}\right) - \Delta rV^{u}.$$
 (A6)

From (A4) we have for a searcher

$$\Delta r V^{u} = (1 + \Delta r) \Delta B + \Delta A (V^{j} - V^{u}) - (1 + \Delta r) \Delta \zeta , \qquad (A7)$$

and substituting into (A6) we get

$$V^{j} - V^{U} = \frac{1 + \Delta r}{r + s + A} \left(W - B - \varsigma \right).$$
(A8)

Hence the fraction of unemployed workers searching at a particular point in time is H(A(W-B)/(r+s)). 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:

$$A = \frac{sN + S(1)AN}{(L-N)H(A(W-B)/(r+s)) + S(1)N}$$
(A9)

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

$$AH\left(\frac{A(W-B)}{r+s}\right) = s\frac{1-U}{U}$$
(A10)

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

¹⁸ For the case when $W^f = W^e$ the argument is analogous.

Appendix 2. Data

Most series come from Nymoen and Rodseth (2003).

 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 $p_t^* = \sum_i v_i \left(\sum_j w_{ij} p_{jt} \right); p_{jt}$ 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*. Export and import values from IMF, Direction of Trade Statistics 1980. Prices from OECD, MEI,

 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.

 u_i : 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.

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

Appendix 3. Auxiliary Regressions

Parameter	Denmark	Finland	Norway	Sweden
Exchange rate e_{t-2} :				
Constant	0.0107	0.0513**	0.0160*	0.0285**
	(0.00680)	(0.0136)	(0.00798)	(0.0112)
0	0.915**	0.856**	0.843**	0.925**
e_{t-2}	(0.0475)	(0.0737)	(0.0788)	(0.0429)
0	-0.0438**	0.135**	0.0919	0.00642
e_{t-3}	(0.0211)	(0.0689)	(0.0983)	(0.0449)
s.e.	0.0504	0.0843	0.0448	0.0752
\mathbb{R}^2	0.58	0.80	0.80	0.88
Foreign price p_t^* :				
Constant	0.0604**	0.0367**	0.0333**	0.0178*
	(0.00890)	(0.00965)	(0.00798)	(0.00940)
n*	1.581**	2.081**	2.068**	2.172**
P_{t-2}	(0.155)	(0.139)	(0.164)	(0.119)
* n	-0.652**	-1.111**	-1.101**	-1.216**
P_{t-3}	(0.149)	(0.141)	(0.164)	(0.116)
s.e.	0.0508	0.0553	0.0549	0.0555
\mathbf{R}^2	0.99	0.99	0.99	0.99
Productivity z_{t-2} :				
Constant	0.0567**	0.119**	0.0623**	0.0781**
	(0.00649)	(0.00564)	(0.00772)	(0.00650)
7	0.529**	0.791**	0.452**	0.639**
\sim_{t-2}	(0.0609)	(0.0973)	(0.102)	(0.149)
7	0.311**	0.243**	0.422**	0.257**
~ <i>t</i> −3	(0.0584)	(0.0941)	(0.0962)	(0.129)
s.e.	0.0391	0.0385	0.0312	0.0490
\mathbf{R}^2	0.97	0.99	0.99	0.98

Table A1. Forecast equations (24)	estimated with b	aseline wage equation
-----------------------------------	------------------	-----------------------

Notes: Numbers in parentheses are standard errors.

Table A2. Exchange rate "reaction function". Dependent variable Δe_t .

Variable	Denmark	Finland	Norway	Sweden
u_{t-1}	0.0268	0.0411*	0.0102	0.0435*
	(0.0179)	(0.0225)	(0.0120)	(0.0245)
$W_{t-1} - \theta_{t-1}$	0.0371	0.155	0.127	0.108
1-1 1-1	(0.0665)	(0.109)	(0.0979)	(0.124)
<i>y</i> _{t-1}	-0.0789	-0.591**	-0.0987	-0.560*
	(0.252)	(0.234)	(0.211)	(0.302)
<i>y</i> _{t-2}	-0.0629	0.504**	0.0283	0.511*
	(0.251)	(0.236)	(0.234)	(0.274)
s. e.	0.034	0.046	0.026	0.043
\mathbf{R}^2	0.12	0.42	0.14	0.36
DW	1.64	2.03	1.46	2.44

Note: y_t is real value added in manufacturing.