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Prices, Productivity, and Wage Bargaining in Open Economies*

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According to the standard union bargaining model, unemployment benefits should have big effects on wages, but product market prices and productivity should play no role in the wage bargain. We formulate an alternative strategic bargaining model, where labour and product market conditions together determine wages. A wage equation is derived and estimated on aggregate data for the Nordic countries. Wages are found to depend on unemployment and the replacement ratio, but also on productivity, international prices and exchange rates. There is evidence of considerable nominal wage rigidity. Exchange rate changes have large and persistent effects on competitiveness.

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I. Introduction

The theory of collective bargaining was developed in order to understand how wages are determined when unions play an important role. 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 wage is predicted to be 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 have no direct effects on the wage. For a given level of unemployment, an increase in productivity will affect the wage if and only if it leads to an increase in unemployment benefits or the value of leisure or home production; see Manning (1993) and Bean (1994) for discussions.

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. 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 labour 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 described above. First, we assume that firms face product demand curves, which are not constant-elastic, but the 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 productivity and product market prices. Second, we assume, as do Gottfries and Westermarck (1998) and Eriksson and Gottfries (2005), 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, 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, and

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 wage curves in European countries while a vertical Phillips curve fits better to US data.

Our 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 Rødseth (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 medium run.

The equation has a good fit and parameter 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; hence exchange rate adjustments and productivity shocks have large and persistent effects on competitiveness.

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 are determined by the “scope” or “main course” for wage increases, i.e. the sum of productivity growth and price increases for tradable goods (Aukrust, Holte and Stoltz (1967), Edgren, Faxén and Odhner (1969, 1970), Aukrust (1977), Lindbeck (1979)).¹ 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* (Hersoug, Kjaer and Rødseth (1986), Calmfors (1990), Holm, Honkapohja, and Koskela (1994)). Subsequent research on aggregate wage determination has been heavily influenced by the *error-*

correction approach, where a long run equilibrium relation between the wage share and unemployment is embedded in a statistical model of the dynamics (Nymoen (1989), Rødseth and Holden (1990), Calmfors and Nymoen (1990), Johansen (1995), Holden and Nymoen (2001), Nymoen and Rødseth (2003), Forslund and Kolm (2004), Bårdsen et. al (2005)). Such a specification implies a direct role for productivity and prices in the wage equation. 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. A difference, though, is that we offer an economic interpretation of the dynamics.

In Section II we derive a static wage equation relating the wage to productivity, product market prices, unemployment, and unemployment benefits. In Section III we make the equation dynamic by adding nominal wage rigidity. In Sections IV and V we present data and empirical results. We end by summarising our results and comparing with other studies.

II. The Wage Equation in an Open Economy

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

$$\Pi_i = P_i Y_i - (W_i + cWS(W_i/W)A)N_i - RK_i, \quad (1)$$

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

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

¹ Calmfors (1979) combined the Scandinavian model of inflation with the *Phillips Curve*.

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

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

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

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

implies a price equation of the form

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

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 $(W_i - \bar{W})^\beta \Pi^{1-\beta}$. 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:

$\bar{W} = (1 - \rho(u))W + \rho(u)B$, 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

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

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.²

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

$$1 + cS'(W^e/W)A = 0. \quad (7)$$

Bargaining occurs in an individual firm, or a group of identical firms, and the firm/group is small, so it takes aggregate labour market conditions as given. To model bargaining, we use a modification of the Rubinstein-Ståhl non-cooperative bargaining model (see Binmore, Rubinstein and Wolinsky (1986), Sutton (1986)). For the worker to quit or for the firm to lay off workers are not credible threats. If there is a conflict, there is delay, no production and no wages are paid, and the two parties make alternating bids. As in Gottfries and Westermarck (1998), we assume that when a bid has been rejected, it may turn out that the workers are unable to continue the strike, and then the firm can set the wage that it prefers, W^e . Let δ be the discount factor relevant to the period 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:

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

² 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, see e. g. Manning (1993), Bean (1994), Nymoen and Rodseth (2003).

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:

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

Workers (insiders) have job security and the utility of the worker is simply the real wage, P^c being the consumer price. In equilibrium the first bid is accepted.³ 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 :

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

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 :

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

The derivative with respect to Θ_i depends on the form of the demand function:

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 I.

To get some intuition, 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 a wage increase to product prices, so the wage increases.

³ 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.

If demand is constant-elastic the wage is independent of the market price and productivity. 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)). Note also that under the conditions stated in *Proposition 1*, the wage depends on the relevant product market prices, but not on the consumer price level.

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):

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

where lower case letters denote logs, $\lambda \geq 0$, $\phi > 0$, 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 (Holden (1990, ch. 6), Gottfries and Westermarck (1998)).

In the present model, 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 :

$$a = \hat{\beta}\chi - \hat{\gamma}u. \quad (13)$$

Wage curves in closed and open economies

We now consider the implications of our theory for wage curves. Consider first the case when workers have *no bargaining power* so that $\lambda = 0$ (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 and the natural rate of unemployment is given by:

$$u = (\hat{\beta} / \hat{\gamma}) \chi . \quad (14)$$

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 $p_i = p$:

$$p = w - z + ha , \quad (15)$$

where $h > 0$ because high turnover increases 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 a *small 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.⁴ In a symmetric equilibrium where $w_i = w$, (12) and (13) imply

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

where $\beta = \phi \hat{\beta} / \lambda$ and $\gamma = \phi \hat{\gamma} / \lambda$. This is our main equation and the basis for our empirical specification. When wages are bargained over in a fixed exchange rate regime, the wage level is “anchored” to the scope $e + p^* + z$. The role of monetary policy is to peg the nominal exchange rate. This, of course, 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 prices of domestically produced goods to deviate from prices of foreign goods, and for labour market conditions to affect wages. In periods of high unemployment, wages are low relative to the scope.

Blanchard and Katz (1999) noted a difference in wage setting between the US and European countries. While an expectations augmented *Phillips curve* (a vertical long run

⁴ In a working paper version of this paper we included non tradable goods; this does not change the qualitative results; see Forslund-Gottfries-Westermarck (2005).

wage-setting curve) fits the US data quite well, there is evidence of a sloping *wage curve* (a relation between the level of the real wage and unemployment) in European countries.⁵ Similarly, Bårdsen, Eitrheim, Jansen and Nymoen (2005, ch. 4.6) found that a Phillips curve fits Norwegian wage data poorly. Our analysis provides a straightforward explanation of this difference. The wage 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 conditions appear more close to the truth in the US than in European countries.

Letting $\chi = b - w$ be the log of the replacement ratio, we may also write

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

The wage depends on a weighted average of $e + p^* + z$ and b , and the elasticity with respect to b 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.⁶ In order to derive an empirical wage equation in the next section, we specify a log linear demand relation

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

where δ represents unobserved factors which affect labour demand and labour supply.

III. 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 typically specify wage increases to take place during the contract period.⁷ To derive a simple dynamic wage equation, we think of wages for period t as being *predetermined*, set two years before,

⁵ See also Cahuc and Zylberberg (2004) chapter 8.

⁶ In the working paper version we show this more explicitly - see Forslund-Gottfries-Westermarck (2005).

⁷ According to Rødseth and Holden (1990), multi-year contracts in Norway only specify the wage increase in the first year. There is bargaining also in later years, but since strikes and lockouts are not allowed during the contract, the initial wage increase should be an important determinant of wages throughout the contract period. This view is consistent with the first-year effects found by Rødseth and Holden (1990). In this paper, we assume wages to be set in advance, but we do not model linkages between wages in different years.

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 wage equation (16), but with expected values replacing actual values which are not yet known

$$w_t = E_{t-2}(\theta_t) + \beta E_{t-2}(\chi_t) - \gamma E_{t-2}(u_t) + \mu_t, \quad (19)$$

where $\theta_t = e_t + p_t^* + z_t$. We have added a shock μ_t which represents unobserved factors. 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 $\rho \leq 1$. Assuming that wage setters observe variables at $t-2$ we can derive the expected value of u_t as

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

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

$$w_t = E_{t-2}(\theta_t) + \frac{\gamma\rho^2}{1+\gamma\eta}[\eta(w_{t-2} - \theta_{t-2}) - u_{t-2}] + \frac{\beta}{1+\gamma\eta}E_{t-2}(\chi_t) + \frac{\mu_t}{1+\gamma\eta}. \quad (21)$$

Lagged wages and labour market conditions enter the wage equation because demand shocks are persistent and $\eta(w_{t-2} - \theta_{t-2}) - u_{t-2}$ measures the position of the labour demand curve at the time when the wages are set (c.f. equation (18)).

A measure of nominal wage rigidity

We also need to construct measures of expected exchange rates, prices, productivity and replacement ratios, but we do not know what information wage setters have when they set wages. We use an approach suggested by Gottfries and Persson (1988) that allows us to decompose the right hand side variables into predictable and unpredictable parts 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 cases. 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 extreme case is that they have enough information to perfectly predict the outcome, so $E_{t-2}(p_t^*) = p_t^*$. Gottfries and 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:

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

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 can predict p_t^* , g_p will be zero; if they know no more than p_{t-2}^*, p_{t-3}^* , g_p will be equal to one. Making the same decomposition for 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

$$w_t - \theta_t - (w_{t-2} - \theta_{t-2}) = -b_w (w_{t-2} - \theta_{t-2}) - b_u u_{t-2} + b_\chi (\chi_t - g_\chi \chi_t^u) - g_e e_t^u - g_p p_t^{*u} - g_z z_t^u + \varepsilon_t \quad (23)$$

where $b_w = 1 - \gamma \rho^2 \eta / (1 + \gamma \eta)$, $b_u = \gamma \rho^2 / (1 + \gamma \eta)$, and $b_\chi = \beta / (1 + \gamma \eta)$. Because of nominal wage rigidity, unexpected variations in the nominal exchange rate, foreign prices, and productivity cause short run deviations from the wage curve. 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 (μ_t) and the noise in our expectations measures (η_t^p etc.).

IV. Data

Most of the data comes from Nymoen and 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 wages relative to the 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 and deterioration of competitiveness which occurred, in all four countries, in the mid 1970's. Since then, benefits have developed quite differently. High benefits could potentially explain the secular increase in unemployment in Denmark, Norway and Sweden, but not in Finland.

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 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 stable wage setting curve (see Forslund, Gottfries and Westermarck (2005)).

V. 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. To construct measures of $p_t^{*u}, e_t^u, z_t^u, \chi_t^u$ we estimated forecasting (projection) equations for each variable including a constant and the variable itself lagged 2 and 3 years. For example, we estimate $p_t^* = h_0 + h_1 p_{t-2}^* + h_2 p_{t-3}^*$, and form the projection error as $p_t^{*u} = p_t^* - P(p_t^* | p_{t-2}^*, p_{t-3}^*) = p_t^* - h_0 - h_1 p_{t-2}^* - h_2 p_{t-3}^*$. If we first estimate the projection equations and then use the calculated projection errors in the wage equation we have a problem with generated regressors. For this reason we substitute for p_t^{*u} in (23) and estimate the wage equation and projection equations jointly.⁸

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 of monetary policy, we may end up in an equilibrium with continuous high wage increases and devaluations (Horn and 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 have small real effects on competitiveness ($g_e = 0$). In fact, this is the opposite of what we find.

Edin and Vredin (1993) found that devaluations in the Nordic countries have been more likely when the economy was in a recession, presumably because the political costs of maintaining a fixed exchange rate rise in a recession. This means that exchange rate changes may be correlated with unemployment, but a correlation between two right hand side variables does not lead to bias. A serious problem arises, however, if there is some omitted

⁸ The econometric issues are thoroughly discussed by Gottfries-Persson (1988) and Gottfries (2002).

state variable, which affects both the wage and the exchange rate. Such an omitted 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, 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 .⁹ The estimated reaction functions, reported in *Appendix 3*, show that high unemployment and low growth predict depreciation of the Swedish and Finnish currencies.

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 adjust downwards. 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 higher than unity, which is not consistent with our theory. As discussed above, the estimate may be biased upwards if 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 as well as wage moderation. In any case, our results strongly contradict the view that wages are flexible and improved competitiveness after devaluation is quickly eliminated by high nominal wage increases.

Estimates of g_p below unity show that foreign price inflation is incorporated into wage increases more quickly than exchange rate changes, possibly because foreign inflation is more predictable than exchange rates and productivity. The adjustment coefficients with respect to productivity, g_z , are high in most cases, again indicating a high degree of nominal wage rigidity.¹⁰ The adjustment coefficient with respect to the benefit ratio g_x 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 the 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_x is well identified. All g -coefficients are economically and statistically significant, which supports our assumption that nominal wages are set in advance and hence adjust sluggishly to shocks.

Implications for the Wage Curve and Comparative Statics

In general, the coefficients of the wage curve cannot be inferred from our dynamic regression. But provided that $\rho \leq 1$, $\underline{\gamma} = b_u / b_w$ and $\underline{\beta} = b_x / b_w$ are lower bounds on γ and β , with equality if $\rho = 1$ (c. f. (23)). If $\rho = 1$ there is no stable demand curve and u and $w - \theta$ are non-stationary, but possibly cointegrated. This interpretation is consistent with the stationarity tests mentioned above, but may be considered implausible from an economic point of view.

According to the panel estimates $\underline{\gamma} = 0.12$; a 10 % increase in unemployment (e. g. from 5 to 5.5 percentage units) will reduce the wage at least 1.2 percent. The panel estimate of

⁹ 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).

¹⁰ There may also be a problem of measurement error because some fluctuations in measured productivity reflect variations in factor utilization rather than true productivity shocks (Carlsson 2003).

β is 0.38, so a 10 percent increase in the replacement *ratio* (e.g. 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.

Blanchflower and 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. Comparing our estimated wage curve parameters to Nymoen and Rødseth (2003) we find that the estimate of γ is similar, but our estimate of β is twice as large.¹¹ Nunziata (2005) estimates a wage cost model with fixed effects on the OECD panel and finds smaller wage curve parameters. Evaluated at 5 percent unemployment and 60 percent replacement ratio, his estimates correspond to $\gamma = 0.04$ and $\beta = 0.11$.¹² Note, however, that the dependent variable in Nymoen and Rødseth (2003) and Nunziata (2005) is the product real wage in terms of the *domestic* price while our equation determines the real wage in terms of the foreign price. Because of partial pass through of wage costs to domestic prices, particularly to nontradeables, we should expect the product real wage in terms of domestic prices to respond less to shocks.¹³ Another reason why we should expect larger coefficients compared to Nunziata (2005) is that all countries in our sample are small open economies where our theory predicts a stronger relation between unemployment and the real wage.

Nymoen and 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.

¹¹ Nymoen & Rødseth (2003) find an average elasticity of the wage with respect to unemployment of 0.13 and the average elasticity of the wage with respect to the benefit ratio is 0.18 (calculated from Table 3 using the “Finland-A” specification).

¹² These numbers are calculated using the preferred equation (14) in Nunziata (2005) *Table 5*:

$$\frac{d \ln W}{d \ln U} = \frac{d \ln W}{d U} U = \frac{-0.220}{1-0.688} 0.05 = -0.04 \quad \text{and} \quad \frac{d \ln W}{d \ln (B/W)} = \frac{d \ln W}{d (B/W)} \frac{B}{W} = \frac{0.058}{1-0.688} 0.60 = 0.11.$$

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 $W / (EP^*)$.

Provided that our dynamic equation is correctly specified, we can calculate the demand elasticity as $\eta = (1 - b_w)/b_u$ independent of the value of ρ .¹⁴ 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 1.05.¹⁵

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 a permanent 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 ($\eta\beta/(1 + \gamma\eta) = \eta b_\chi = 2.2$). 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 effect is similar to what Layard, Nickell and Jackman (1991) and others have found in cross country regressions and somewhat larger than the estimate by Nickell, Nunziata and Ochel (2005).¹⁶

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 allow for this, let the probability to get a job be

¹⁴ The demand elasticity is identified from the reduced form wage equation because $\eta(w_{t-2} - \theta_{t-2}) - u_{t-2}$ measures the demand shock, which determines the necessary wage adjustment (c. f. equation (20)).

¹⁵ $\frac{\Delta N}{N} = -\frac{\Delta(L - N)}{L - N} \frac{(L - N)/L}{N/L} = -20 \frac{5}{95} = -1.05$.

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. This effect is of similar magnitude.

¹⁶ Translating the results of Nickell, Nunziata & Ochel (2005), Table 5, we get

$$\frac{d \ln U}{d \ln(B/W)} = \frac{dU}{d(B/W)} \frac{B/W}{U} = \frac{2.21}{1 - 0.86} \frac{0.6}{5} = 1.9.$$

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

$$A = \frac{sN + SAN}{L - N + \nu M + SN} . \quad (24)$$

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. 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 $M=0$:

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

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.¹⁷

VI. Concluding Remarks

In this paper we have investigated how domestic and international factors together determine wages in small open economies with strong unions. 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 an important aspect of wage determination in these countries.

Unemployment benefits are not as important as suggested by the standard Nash bargaining model, but they still play an important role. When replacement ratios increased around 1970, unemployment first remained low, but the increase in benefits helps to explain

subsequent high nominal wage increases and loss of competitiveness, which eventually lead to rising unemployment.

We find evidence of pervasive nominal wage rigidity. This result is contrary to the findings of Layard, Nickell and Jackman (1991, ch. 9) and Cahuc and 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, this test has serious weaknesses. First, inflation need not be a random walk but could follow some other stochastic process. Second, price inflation is clearly not exogenous. Unobserved wage shocks (μ_t) 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 test for nominal rigidity by examining how quickly wages respond to more exogenous shocks such as foreign price and exchange rate changes. We find that nominal wages adjust very slowly to such shocks. This high degree of nominal wage rigidity may appear implausible. But union contracts are often two or three years long, and high nominal wage rigidity is consistent with evidence from structural VAR models, which also show very slow response of wages and prices to monetary shocks, even in the U.S. (Blanchard (1989), Christiano, Eichenbaum and Evans (1999)).

High nominal wage rigidity means that changes in nominal exchange rates have large and persistent effects on competitiveness. From other studies we know that competitiveness affects demand and production (Gottfries (2002)). More generally, high 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.

¹⁷ 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.

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Table 1. Baseline wage equation.

Parameter	Denmark	Finland	Norway	Sweden	Panel
b_w	0.136** (0.0376)	0.199** (0.0331)	0.519** (0.130)	0.295** (0.0580)	0.287** (0.0509)
b_u	0.0303** (0.00370)	0.0319** (0.0147)	0.0543** (0.0231)	0.0418** (0.0148)	0.0353** (0.00956)
b_χ	0.161** (0.0350)	0.150** (0.0257)	0.425** (0.0884)	0.217** (0.0227)	0.109** (0.0342)
g_e	1.385** (0.0402)	1.071** (0.0716)	0.935** (0.215)	1.304** (0.0758)	1.200** (0.0451)
g_p	0.152** (0.0592)	0.220** (0.0560)	0.630** (0.176)	0.580** (0.0848)	0.322** (0.0555)
g_z	1.121** (0.0587)	1.168** (0.103)	0.454** (0.0772)	0.894** (0.0965)	0.921** (0.0688)
g_χ	0	0	0	0	0.493 (0.328)
Trend De	0.00328** (0.000602)				0.00497** (0.00153)
Trend Fi		-0.000396 (0.00112)			0.000148 (0.00199)
Trend No			0.00294 (0.00193)		0.00287 (0.00220)
Trend Sw				0.000656 (0.00135)	-0.00080 (0.00249)
s. e.	0.013	0.018	0.041	0.023	0.016, 0.016, 0.055, 0.031
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
Autocorrelation 1 lLag	0.100 (0.186)	0.315 (0.196)	0.347** (0.174)	0.188 (0.177)	
Autocorrelation 2 Lags	-0.380** (0.188)	-0.064 (0.215)	-0.0931 (0.194)	-0.0525 (0.183)	
Autocorrelation 3 Lags	-0.126 (0.212)	-0.0214 (0.215)	-0.0172 (0.195)	0.0335 (0.183)	
Period	1968-1997	1963-1994	1965-1997	1966-1997	1968-1994
$\gamma = b_u / b_w$	0.223** (0.0569)	0.161* (0.0827)	0.104** (0.0370)	0.142** (0.0314)	0.123** (0.0316)
$\beta = b_\chi / b_w$	1.183** (0.447)	0.756** (0.222)	0.819** (0.166)	0.737** (0.187)	0.381** (0.153)
$\eta = \frac{1 - b_w}{b_u}$	28.5** (4.12)	25.1** (11.4)	8.86* (5.49)	16.87** (7.14)	20.21** (6.20)

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.

Table 2. Wage equation with labour market programs.

Parameter	Denmark	Finland	Norway	Sweden	Panel
b_w	0.250** (0.0780)	0.262** (0.0377)	0.157 (0.144)	0.360** (0.0666)	0.301** (0.0491)
b_u	0.0295** (0.00949)	0.0512** (0.0173)	0.0222 (0.0194)	0.0639** (0.0191)	0.0352** (0.00917)
b_{χ}	0.111 (0.0782)	0.101** (0.0256)	0.336** (0.0858)	0.263** (0.0281)	0.115** (0.0340)
b_{imp}	0.161* (0.0906)	0.134** (0.0591)	-0.293** (0.0558)	-0.0184** (0.00288)	-0.00662 (0.00680)
g_e	1.307** (0.0584)	1.046** (0.0678)	1.343** (0.184)	1.241** (0.0728)	1.185** (0.0444)
g_p	0.175** (0.0593)	0.203** (0.0520)	0.985** (0.147)	0.490** (0.0897)	0.326** (0.0561)
g_z	1.046** (0.119)	1.291** (0.113)	0.452** (0.0729)	0.793** (0.108)	0.933** (0.0682)
g_{χ}	0	0	0	0	0.534* (0.306)
Trend De	0.00586** (0.00187)				0.00514** (0.00152)
Trend Fi		-0.00306 (0.00201)			-0.00033 (0.00199)
Trend No			-0.00089 (0.00234)		0.00298 (0.00217)
Trend Sw				0.00149 (0.00121)	-0.00194 (0.00264)
s. e.	0.012	0.018	0.032	0.022	0.016, 0.016, 0.054, 0.031
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

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

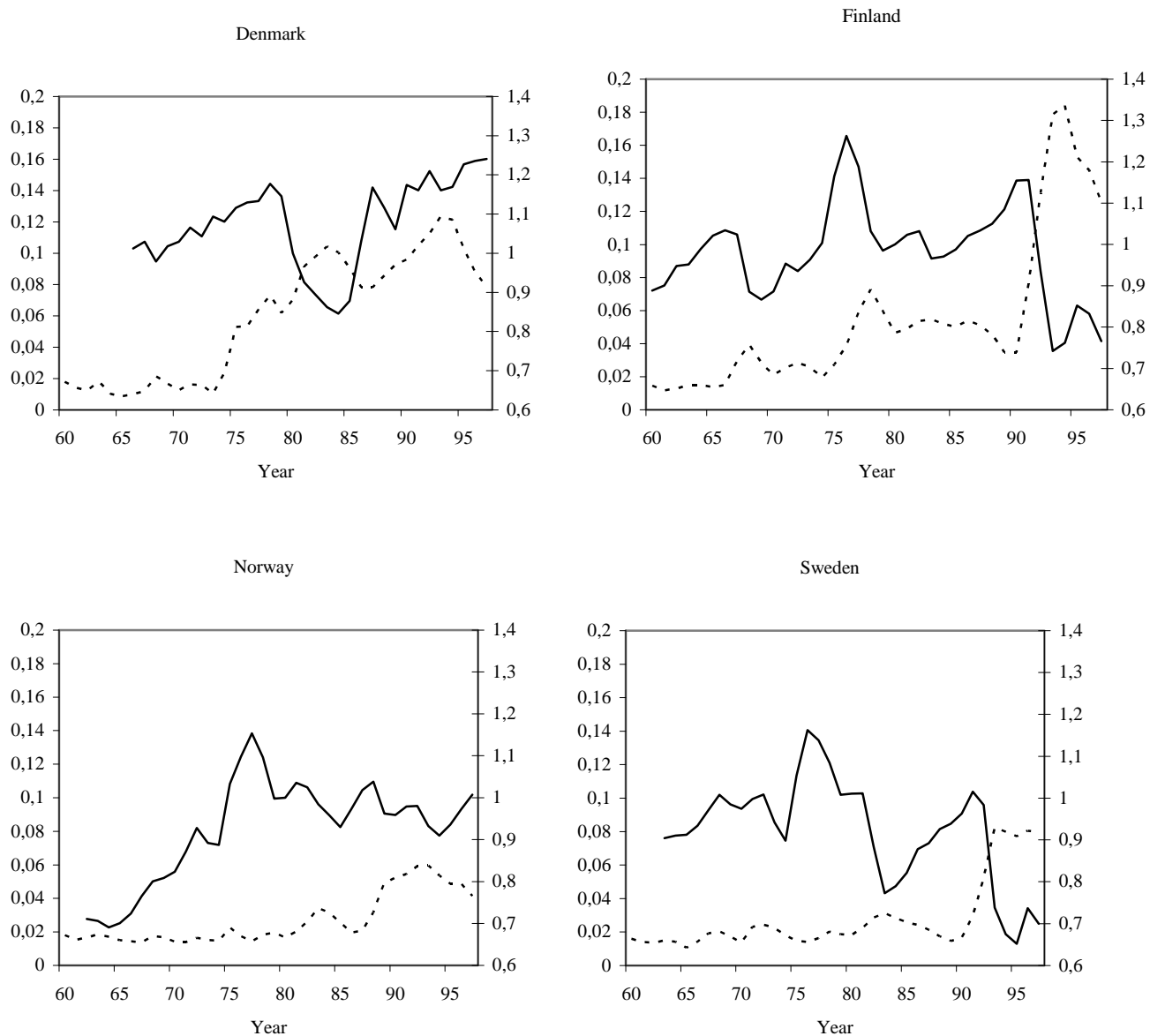


Fig. 1. Wage relative to scope and unemployment

Notes: Solid lines: wage relative to scope (right scale); dashed lines: unemployment (left scale).

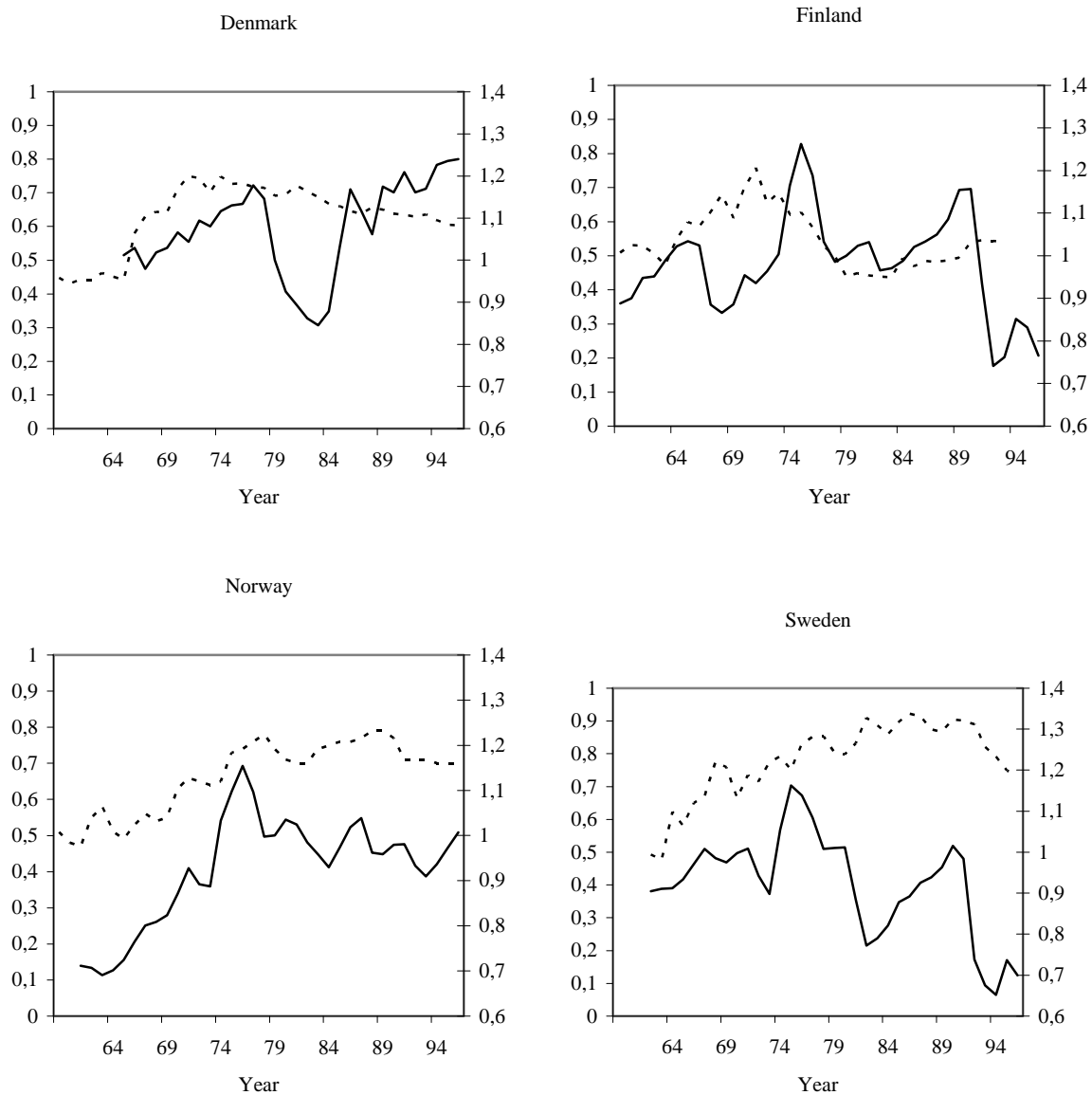


Figure 2. Solid lines: wage relative to scope (right scale); dashed lines: replacement ratio (left scale)

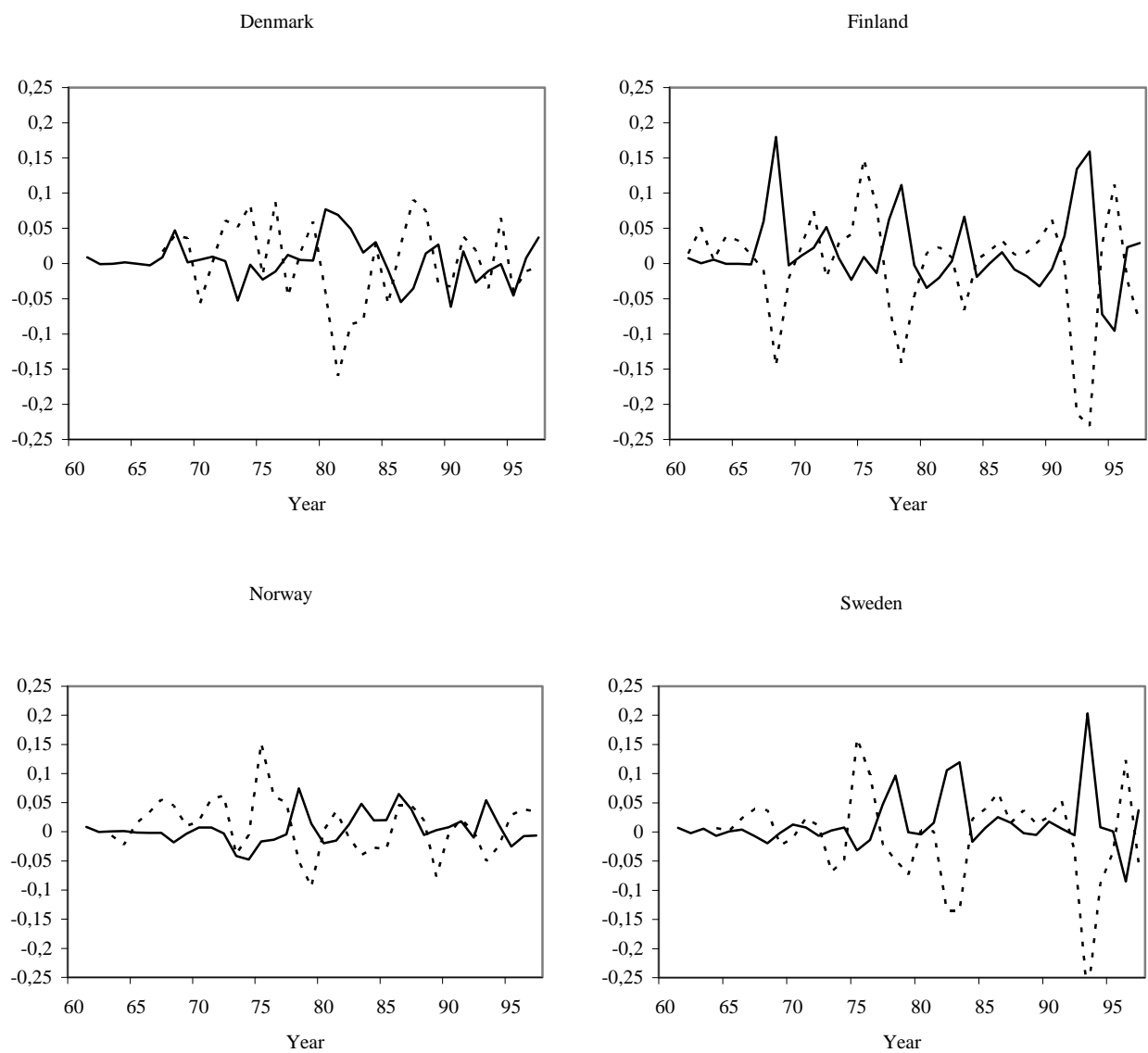


Fig. 3. Changes in exchange rate and wage/scope

Note: Solid lines: change in exchange rate (log); dashed lines: change in wage/scope (log).

Appendix 1. Additional Derivations

Proof of Proposition 1

Note first that equations (8) and (9) imply $W^w > W^f \geq W^e$.¹⁸ Assume now that $W^f > W^e$.¹⁹

To find the effect of Θ on the wage we differentiate (10):

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

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

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

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:

$$\frac{\Pi_{\Theta}(W_i, \Theta)}{\Pi(W_i, \Theta)} \Theta = \frac{(1-\alpha)MC}{P_i/P - MC} = -(1-\alpha)\frac{P_i/P + D/D'}{D/D'} = (1-\alpha)\left[\frac{D'(P_i/P)P_i}{D(P_i/P)P} - 1\right], \quad (A3)$$

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

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

¹⁸ 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 $W^w > W^e$ since profits fall when the wage increases.

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

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

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

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

From (A4) we have for a searcher

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

and substituting into (A6) we get

$$V^j - V^u = \frac{1 + \Delta r}{r + s + A} (W - B - \zeta). \quad (\text{A8})$$

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:

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

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

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

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

¹⁹ 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 Main Economic Indicators.

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_t : log of open unemployment rate. 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.

rr_t : log of replacement ratio. Source: Nymoen et al database. The Swedish series was recalculated after tax to take accounts of a change in the tax treatment of benefits.

Appendix 3. Auxiliary Regressions

Table A1. Forecast equations (24) estimated with baseline wage equation

Parameter	Denmark	Finland	Norway	Sweden
Exchange rate e_{t-2} :				
Constant	0.0107 (0.00680)	0.0513** (0.0136)	0.0160* (0.00798)	0.0285** (0.0112)
e_{t-2}	0.915** (0.0475)	0.856** (0.0737)	0.843** (0.0788)	0.925** (0.0429)
e_{t-3}	-0.0438** (0.0211)	0.135** (0.0689)	0.0919 (0.0983)	0.00642 (0.0449)
s.e.	0.0504	0.0843	0.0448	0.0752
R²	0.58	0.80	0.80	0.88
Foreign price p_t^* :				
Constant	0.0604** (0.00890)	0.0367** (0.00965)	0.0333** (0.00798)	0.0178* (0.00940)
p_{t-2}^*	1.581** (0.155)	2.081** (0.139)	2.068** (0.164)	2.172** (0.119)
p_{t-3}^*	-0.652** (0.149)	-1.111** (0.141)	-1.101** (0.164)	-1.216** (0.116)
s.e.	0.0508	0.0553	0.0549	0.0555
R²	0.99	0.99	0.99	0.99
Productivity z_{t-2} :				
Constant	0.0567** (0.00649)	0.119** (0.00564)	0.0623** (0.00772)	0.0781** (0.00650)
z_{t-2}	0.529** (0.0609)	0.791** (0.0973)	0.452** (0.102)	0.639** (0.149)
z_{t-3}	0.311** (0.0584)	0.243** (0.0941)	0.422** (0.0962)	0.257** (0.129)
s.e.	0.0391	0.0385	0.0312	0.0490
R²	0.97	0.99	0.99	0.98

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 (0.0179)	0.0411* (0.0225)	0.0102 (0.0120)	0.0435* (0.0245)
$w_{t-1} - \theta_{t-1}$	0.0371 (0.0665)	0.155 (0.109)	0.127 (0.0979)	0.108 (0.124)
y_{t-1}	-0.0789 (0.252)	-0.591** (0.234)	-0.0987 (0.211)	-0.560* (0.302)
y_{t-2}	-0.0629 (0.251)	0.504** (0.236)	0.0283 (0.234)	0.511* (0.274)
s. e.	0.034	0.046	0.026	0.043
R²	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.