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Optimal wage indexation with exchange rate uncertainty in an oligopolistic and unionized economy

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Abstract

In this paper we look at the role of wage indexation as a policy instrument in a model of an oligopolistic and unionized economy. There is uncertainty on the future exchange rate evolution when writing labour contracts. The optimal degree of indexation is chosen such that steady state employment is maximized taking also into account losses due to imperfect information. Product market characteristics are among the determinants of the optimal degree of indexation.

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1. Introduction

The importance of uncertainty for wage formation has recently received a lot of attention. An important conclusion which has been drawn is that policy actions not only can adjust the economy towards the steady state, but may also have impact on the steady state itself because they determine how uncertainty is transmitted into the way wages are formed [see Naish (1988), Sørensen (1992) and Jensen (1993)][1].

In this paper we look at the role of wage indexation as a policy instrument, introducing uncertainty on the future exchange rate evolution into a monopoly union model. The paper is closely related to the work of Andersen and Sørensen (1988) and Vilmunen (1992). Contrary to these two studies, the product market is modelled in line with industrial organization theory, making use of the conventional concept of conjectural variation.

It is shown that in this model the importance of exchange rate uncertainty for wage formation is less clear than is generally thought and depends in a complex way on the degree of indexation. The optimal degree of indexation is chosen such that steady state employment is maximized taking also into account losses due to imperfect information. Hence, the objective function of the authorities weights gains from increased employment against potential losses due to the fact that labour contracts are signed before uncertainty on the exchange rate is realized. Product market characteristics are among the determinants of optimal indexation.

The plan of the paper is as follows. Pricing and employment decisions in an oligopoly model of international trade are considered in Section 2. Section 3 looks at monopoly union

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[1] Naish (1988) considers the importance of uncertainty in wage formation for fully anticipated monetary changes to have real effects. Sørensen (1992) finds that, because of uncertainty, equilibrium unemployment depends on whether the authorities opt for a discretionary or a state contingent monetary policy regime. Jensen (1993) demonstrates that with uncertainty cooperative monetary stabilization policies between two countries need not be advantageous.

wage setting taking into account exchange rate uncertainty and wage indexation. This enables us to derive and analyze optimal wage indexation in Section 4. Conclusions are offered in Section 5.

2. Firms' Pricing Strategy and Employment Decision

Up to today, many models built in the open-economy literature make use of one of two standard theories on price relationships. The first is presented by international purchasing power parity (PPP) and relies on *traditional Walrasian market clearing*, where prices are fully flexible to demand and supply shifts so as to clear product markets. The alternative is called *traditional Keynesianism*; contrary to PPP it holds that a 1% change in the exchange rate results in a 1% change in relative prices, affecting the distribution of total domestic demand among domestic producers and importers.

The assumptions made in these standard models are unsatisfactory. PPP is valid only for perfect goods arbitrage on world markets and for homogeneous goods[2]. Also, PPP and its Keynesian alternative traditionally refer to products which are traded on markets where producers have no market power. It is undeniable however that the major part of international trade between industrialized economies today consists of trade in differentiated products on markets that are far from being perfectly competitive. This observation has led macroeconomists to be more explicit on product market properties. Following this line of research, we shall take into account the influences of product differentiation, market shares and market conduct.

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[2] For an empirical account of PPP-deviations, see e.g. Daniel (1986), Corbae and Ouliaris (1988) and Enders (1988), to mention just a few. For a recent survey, see Giovannetti (1992).

The Profit-Maximizing Firm

Let us assume that there is only one industry with two selling groups of producers, n_d domestic ones and n_m foreign ones, each of which produces a differentiated product that is sold on the domestic market. The total number of firms equals $n=n_d+n_m$. A representative domestic firm i maximizes its profit with respect to its price while taking into account that the price it sets has consequences for the quantity it can produce and offer for sale[3]:

$$\max_{P_i} \pi_i = P_i \, Q_i(P) - C_i(Q_i)$$

where Q_i is real demand for firm i's product, P_i is the price of firm i's product, P is a price vector including all prices P_j (j:1,..,n) and C_i is total variable costs of firm i. This gives:

$$\frac{\partial \pi_i}{\partial P_i} = Q_i + (P_i - MC_i)\left(\frac{\partial Q_i}{\partial P_i} + \sum_{\substack{j=1 \\ j \neq i}}^{n} \frac{\partial Q_i}{\partial P_j} \frac{\partial P_j}{\partial P_i} \right) = 0$$

where MC_i are marginal costs. Multiplying by P_i/Q_i and rearranging yields the following mark-up relationship:

$$P_i = \frac{\epsilon_{ii} + \sum_{j \neq i} \epsilon_{ij}\phi_{ji}}{1 + \epsilon_{ii} + \sum_{j \neq i} \epsilon_{ij}\phi_{ji}} MC_i \qquad (1)$$

where $\epsilon_{ii}=(\partial Q_i/\partial P_i)(P_i/Q_i)$ and $\epsilon_{ij}=(\partial Q_i/\partial P_j)(P_j/Q_i)$ represent the own and cross-price elasticities of demand, respectively. $\phi_{ji}= [(\partial P_j/\partial P_i)(P_i/P_j)]_{conj}$ $(0 \leq \phi_{ji} \leq 1)$ is called the *conjectural reaction elasticity* and is a measure of collusive behaviour in the industry[4]. $\epsilon_{ii}+\sum_{j \neq i}\epsilon_{ij}\phi_{ji} > 0$ or < -1 is necessary to ensure a

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[3] The analysis for a representative importer firm is quite analogous and will not be fully presented in the text.

[4] We adopt the conjectural variations approach because of its generality. It embraces varying degrees of competition and is therefore quite useful for comparative statics purposes. The usual citicism on the approach applies [see e.g. Shapiro (1989)].

positive value for the equilibrium price. The mark-up in equation *1* differs from its counterpart in the monopolistic case in that it has an additional term that incorporates competitive price reactions.

The Structure of Demand

To be more specific on the mark-up elasticities, we need to know details on consumers' demand. Let demand for firm i's product be given by[5]:

$$Q_i(P) = \frac{\alpha_i P_i^{-\sigma}}{\sum \alpha_j P_j^{1-\sigma}} Y_d \qquad (2)$$

where σ is the elasticity of product substitution [$\sigma=1/(1-\rho)$] and Y_d is total expenditures of domestic residents. The market share of firm i is given by:

$$S_i = P_i Q_i / Y_d = \frac{\alpha_i P_i^{1-\sigma}}{\sum \alpha_j P_j^{1-\sigma}} \qquad \text{with } \sum S_j = 1 \qquad (3)$$

The α_j's are the shares of the market that firms would have if their prices were equalized. These 'basic' market shares may depend on tastes, advertising, etc. By simple calculation we get the price elasticities of demand for firm i's product:

$$\epsilon_{ii} = \sigma(S_i - 1) - S_i \qquad (4a)$$
$$\epsilon_{ij} = (\sigma - 1) S_j \qquad j \neq i \qquad (4b)$$

It is easily shown that, for $\sigma > 1$, $\epsilon_{ii} < -1$, while $\epsilon_{ij} > 0$. The direct and cross-price elasticities of demand depend on the

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[5] The demand functions can be derived from maximizing a CES utility function in Q_i subject to the domestic consumer's budget constraint [see Layard and Walters (1978), p. 272-275]:

$$\max_{Q_i} U_d = [\, \sum \alpha_j^{1-\rho} Q_j^{\rho} \,]^{1/\rho}$$
$$\text{s.t. } \sum P_j Q_j = Y_d$$

where $\rho \le 1$, $0 \le \alpha_j \le 1$ (j:1,..,n) and $\sum \alpha_j = 1$.

elasticity of substitution between products and on market shares[6]. A higher elasticity of product substitution or a lower own market share makes the demand facing firm i more elastic with respect to its price.

Pricing and Market Shares

We can now substitute information on demand into the price equation *1*. Following Slade (1986) we assume that $\phi_i=\phi_{ji}$ for all j:1,..,n ($j\neq i$). After some algebraic manipulation, we obtain the equilibrium price as:

$$P_i = \frac{1}{1-\phi_i}\left[\frac{\sigma}{\sigma-1} + \frac{1}{\sigma-1}\frac{S_i}{1-S_i} - \phi_i\right] MC_i \qquad (5)$$

It follows that the mark-up of the price over marginal costs is related to the market share ratio, the elasticity of product substitution and the reaction elasticity. By taking partial derivatives, it is easily verified that the larger the firm's market share or the greater the reaction elasticity, the larger is the mark-up. The greater the possibilities of product substitution, the lower is the mark-up.

Equation *5* is not a fully reduced price equation since market shares are not independent from prices. Upon replacing the market share ratio, totally differentiating and then integrating, we obtain the following logarithmic representation: (lowercase variables denote logarithms of the corresponding uppercase variables)

$$p_i = cte + \frac{\sigma - (\sigma-1)\,[S_i+(1-S_i)\phi_i]}{\sigma - (\sigma-1)\,(1-S_i)\phi_i}\, mc_i + \frac{(\sigma-1)\,S_i}{\sigma - (\sigma-1)\,(1-S_i)\phi_i}\,\frac{1}{1-S_i}\sum_{j\neq i} S_j\, p_j \qquad (6)$$

Equation *6* presents the price change as a linearly homogeneous function of the changes in own marginal costs and competitors' prices. It is interesting to have a look at the elasticity

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[6] Our model therefore relaxes the usual assumption of a constant elastic demand function, which results in a simple mark-up pricing in which competitor prices do not feature explicitly.

formulae[7]:

$$\epsilon_i^C = \frac{\partial \log P_i}{\partial \log MC_i} = \frac{\sigma - (\sigma-1)[S_i+(1-S_i)\phi_i]}{\sigma - (\sigma-1)(1-S_i)\phi_i}$$

$$\epsilon_{ij}^P = \frac{\partial \log P_i}{\partial \log P_j} = \frac{(\sigma-1)S_i}{\sigma - (\sigma-1)(1-S_i)\phi_i} \frac{S_j}{1-S_i}$$

$$0 < \epsilon_i^C, \epsilon_{ij}^P < 1 \quad \text{and} \quad \epsilon_i^C + \sum_{j \neq i} \epsilon_{ij}^P = 1.$$

The price set by firm i depends directly on its marginal costs and indirectly, through the market share, on the price of the competing products. Taking partial derivatives, it is easily shown that the price reacts more to competitors' prices and less to own marginal costs, the greater the product substitutability, the higher the firm's market share in total sales or the higher the reaction elasticity.

Both the elasticities are between zero and unity. The reasoning is straightforward and goes as follows. If marginal costs increase, then the price increases initially with the same percentage. However, this is not the end of the story. It also results in a fall in the market share, which through a decrease in the own-price elasticity and an increase in the cross-price elasticities impacts the price as well. The price change again has consequences for the market shares; and so forth. It follows that the total effect of an increase in marginal costs is positive and less than the increase in marginal costs.

A similar reasoning applies to the effects of a change in one of the prices of competing firms. An increase in one of these prices leads to an increase in firm i's market share; this induces a change in its price through a rise in the own-price elasticity and a decline in the cross-price elastici-

7 In what follows, we assume that the elasticities ϵ_i^C and ϵ_{ij}^P are constant. Equation *6* must therefore be considered as an approximation, with market shares equal to their initial values. Also, since the integration constant (cte) is not crucial to the analysis, it will be deleted from the derivations below.

ties; this in turn changes firm i's market share, which again leads to a change in its price; and so forth. The total change in the price set by firm i due to an increase in one of the other firms' prices is positive, though firm i's price will not change by the same percentage.

If the representative firm is an importer firm, then ϵ_i^C measures the tendency to maintain local currency prices at a constant level in the presence of exchange rate fluctuations[8]. Indeed, measured in domestic currency units, the importer firm's marginal costs are presented by $mc_i^* + e$, where e represents the (log of the) exchange rate (units of domestic currency per unit of foreign currency) and the asterisk * refers to foreign currency denotation. The exchange rate pass-through is complete when the importer does not adjust prices in his home currency. Pass-through is zero if its price in local currency remains stable. The reason why the exchange rate pass-through is between zero and unity is that a change in the currency is associated with fluctuations in the mark-up of the importer's price over his marginal costs.

Market Structure

Within the model, we can characterize different market structures. Clearly, the higher is the conjectural elasticity and the lower is the degree of product substitutability, the less competitive is the industry [see Fama and Laffer (1972)]. In general, the value of ϕ_{ji} can be any real number, but it is often assumed that it is within the range of 0 and 1. Specifically, an elasticity equal to one corresponds to complete collusion. This we interprete to mean that each producer believes that the others will react to his price change so as to maintain market shares. If the reaction elasticity is zero, competitors are not expected to follow any price movement. This corresponds to Bertrand behaviour. If $\sigma=\infty$, then the price elasticity of demand is infinite, so that pure competition

[8] An extensive literature exists which examines the topic of exchange rate pass-through. See, e.g., Krugman (1987), Hooper and Mann (1989), Knetter (1989, 1993), Marston (1990) and Ohno (1989,1990), among many others.

rules and there must hold $p_i = mc_i$. On the other hand, if $\sigma=\infty$, then the products are perfect substitutes; thus the only stable solution is $p_i = p_j$ for all $j\neq i$. Therefore if $\sigma=\infty$, there holds $p_i = mc_i = p_j$ (for all $j\neq i$), so that $\epsilon_i^C = \epsilon_{ij}^P = 1$ (for all $j\neq i$). Note that the market shares are indefinite if $\sigma=\infty$. Also, in the perfectly competitive equilibrium there is no strategic interaction (i.e. the conjectural elasticity equals zero).

Production Technology and Marginal Costs

Each individual firm produces a single output using labour as the only input. To get simple analytical results, we assume that one unit of labour produces one unit of ouput. Firm employment therefore equals firm output[9]:

$$Q_i = L_i \tag{7}$$

where L_i is the labour input by firm i. In the domestic industry, firms' marginal costs equal the nominal wage w_d (in logs). For importer firms, marginal costs are $\overline{w}^*_m+e$ (also in logs). For the sake of simplicity, the wage in the foreign industry is taken as fixed throughout the text (a bar denotes that the variable is exogenous).

Aggregate Domestic and Import Price Equations

By making use of an exact aggregation method, we can derive aggregate price equations [see Deaton and Muellbauer (1986)]. Noting that $1-S_i = \sum_{j\neq i} S_j$, the weight of import prices in the representative domestic firm's price equation will be almost exactly equal to the proportion of importer firms to the total number of firms in the industry. This ratio will be denoted λ[10]. A representative <u>domestic</u> firm's price equation can now be written as:

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[9] Obviously, this simplification has consequences for the channels through which the exchange rate affects pricing behaviour. Indeed, by doing so we cut off the exchange rate effect on costs whenever there is an imported input which has to be paid for in domestic currency.

[10] Notice that the correct weight is $n_m/(n_m+n_d-1)$, which equals $\lambda = n_m/(n_m+n_d)$ for large values of n_d and n_m.

$$p_i = \epsilon_i^C \, mc_{di} + \epsilon_{ij}^P \, [\lambda p_m + (1-\lambda) p_d] \qquad 0 \leq \lambda \leq 1 \qquad (8)$$

p_d is (the log of) the domestic price and p_m is (the log of) the import price. Adding up over all domestic firms we obtain:

$$p_d = \frac{\epsilon_d^C}{1-(1-\lambda)\epsilon_{dm}^P} \, mc_d + \frac{\lambda \epsilon_{dm}^P}{1-(1-\lambda)\epsilon_{dm}^P} \, p_m \qquad (9a)$$

where

$$\epsilon_d^C = \frac{\sigma - (\sigma-1)[S_d+(1-S_d)\phi_d]}{\sigma - (\sigma-1)(1-S_d)\phi_d} \quad \text{and} \quad \epsilon_{dm}^P = \frac{(\sigma-1)S_d}{\sigma - (\sigma-1)(1-S_d)\phi_d}$$

In a similar way we can derive the aggregate <u>import</u> price equation:

$$p_m = \frac{\epsilon_m^C}{1-\lambda\epsilon_{md}^P} \, (mc_m^* + e) + \frac{(1-\lambda)\epsilon_{md}^P}{1-\lambda\epsilon_{md}^P} \, p_d \qquad (9b)$$

where

$$\epsilon_m^C = \frac{\sigma - (\sigma-1)[S_m+(1-S_m)\phi_m]}{\sigma - (\sigma-1)(1-S_m)\phi_m} \quad \text{and} \quad \epsilon_{md}^P = \frac{(\sigma-1)S_m}{\sigma - (\sigma-1)(1-S_m)\phi_m}$$

The equilibrium between the two countries is represented by the crossing of the two reaction functions. Solving these functions, we obtain:

$$p_d = \tau_1 w_d + \tau_2 (\overline{w}^*_m + e) \qquad (10a)$$

$$p_m = \delta_1 (\overline{w}^*_m + e) + \delta_2 w_d \qquad (10b)$$

where

$$\tau_1 = \frac{\epsilon_d^C}{[1-(1-\lambda)\epsilon_{dm}^P] \; Z} \qquad \delta_1 = \frac{\epsilon_m^C}{[1-\lambda\epsilon_{md}^P] \; Z}$$

$$\tau_2 = \frac{\lambda\epsilon_{dm}^P \epsilon_m^C}{[1-(1-\lambda)\epsilon_{dm}^P][1-\lambda\epsilon_{md}^P] \; Z} \qquad \delta_2 = \frac{(1-\lambda)\epsilon_{md}^P \epsilon_d^C}{[1-(1-\lambda)\epsilon_{dm}^P][1-\lambda\epsilon_{md}^P] \; Z}$$

and $Z = 1 - \dfrac{\lambda\epsilon_{dm}^P \; (1-\lambda)\epsilon_{md}^P}{[1-(1-\lambda)\epsilon_{dm}^P][1-\lambda\epsilon_{md}^P]}$

$0 \leq \tau_1, \tau_2, \delta_1, \delta_2 \leq 1$ and $\tau_1+\tau_2 = 1, \; \delta_1+\delta_2 = 1.$

Industry Labour Demand
Labour demand follows from recognizing that, once the price level has been determined, output is set in order to satisfy demand. The price equations can be substituted into the demand equation, from which employment can be solved by using the production relation. By this reasoning, demand for labour is written as[11]:

$$l_d = \{(1-\lambda)[\sigma(S_d-1)-S_d]\tau_1+\lambda(\sigma-1)S_m\delta_2\}w_d \\ + \{(1-\lambda)[\sigma(S_d-1)-S_d]\tau_2+\lambda(\sigma-1)S_m\delta_1\}(\overline{w}^*_m+e) \qquad (11)$$

Further on in the text we shall denote the elasticity of labour demand w.r.t. the domestic wage for short ϵ.

3. Indexation with Exchange Rate Uncertainty in a Unionized Economy

Although the economic analysis of trade unions has been topical for several years now, less work has been done on wage setting behaviour under uncertainty. Oswald (1982) investigated the implications of uncertainty for a monopoly union and found that uncertainty has little effect on the qualitative predictions of the model. Very recently, however, it is found that uncertainty is much more significant and affects the union's choice of wage rate in a manner that has important implications for the working of stabilization policies.

In this section we analyze the importance of exchange rate uncertainty for the way a monopoly union sets the industry wage. The nominal wage is fixed on a long-term basis, e.g. because changes are associated with large transaction costs. Firms set their prices and employment given the contract wage. It is obvious that, since labour contracts are filled-in some period in advance, the union will incorporate expectations concerning the variables that strongly affect the realized

[11] To obtain equation *11* the demand equations must be approximated: $q_i=\sum_{j\neq i}(\sigma-1)S_jp_j+[\sigma(S_i-1)-S_i]p_i$. By aggregation, $q_d=\lambda(\sigma-1)S_mp_m+(1-\lambda)[\sigma(S_d-1)-S_d]p_d$.

terms of the contracts. This means contracts are signed under uncertainty regarding the evolution of the exchange rate during the contract period.

Union Behaviour

Let us assume that the union utility function has a utilitarian form being simply the sum of the utilities of each of its individual members [see Oswald (1985)]. Such a function may be written as follows:

$$U = Lu(W/P_c) + (\bar{L}-L)u(\Omega) \tag{12}$$

where u(·) denotes the utility function of an individual member. From total union membership ($\bar{L}$), L are employed and in receipt of the wage set by the union, while the remaining members ($\bar{L}$-L) are unemployed and in receipt of state unemployment benefits (Ω). Let union members be risk-neutral, then u(·)=·. Given these properties, the union's objective is to maximize <u>expected</u> utility w.r.t. the contract wage:

$$\max_{W_d^c} E[L_d(W_d/P_c - \Omega)]$$

The expectations operator *E* reflects the assumption that unions fill-in the wage contract one period in advance, this means before uncertainty on the exchange rate is resolved. Notice also that unions care about wages deflated by consumer prices because this determines purchasing power. Consumer prices are set as a simple weighted average of domestic and import prices: $P_c = P_d^{Sd}\ P_m^{1-Sd}$ [12]. The ex-post, actual, wage is assumed to be indexed according to the formula:

$$W_d = W_d^c(P_c/P_c^e)^b \tag{13}$$

[12] S_d and 1-S_d are the shares of the domestic and foreign products in total domestic consumption. It is known from Section 2 that market shares are a function of relative prices. For the sake of simplicity, we set market shares equal to their initial value, leading to constant weights in the consumer price formula.

where b is the indexation coefficient and the superscript e denotes expectations. The indexation parameter is set by the authorities immediately after shocks occur. Allowing for indexation of wages to the price prediction error is similar to what is encountered in the traditional literature [see, e.g., Van Gompel (1994)]. Solving the problem gives the following first-order condition for a maximum[13]:

$$\Phi(W_d^c) = W_d^c\, E(P_c^{-[(1-b)-b\epsilon]}) - \Omega\, \Theta\, [P_c^e]^b E(P_c^{b\epsilon}) = 0 \qquad (14)$$

where

$$\Theta = [\ 1 + \frac{1-h_l}{\epsilon}\ ]^{-1}$$

$h_l = S_d\tau_1 + S_m\delta_2$ $(0 \le h_l \le 1)$ and $\epsilon = (1-\lambda)[\sigma(S_d-1)-S_d]\tau_1 + \lambda(\sigma-1)S_m\delta_2$.

A sufficient condition to have a positive wage is $\Theta > 0$. Let further $p_c \sim N(E(p_c), \sigma^2_{pc})$. Taking the logarithm of equation *14*[14]:
$w_d^c = \log\Omega + \log\Theta + b\log P_c^e + (1-b)\{\ E(p_c) - \frac{1}{2}[(1-b)-2b\epsilon]\sigma^2_{pc}\ \}$
Using $\log P_c^e = \log E(P_c) = E(p_c) + \frac{1}{2}\sigma^2_{pc}$ equation *14* finally becomes:

$$w_d^c = \omega + \theta + E(p_c) - \tfrac{1}{2}\Delta \qquad (15)$$

where
$\omega = \log\Omega$, $\theta = \log\Theta$ and $\Delta = [(1-b)^2 - 2b(1-b)\epsilon - b]\sigma^2_{pc}$.

We can immediately see that an increase in expected consumer prices results in a proportional increase in the contract wage, i.e. $\partial w_d^c / \partial E(p_c) = 1$. The union acts as choosing the expected real consumption wage $E(w_d^c - p_c)$ as a mark-up θ over the level of unemployment benefits ω. In addition, the union

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13 In fact, the f.o.c. for the maximum should be written as $(1-b\zeta)(1+\sum_{k=1}^{\infty}[bh_l]^k)\Phi(W_d^c)=0$, where $\zeta = (\partial P_c^e/\partial W_d^c)(W_d^c/P_c^e)$, i.e. the elasticity of the expected consumer price with respect to the contract wage. To obtain *14*, we have implicitly imposed the conditions $b\zeta \neq 1$ and $\Sigma[bh_l]^k \neq -1$.

14 Recall that the moment generating function of a normal variable X is $M_X(t) = E\{\exp[tX]\} = \exp\{mt + \frac{1}{2}\sigma^2 t^2\}$ where m is the mean of X, σ^2 the variance of X and t is a real variable.

'insures' against uncertainty by taking into account the risk factor Δ. For fully indexed wages (b=1), the contract wage fully reflects the risk due to variability in consumer prices. Under full indexation we have $w-p_c = \omega+\theta$, meaning that real consumption wages are constant and independent of the distribution of consumer prices. This is due to the particular way in which the distribution of consumer prices affects contract wages with full indexation.

The mark-up parameter θ depends on the elasticities of labour demand and consumer prices w.r.t. the domestic wage. The more elastic are labour demand or consumer prices w.r.t. the actual wage, the lower is the mark-up parameter. Notice also there is no effect of indexation on the mark-up factor θ.

The solution for the contract wage differs from the ones derived by Andersen and Sørensen (1989) and Vilmunen (1992) in that the mark-up factor and the risk factor reflect imperfect competition in the product market.

Exchange Rate Uncertainty

Equation *15* is not a fully reduced wage equation in that $E(p_c)$ is not independent from the contract wage. Since the exchange rate is the only source of variability, we can express the mean-variance structure as follows:

$$E(p_c) = h_l\ [w_d^c - \tfrac{1}{2}\sigma^2_{pc}] + (1-h_l)\ [\overline{w}^*_m + E(e)]$$

$$\sigma^2_{pc} = [(1-h_l)/(1-bh_l)]^2\ \sigma_e^2$$

Inserting these expressions in the equation for the contract wage chosen by the union we get:

$$w_d^c = \frac{\omega+\theta}{1-h_l} + \overline{w}^*_m + E(e) - \tfrac{1}{2}\Delta' \qquad (16)$$

where

$$\Delta' = \left[\frac{(1-b)^2-2b(1-b)\epsilon}{1-h_l} - b\right] \left[\frac{1-h_l}{1-bh_l}\right]^2 \sigma_e^2$$

Equation *16* is derived under the assumption that, at the time of setting the wage, the union does not know the exchange rate in the period to come. It only takes into account anticipated currency changes. It is seen that the contract wage is proportional to the expected exchange rate. Notice also that the impact of exchange rate variability on the contract wage is not fully determinate. It is clear that the effect depends both qualitatively and quantitatively on the degree of wage indexation, though this dependence is rather complex.

4. Optimal Wage Indexation

The final topic taken up in the paper concerns calculating the optimal degree of wage indexation in the presence of exchange rate uncertainty. As in Vilmunen (1992, p.125), we assume that the authorities choose b according to the following maximization problem[15]:

$$\max_{b} H = d_1 E(l_d) - d_2 E\{(l_d - l_d^f)^2\}$$

The objective takes account of two issues. First, indexation is chosen to maximize steady state employment, which is measured by the first term in the objective function H. However, costs are incurred as a result of aggravating inefficiencies due to imperfect information, i.e. due to the fact that contracts are signed before uncertainty on the exchange rate is resolved. The second term measures this loss (l_d^f denotes full information employment, i.e. employment resulting from monopoly union wage setting under perfect information about the exchange rate). d_1 and d_2 are weights attached to both objectives.

The actual nominal wage which takes into account the indexing operation is given by:

[15] It is clear that, since employment equals output, the objective function H can also be written in terms of output.

$$w_d = \frac{\omega+\theta}{1-h_l} + \overline{w}^*_m + E(e) + \frac{b(1-h_l)}{1-bh_l}[e-E(e)]$$

$$-\tfrac{1}{2}\frac{(1-b)^2-2b(1-b)\epsilon}{1-h_l}\left[\frac{1-h_l}{1-bh_l}\right]^2 \sigma_e^2 \qquad (17)$$

from which expected actual employment can be computed as:

$$E(l_d) = \epsilon\left[\frac{\omega+\theta}{1-h_l} + \overline{w}^*_m + E(e) - \tfrac{1}{2}\frac{(1-b)^2-2b(1-b)\epsilon}{1-h_l}\left(\frac{1-h_l}{1-bh_l}\right)^2 \sigma_e^2\right] + \epsilon^*\left[\overline{w}^*_m + E(e)\right] \qquad (18)$$

ϵ^* simply denotes the elasticity of domestic labour demand w.r.t. the foreign wage. The perfect information solution to the union's maximization problem is given by:

$$w_d = \frac{\omega+\theta}{1-h_l} + \overline{w}^*_m + e \qquad (19)$$

The difference between actual and full information employment equals:

$$l_d - l_d^f = -\epsilon\frac{1-b}{1-bh_l}[e-E(e)] - \epsilon\frac{\tfrac{1}{2}(1-b)^2-2b(1-b)\epsilon}{1-h_l}\left(\frac{1-h_l}{1-bh_l}\right)^2 \sigma_e^2 \qquad (20)$$

It can immediately be verified that for fully indexed wages, actual employment equals full information employment. The objective function can now be written as:

$$H = B - \tfrac{1}{2}d_1\,\epsilon\,(1-b)\frac{(1-b)-2b\epsilon}{1-h_l}\left(\frac{1-h_l}{1-bh_l}\right)^2 \sigma_e^2$$

$$- d_2\,\epsilon^2\left(\frac{1-b}{1-bh_l}\right)^2\left\{\sigma_e^2 + \left[\frac{\tfrac{1}{2}(1-h_l)[(1-b)-2b\epsilon]}{1-bh_l}\right]^2 \sigma_e^4\right\} \qquad (21)$$

where B is a constant excluding the indexation parameter b. In what follows we shall first analyze optimal indexation subject to the restriction $d_2 = 0$ or $d_1 = 0$. In a final paragraph we consider the general case where neither d_1 nor d_2 is zero.

a) Only Steady State Employment Maximization Matters ($d_2 = 0$)

With $d_2 = 0$, the maximization problem reduces to:

$$\max_{b} H_1 = - \tfrac{1}{2}\, \epsilon\, (1-b)\, \frac{(1-b)-2b\epsilon}{1-h_l} \left(\frac{1-h_l}{1-bh_l}\right)^2 \sigma_e^2$$

Differentiating H_1 with respect to b and solving the implied first-order condition for a maximum yields:

$$b^o = \frac{h_l - \epsilon - 1}{\epsilon h_l - 2\epsilon + h_l - 1} \tag{22}$$

The optimal degree of wage indexation is a function of the elasticity of consumer prices and labour demand w.r.t. the domestic wage, represented by the parameters h_l and ϵ, respectively. The less elastic are consumer prices and labour demand, the smaller is optimal indexation. Perhaps even a negative amount is required. The classification given in table 1 clarifies the relationship in more detail. Notice that when h_l equals unity the value of b becomes irrelevant. It is immediately seen that H_1 is always zero with h_l=1.

Table 1. Optimal wage indexation as a function of h_l and ϵ

<u>case 1</u> $-0.5 < \epsilon \leq 0$	
$0 \leq h_l < (2\epsilon+1)/(\epsilon+1)$	$b^o \geq 1$
$h_l = (2\epsilon+1)/(\epsilon+1)$	$b^o = \pm\infty$
$(2\epsilon+1)/(\epsilon+1) < h_l \leq \epsilon+1$	$b^o \leq 0$
$\epsilon+1 < h_l < 1$	$0 < b^o < 1$
$h_l = 1$	b irrelevant
<u>case 2</u> $-1 < \epsilon \leq -0.5$	
$0 \leq h_l \leq \epsilon+1$	$b^o \leq 0$
$\epsilon+1 < h_l < 1$	$0 < b^o < 1$
$h_l = 1$	b irrelevant
<u>case 3</u> $-\infty < \epsilon \leq -1$	
$0 \leq h_l < 1$	$(\epsilon+1)/(2\epsilon+1) \leq b^o < 1$
$h_l = 1$	b irrelevant

b) Only Minimization of Losses due to Imperfect Information Matters ($d_1 = 0$)

With $d_1 = 0$, only the minimization of inefficiencies due to the fact that contracts are signed in advance counts in the authorities' objective:

$$\min_b H_2 = \epsilon^2 \left(\frac{1-b}{1-bh_l}\right)^2 \{\sigma_e^2 + [\frac{\frac{1}{2}(1-h_l)[(1-b)-2b\epsilon]}{1-bh_l}]^2 \sigma_e^4\}$$

We can immediately see that, no matter what h_l and ϵ are, the optimal degree of wage indexation corresponds to unity, $b^o=1$. Full indexation makes the contracted wage under exchange rate uncertainty identical to the perfect information wage and reduces contract inefficiencies to zero.

c) Wage Indexation and Product Market Properties

In general, when both d_1 and d_2 differ from zero, the optimal degree of wage indexation is some combination of the two cases analyzed above. Since the analytical derivation is rather cumbersome, we have simulated b^o to give a sense of concreteness (table 2). Both objectives have been given an equal weight.

Table 2. Optimal indexation: a simulation exercise

ϵ \ h_l	0	0.25	0.5	0.75	1
-2	0.717	0.780	0.848	0.921	-
-1	0.668	0.751	0.834	0.917	-
-0.5	0.501	0.667	0.800	0.909	-
-0.25	-5.868	0.005	0.667	0.889	-
0	-	-	-	-	-

-: value b irrelevant
parameter values: $\sigma_e^2=0.1$, $d_1=d_2=1$.

It is apparent from table 2 that:

(i) with $h_l = 1$ or $\epsilon = 0$, the value of b becomes irrelevant;

(ii) the optimal degree of indexation is not limited to (0,1) but may take any;

(iii) the higher h_l or the lower ϵ, the higher is b^o (Notice however the discontinuity of b^o at $h_l = (2\epsilon+1)/(\epsilon+1)$ for $-0.5 < \epsilon \leq 0$, see table 1, case 1).

The last observation deserves more attention. Since h_l and ϵ are determined by product market characteristics (in particular σ, λ and ϕ), it is possible to relate optimal indexation to the product market (table 3)[16].

Table 3. Product market characteristics and optimal indexation

	σ		λ	ϕ	
	$S_d < S_d^{crit}$	$S_d > S_d^{crit}$		$S_d < S_d^{crit}$	$S_d > S_d^{crit}$
b^o	+	-	-	+	-

+: positively related
-: negatively related

First, table 3 shows us that optimal indexation is decreasing with the proportion of importer firms to the total number of firms in the industry. An increase in the number of importer firms makes the domestic and importer price less responsive to the domestic wage (and more reponsive to the foreign wage). This lowers h_l, $|\epsilon|$ and b^o. The impact of product substitutability and collusive behaviour on optimal indexation is less clear. It depends on whether the domestic market share is above or below some critical value (denoted S_d^{crit} in the table), which is a complex function of all other parameters in the model.

5. Conclusions

Previous studies in the literature obtained that the optimal degree of wage indexation is crucially determined by the kind of shock experienced in the economy (cf. the path-breaking papers by Gray and Fischer). Whereas these studies focus on the effects of indexation on fluctuations around a fixed nonstochastic steady state, our analysis also incorporates effects on the steady state itself. The latter effects arise because of the existence of uncertainty on the future exchange rate evolution when writing labour contracts. It has been

[16] In fact, characteristics of the product market only matter for the maximization of steady state employment.

shown that the optimal degree of indexation under exchange rate uncertainty is crucially determined by product market characteristics. Therefore, choosing a unique degree of indexation across strongly different industries has sense only if exchange rate variability is low.

References

Andersen, T. and Sørensen, J.R.: Exchange rate variability and wage formation in open economies. *Economics Letters* 28, 263-268, 1988.

Corbae, D. and Ouliaris, S.: Cointegration and tests of purchasing power parity. *The Review of Economics and Statistics* 70, 508-511, 1988.

Daniel, B.C.: Empirical determinants of purchasing power parity deviations. *Journal of International Economics* 21, 313-326, 1986.

Deaton, A. and Muellbauer, J.: Economics of consumer behaviour. Cambridge University Press, Cambridge, 1986.

Enders, W.: ARIMA and cointegration tests of PPP under fixed and flexible exchange rate regimes. *The Review of Economics and Statistics* 70, 504-508, 1988.

Fama, E.F. and Laffer, A.B.: The number of firms and competition. *American Economic Review* 62, 670-674, 1972.

Giovannetti, G.: A survey of recent empirical tests of the purchasing power parity hypothesis. *Banca Nazionale Del Lavoro Quarterly Review* 180, 81-101, 1992.

Hooper, P. and Mann, C.L.: Exchange rate pass-through in the 1980s: the case of US imports of manufactures. *Brookings Papers on Economic Activity*, 297-337, 1989.

Jensen, H.: Uncertainty in interdependent economies with monopoly unions. *Journal of Macroeconomics* 15, 1-24, 1993.

Knetter, M.M.: Price discrimination by U.S. and German exporters. *American Economic Review* 79, 198-210, 1989.

Knetter, M.M.: International comparisons of pricing-to-market behavior. *American Economic Review* 83, 473-486, 1993.

Krugman, P.: Pricing to market when the exchange rate changes, in S.W. Arndt and J.D. Richardson (eds.), Real-financial linkages among open economies. MIT Press, Cambridge, 1987.

Layard, P.R.G. and Walters, A.A.: Microeconomic theory. McGraw-Hill, New York, 1978.

Marston, R.C.: Pricing to market in Japanese manufacturing. *Journal of International Economics* 29, 217-236, 1990.

Naish, H.F.: Optimal wage setting behaviour and the non-neutrality of anticipated monetary changes. *Oxford Economic Papers* 40, 346-364, 1988.

Ohno, K.: Export pricing behavior of manufacturing: a U.S.-Japan comparison. *IMF Staff Papers* 36, 550-579, 1989.

Ohno, K.: Exchange rate fluctuations, pass-through, and market share. *IMF Staff Papers* 37, 294-310, 1990.

Oswald, A.J.: Uncertainty and trade unions. *Economics Letters* 9, 105-111, 1982.

Oswald, A.J.: The economic theory of the trade union: an introductory survey. *Scandinavian Journal of Economics* 87, 160-193, 1985.

Shapiro, C.: Theories of oligopoly behaviour, in R. Schmalensee and R.D. Willig (eds.), Handbook of industrial organization. North-Holland, Amsterdam, 329-414, 1989.

Slade, M.: Conjectures, firm characteristics, and market structure. *International Journal of Industrial Organization* 4, 347-369, 1986.

Sørensen, J.R.: Uncertainty and monetary policy in a wage bargaining model. *Scandinavian Journal of Economics* 94, 443-455, 1992.

Van Gompel, J.: Achieving macroeconomic stabilization: the role of wage indexation and exchange rate policy. *Australian Economic Papers*, forthcoming, 1994.

Vilmunen, J.: Labour markets, wage indexation and exchange rate policy. Bank of Finland Publications, Series B:45, Helsinki, 1992.

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