OPTIMAL WAGE INDEXATION, MONETARY POLICY AND THE EXCHANGE RATE REGIME

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Research Discussion Paper

8909

December 1989

Research Department

Reserve Bank of Australia

I am grateful for helpful suggestions from Larry Ball, Ben Bernanke, Alan Blinder, Bill Branson, seminar participants at Princeton and colleagues at the RBA. Any errors are mine alone. The views expressed herein are those of the author and do not necessarily reflect the views of the Reserve Bank of Australia.

ABSTRACT

The optimal (labour market clearing) degree of wage indexation is derived from a simple neo-classical model, and is shown to be conditional on the variance of a number of supply and demand shocks, as well as the exchange rate regime. The model is estimated for nine industrial countries over the period 1973 through 1988. In no case was the actual degree of wage indexation found to be significantly greater than the optimum, suggesting that mechanisms other than "excessive wage indexation" were responsible for the increases in unemployment in these countries over this period.

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1. INTRODUCTION

The deterioration in macroeconomic performance of many of the industrial economies since the early 1970's has been difficult both to explain and to counteract. This paper presents a cross-country study which examines this deterioration in terms of the degree of wage indexation, the choice of exchange rate regime, and the effects of various shocks that have buffeted these economies during this time. To my knowledge, this is the first attempt to address all of these issues empirically.[1]

While macroeconomic performance, particularly in the labour market, has been generally poor over this period, some countries have fared better than others. A common explanation for this divergence in performance is that those countries with the most

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[1] In a recent paper, Kaufman and Woglom (1987) estimate the optimal degree of wage indexation for a number of countries, but do not address the question of the exchange rate regime. Aizenman and Frenkel (1985), Turnovsky (1987) and Devereaux (1988) present exhaustive theoretical treatments of these issues. Recent contributions to the literature on comparative macroeconomic performance include Bruno and Sachs (1986), Metcalf (1987), Alogoskoufis and Manning (1988) and Gordon (1988).

flexible labour market institutions have been in the best position to withstand the shocks of the period. The theoretical rationale for this explanation can be found in the early literature on the macroeconomics of wage indexation (Gray (1976), Fischer (1977)), which found that wage indexation stabilizes output around a desired level in the presence of demand shocks, but destabilizes output in the face of supply shocks. The optimal (labour market clearing) degree of wage indexation therefore depends on the relative prevalence of those shocks.[2]

It is well recognized that sticky real wages in the presence of supply shocks can lead to sub-optimal macroeconomic outcomes. What is not generally appreciated, however, is that the choice of an optimal exchange rate regime [3] can partially offset the negative consequences of that rigidity. Consequently, the optimal degree of wage indexation is a function not just of the relative strength of demand and supply shocks but also of the degree of nominal exchange rate flexibility. Equivalently, the optimal exchange rate regime is a function of the degree of wage indexation.[4]

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[2] More precisely, since the shocks are stochastic and unobservable, but are assumed to have a known variance, the ex-ante optimal degree of wage indexation (which is contingent on the observed price level) depends on the relative magnitude of those variances.

[3] I define an exchange rate regime to be the degree of nominal exchange rate flexibility.

[4] Specifically, monetary policy can be used to obtain a degree of nominal exchange rate flexibility. The optimal degree of flexibility, given the existence of a certain degree of wage indexation, is that which leads to the attainment of the labour market clearing real wage. Under complete wage indexation, however, monetary policy cannot alter the real wage, and the optimal degree of exchange rate flexibility is indeterminate.

Two issues are worth noting. The first is that the choice of exchange rate regime and degree of wage indexation are simultaneous decisions, made conditional on such factors as the presence of certain shocks. Under decentralized decision making, it is not obvious that ex-post optimal outcomes will occur, given the available information at the time the decisions are made.

The second issue is that although the period since 1973 is often characterized as that of "generalized floating" exchange rates, exchange market intervention has occurred on a fairly regular, albeit *ad hoc* basis. Governments, or central banks, might conceivably have chosen the degree of flexibility in the exchange rate to offset perceived labour market rigidities. Conversely, the behaviour of wage setters might have been a function of the existing exchange rate regime.

In this paper I employ a simple neo-classical macroeconomic model to investigate whether, over the period 1973 to 1988, the degree of wage indexation in several economies was optimal given their chosen exchange rate regime and the shocks they experienced. (Equivalently, one can ask whether the choice of exchange rate regime was optimal, given those shocks and the degree of wage indexation). The countries examined are the G7 countries [5] plus two small open economies, Australia and Austria. The paper is organized as follows. The model is outlined in sections 2 and 3 with empirical questions being addressed in sections 4 and 5. Section 6 contains a summary and some concluding remarks.

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[5] These are Canada, France, Germany, Italy, Japan, the United Kingdom and the United States.

2. THE MODEL

The model is an aggregate demand/aggregate supply specification with the variables defined in terms of their innovations i.e. unexpected components.[6] Thus, for instance, the innovations to wages are indexed to the innovations to prices. This formulation is consistent with an efficient wage contract, as rationally anticipated price increases ought to be incorporated in the base wage level.[7]

The production function is

$$Y = e^{u}N^{\varepsilon/1+\varepsilon} \tag{1}$$

where N is labour and u is a productivity shock. Differentiating with respect to N, setting the result equal to the real wage, and taking logs, yields labour demand:

$$n = -(1+\varepsilon)(w - p - u). \tag{2}$$

Employment is assumed to be exclusively demand determined and so the aggregate supply function is found by substitution:

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[6] A model in innovation form can be derived from a general dynamic structural model. See, for example, Blanchard and Watson (1986).

[7] Implicitly, the model assumes the existence of wage contracts of length greater than one quarter. A base real wage is set at the beginning of each contract period, with provision for indexing to anticipated price increases as they occur. In addition, the contract stipulates the extent to which unanticipated price increases are passed onto wages. This is the degree of wage indexation in this model.

$$y = -\varepsilon(w - p - u) + u. \tag{3}$$

The wage indexation rule is

$$w = \theta p + x, \qquad 0 \leqslant \theta \leqslant 1. \tag{4}$$

The other equations are

$$y = -\beta_1 r + \beta_2(e + pf - p) + g + \eta; \tag{5}$$

$$m = -\alpha p + \delta; \tag{6}$$

$$m = p + \beta_3 y - \beta_4 i + \tau; \tag{7}$$

$$e = \xi; \tag{8}$$

$$g = \kappa; \tag{9}$$

$$pf = \upsilon; \tag{10}$$

$$r \equiv i - \dot{p}_e. \tag{11}$$

All variables, except the interest rates, are in natural logarithms, with time subscripts omitted. Equation (5) is an IS curve, with real demand a function of the real interest rate, the real exchange rate, real government expenditure and a stochastic shock. Equation (6) is a money supply reaction function. Innovations to the money supply depend negatively on innovations to the price level, and include a random component, δ. Equation (7) specifies the demand for money, with τ reflecting shocks to liquidity preference. Equations (8), (9) and (10) specify that innovations to the nominal exchange rate (the domestic price of foreign currency), real government expenditure and foreign prices have no structural determinants; they are simply random disturbances.[8] Equation (11) defines the real interest rate innovation to be the difference between innovations to the nominal interest rate and the expected inflation rate. All the shocks are assumed to be serially uncorrelated with a known finite variance, zero mean and zero covariance.[9]

The wage indexation rule, adopted for analytical convenience, is unorthodox in that wages are indexed to producer prices, rather than consumer prices (the usual basis for indexing arrangements). This is justified if the innovation in consumer prices equals the innovation in producer prices plus a random disturbance:

$$p_c = p + z.$$

To see this, let wages be indexed to consumer prices:

$$\theta w = \theta p_c$$

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[8] Anticipated changes in the exchange rate are determined by monetary policy; only the innovations are assumed to be random. This specification is therefore compatible with any exchange rate regime.

[9] The assumption of zero covariance between the shocks is justified if these shocks are "primitive" i.e. without common causes. This assumption is used to identify the parameters of the model; see Section 4 below.

$$= \theta(p + z)$$

$$= \theta p + x$$

which is also equation (4) above. x can be thought of as that part of wage innovations not captured by the indexing of wages to producer price innovations.

It is also apparent that this model contains no role for stabilizing fiscal policy. This does not mean that I adopt the counter-factual view that government purchases have no output effects. I do, however, assume that fiscal policy is not used to offset the effects of various shocks that hit the economy.

The link between monetary policy and the exchange rate is the parameter α, which can be interpreted as an indirect measure of the degree of exchange rate flexibility. When the nominal exchange rate is fixed, $\alpha = \infty$ and the central bank loses all control over the money supply. Maximum control of the money supply occurs when the exchange rate is perfectly flexible ($\alpha = 0$); in this case innovations to the money supply are zero up to the random shock δ. Observed deviations of α from zero under an ostensibly flexible exchange rate regime can be interpreted as evidence of intervention in the foreign exchange market by the central bank, motivated by a desire to achieve a particular exchange rate outcome.

The model is solved by substituting (4) into (3), equating (6) and (7) to obtain the LM equation and then using (5) to solve for an aggregate demand equation.[10] The resulting system of equations is

$$\begin{bmatrix} 1 & \varepsilon(\theta - 1) \\ \beta_4+\beta_1\beta_3 & \beta_4\beta_2 + \beta_1(\alpha + 1) \end{bmatrix} \begin{bmatrix} y \\ p \end{bmatrix} =$$

$$\begin{bmatrix} u(1+\varepsilon) - \varepsilon x \\ \beta_4(\kappa + \eta) + \beta_4\beta_2(\xi + \upsilon) + \beta_1(\delta - \tau) \end{bmatrix}$$

The reduced form solutions are

$$y = \{(u(1 + \varepsilon) - \varepsilon x)(\beta_4\beta_2 + \beta_1(\alpha + 1)) + \varepsilon(1 - \theta)[\beta_4(\kappa + s)$$

$$+ \beta_4\beta_2(\xi + \upsilon) + \beta_1(\delta - \tau)]\}/D, \tag{12}$$

[10] In deriving the aggregate demand equation, the term $-\beta_1 r$ in (5) is replaced by $-\beta_1 i$ and the aggregate demand shock η is replaced by another shock s. This implies $s = \beta_1 \dot{p}_e + \eta$. s is thus a linear combination of two mean-zero random variables, and so has a mean of zero itself.

$$p = \{\beta_4(\kappa + s) + \beta_4\beta_2(\xi + \upsilon) + \beta_1(\delta - \tau) - (\beta_4+\beta_1\beta_3)(u(1+\varepsilon) - \varepsilon x)\}/D, \tag{13}$$

where $D = \beta_4\beta_2 + \beta_1(\alpha + 1) + \varepsilon(1 - \theta)(\beta_4+\beta_1\beta_3) > 0$.

The comparative static properties of this model can be found in Table 1. The qualitative effects of the various shocks on output and prices are standard, and need not be elaborated in detail. It is interesting to note, however, that the effects of the demand shocks are larger the smaller is α i.e. the more flexible is the nominal exchange rate. (The corresponding effects from the supply shocks cannot be signed unambiguously.)

Table 1

COMPARATIVE STATICS

SHOCK	OUTPUT RESPONSE	PRICE RESPONSE
u	$((1+\varepsilon)(\beta_4\beta_2+\beta_1(1+\alpha))/D > 0$	$-(1+\varepsilon)(\beta_4+\beta_1\beta_3)/D < 0$
x	$-\varepsilon(\beta_4\beta_2+(1+\alpha)\beta_1)/D < 0$	$\varepsilon(\beta_4+\beta_1\beta_3)/D > 0$
ξ,υ	$\beta_4\beta_2(1-\theta)/D \geq 0$	$\beta_4\beta_2/D > 0$
κ,s	$\beta_4\varepsilon(1-\theta)/D \geq 0$	$\beta_4/D > 0$
$\delta,-\tau$	$\beta_1\varepsilon(1-\theta)/D \geq 0$	$\beta_1/D > 0$

Also of interest is the special case of complete wage indexation, $\theta = 1$. In this case

$$dy/du = 1+\varepsilon;$$

$$dy/dx = -\varepsilon;$$

$$dy/d\psi = 0,$$

where ψ is a generic demand shock.

Under complete wage indexation, therefore, the effects of real shocks on output are independent of the degree of exchange rate flexibility (monetary policy), and demand shocks have no effect on output.

3. THE OPTIMAL DEGREE OF WAGE INDEXATION

The optimal degree of wage indexation is defined as that which makes the ex-post real wage as close as possible to the market clearing real wage. Specifically, the social objective is to minimize the following loss function:[11]

$$L = E\,\{(w - p)^{*} - (w - p)\}^{2} \tag{14}$$

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[11] A standard objection to this definition of optimality is that efficient wage contracts will not be restricted to the information contained in the price level; they will be contingent on a range of variables. Nevertheless, for reasons of analytical tractability, I only consider the type of indexing scheme above.

where E is the expectations operator and $(w - p)^*$ is the real wage that clears the labour market.

Following the usual practice in the literature, I assume labour supply to be completely wage inelastic and non-stochastic. It is then trivial to show that the real wage innovation that clears the labour market is equal to u, the productivity shock. Substituting for p and w, the loss function becomes

$$L = E\,\{u - x + (1 - \theta)p\}^2.$$

Minimizing L with respect to θ yields

$$\theta - 1 = \{E(pu) - E(px)\}/\sigma^2_p.$$

Using (13) and the assumed orthogonality of the shocks, the optimal degree of wage indexation is obtained:

$$\Theta = 1 - [(\beta_4 + \beta_1\beta_3)\{\beta_4\beta_2 + \beta_1(\alpha + 1)\}\{(1+\varepsilon)\sigma^2_u + \varepsilon\sigma^2_x\}]/[V_1 + V_2] \tag{15}$$

where $V_1 = (\beta_4\beta_2)^2(\sigma^2_\xi + \sigma^2_\upsilon) + \beta^2_4(\sigma^2_\kappa + \sigma^2_s) + \beta^2_1(\sigma^2_\delta + \sigma^2_\tau)$,

$V_2 = (\beta_4 + \beta_1\beta_3)^2\sigma^2_u(1+\varepsilon)$.

The optimal degree of wage indexation, Θ, is thus a function of the structural parameters and the variances of the shocks. Θ

varies positively with the degree of flexibility in the nominal exchange rate. Given the variances of the shocks, the loss function (14) can be minimized with a high degree of wage indexation and a relatively flexible exchange rate, a low degree of wage indexation and a relatively fixed exchange rate, or some combination of the above.

Inspection of (15) also reveals that it is consistent with the Gray-Fischer result that the optimal degree of wage indexation increases as the variance of the demand side shocks increases, and that, in the absence of real shocks, Θ is equal to unity. However, it is not clear that another standard result of that literature holds - that Θ decreases as σ^2_u increases. In fact, differentiation of (15) with respect to σ^2_u reveals that

$$d\Theta/d\sigma^2_u < 0 \quad \text{if, and only if,} \quad \sigma^2_x < V_1/(\beta_4+\beta_1\beta_3)^2\varepsilon.$$

In the presence of wage shocks, the optimal degree of wage indexation is not necessarily decreased when the variance of productivity shocks increases. Whether this is the case is an empirical question. (In the Gray-Fischer formulation $\sigma^2_x = 0$ and so no ambiguity arises).

4. ESTIMATION

The empirical question of interest is how close θ was to Θ over the sample period. The hypothesis $\theta = \Theta$ can be tested since the parameters and variances in the model are recoverable from the data. To estimate the model equations (5) and (7) are combined to obtain an aggregate demand equation:

$$y = [1/(\beta_4+\beta_1\beta_3)][\beta_1 m + \beta_4\beta_2 e + \beta_4\beta_2 pf - (\beta_4\beta_2 + \beta_1)p$$

$$+ \beta_4 g + \beta_4 s - \beta_1\tau]$$

$$= \pi_1 m + \pi_2 e + \pi_3 pf + \pi_4 p + \pi_5 g + u_d. \tag{16}$$

Two restrictions are implied from this equation:

(i) $\pi_2 = \pi_3$;

(ii) $\pi_1 + \pi_2 + \pi_4 = 0$.

The structural parameters β_1, β_2, β_3, β_4 can be recovered from the quasi-reduced form parameters π_i as follows:

$$\beta_4/\beta_1 = \pi_5/\pi_1,$$

$$\beta_2 = \pi_2/\pi_5,$$

$$\beta_3 = (1 - \pi_5)/\pi_1.$$

Only three parameters are estimated (π_1,π_2,π_5) but there are four structural parameters of interest ($\beta_1,\beta_2,\beta_3,\beta_4$). Obviously one of the structural parameters cannot be identified, and must therefore be imposed. It is convenient to choose β_1 for this purpose, and its value is set at unity. This normalization only affects the interpretation of β_4, which is now appropriately viewed as the relative interest elasticity in the model. Fortunately, the question at hand is unaffected by this normalization. Inspection of (15) reveals that the value of Θ is invariant to the value of β_1 (as is the variance of Θ).

The other equations to be estimated are for the price, wage and money supply innovations. The aggregate supply equation (3) is inverted to derive a price equation:

$$p = w + \gamma y + u_p \qquad (17)$$

where $\gamma = 1/\varepsilon$ and $u_p = -((1+\varepsilon)/\varepsilon)u$.

The wage and money supply equations are simply (4) and (6), reproduced below:

$$w = \theta p + x, \qquad (4)$$

$$m = -\alpha p + \delta. \qquad (6)$$

The model is estimated by a two-step procedure. First, the innovations are obtained by estimating a seven equation vector autoregression for p, y, w, m, e, g and pf.[12] The data are quarterly, and are estimated in log difference form, with four lags allowed for each variable.[13] The estimation period is 1973(1) to

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[12] See Appendix 1 for data definitions and sources.

[13] The VAR estimates are of no intrinsic interest and so are not reported in this paper. They are available on request from the author.

1988(4). To conserve scarce degrees of freedom, a mixed estimation method is implemented which imposes Bayesian priors on the weights given to each variable in each regression, relatively greater weight being given to the own lags in each equation. The VAR residuals, which by construction are uncorrelated to the information set used in the first stage estimation, are the innovations to be used in the estimation of the structural model.

Since the structural model contains no exogenous variables, identification by the conventional method of zero restrictions is obviously not possible in this case. Identification is achieved instead by covariance restrictions; specifically, the structural shocks are assumed to be mutually orthogonal.[14] An n equation system has n(n+1)/2 covariances, which is the maximum number of parameters that can be estimated, including the variances of the structural shocks. As only thirteen parameters in this seven equation system are estimated, the model is over-identified, which permits tests of the identifying restrictions. The results of these tests are reported in Appendix 2.

The model is estimated by Sargan's (1958) Generalised Instrumental Variables Estimator, a procedure which makes use of all the available instruments.[15] Valid instruments are generated by the identification restrictions. These are firstly the e, g and pf innovations. In addition, the covariance restrictions imply that the

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[14] See Hausman and Taylor (1983) and Hausman, Newey and Taylor (1987) for comprehensive treatments of the issues pertaining to the identification and estimation of simultaneous equations models with covariance restrictions.

[15] This estimator is computationally equivalent to Hansen's (1982) Generalized Method of Moments Estimator when the structural disturbances are serially uncorrelated and homoscedastic.

residuals from the estimation of any structural equation can be used as instruments in the estimation of any subsequent equation.

Consistent estimates of σ^2_ξ, σ^2_κ and σ^2_υ are the variances of the VAR residuals from the exchange rate, government expenditure and foreign price equations, respectively. Estimates of σ^2_x and σ^2_δ are the variances of the residuals in the structural equations for wages and the money supply. Estimates of σ^2_u and $\beta^2_1\sigma^2_\tau + \beta^2_4\sigma^2_s$ are given by

$((1/(1 + \gamma))^2\sigma^2_{up}$ and $(\beta_4+\beta_1\beta_3)^2\sigma^2_{ud}$, respectively.

5. RESULTS

The estimation results are reported in Tables 2 and 3. The estimates of the wage indexation parameter, θ, are shown in the first column of Table 2. They range from a low of 0.041 for Canada to a high of 0.662 for Austria. One should emphasize that these results do not imply, for example, that nominal wages were almost rigid in Canada over the sample period. Rather, they imply that, over this period, unanticipated Canadian inflation had practically no effect on Canadian nominal wages. In Austria, on the other hand, about two-thirds of unanticipated inflation was passed through to wages growth. The divergences in the estimated values of θ reflect differences in (perhaps implicit) wage contracts in these nine countries. The estimates of θ are reasonably well-determined, being significantly different from zero (at the ten percent level) in the majority of cases.

TABLE 2

COUNTRY	ESTIMATED PARAMETERS					
	θ	α	γ	π_1	π_2	π_5
Australia	0.125	0.300	1.000	0.064	0.004	0.199
	(0.703)	(0.885)	*	(0.051)	(0.026)	(0.056)
Austria	0.662	1.357	1.000	0.100	0.085	0.135
	(3.083)	(3.363)	*	*	(0.027)	(0.070)
Canada	0.041	0.137	1.000	0.101	0.022	0.158
	(0.067)	(0.847)	*	(0.032)	(0.053)	(0.060)
France	0.144	2.250	1.000	0.052	0.013	0.131
	(0.085)	(1.931)	*	(0.019)	(0.025)	(0.077)
Germany	0.117	2.360	1.000	0.316	0.017	0.205
	(0.060)	(3.197)	*	(0.105)	(0.047)	(0.085)
Italy	0.391	0.595	1.000	0.328	0.070	0.100
	(0.210)	(0.640)	*	(0.060)	(0.044)	*
Japan	0.253	4.320	1.000	0.228	0.001	0.143
	(0.085)	(3.697)	*	(0.077)	(0.020)	(0.058)
UK	0.607	1.021	1.000	0.100	-0.016	0.357
	(0.287)	(2.241)	*	*	(0.018)	(0.113)
US	0.108	1.699	0.494	0.534	0.010	0.100
	(0.277)	(1.920)	(0.966)	(0.107)	(0.037)	*

Standard errors in parentheses

* parameter is imposed

TABLE 3

COUNTRY	VARIANCES OF THE SHOCKS *						
	Supply		Demand				
	σ^2_u	σ^2_x	σ^2_ξ	σ^2_κ	σ^2_υ	σ^2_δ	$\beta^2_1\sigma^2_\tau+\beta^2_4\sigma^2_s$
Australia	0.112	0.153	1.585	0.354	0.007	0.389	23.386
Austria	0.048	0.165	0.098	0.018	0.014	0.411	1.549
Canada	0.042	0.003	0.185	0.201	0.011	0.604	6.271
France	0.017	0.006	0.422	0.057	0.012	1.560	10.072
Germany	0.030	0.004	0.540	0.162	0.009	0.417	0.864
Italy	0.032	0.016	0.374	0.314	0.010	0.206	0.756
Japan	0.028	0.008	1.568	0.222	0.008	0.758	1.209
UK	0.014	0.010	1.154	0.031	0.010	0.332	3.798
USA	0.019	0.016	0.548	0.123	0.020	0.115	0.349

* x1000

The second column of Table 2 shows the estimated values of α, the money-reaction parameter. These reveal a wide variety of monetary reactions across countries. However, the standard errors of these estimates are uncomfortably large; the difficulty in obtaining robust estimates for α might be due to changes in the way monetary policy was conducted in these countries over the sample period.

In all cases except for the United States, the parameter γ in the price equation was estimated to have the wrong sign. This created a problem since the concept of optimal wage indexation makes little sense if the aggregate supply curve has a negative slope. At the very least, such an occurrence suggests the possibility of a dynamically unstable model. This difficulty was resolved by imposing a positive value for γ. A value of unity was chosen; this choice did not substantially affect the estimated value of Θ, and so did not affect the test of whether the degree of wage indexation was optimal.

The third, fourth and fifth columns of Table 2 report the estimated values of the parameters of the aggregate demand equation (16), π_1, π_2 and π_5. Turning first to π_2, the results show that, for almost all countries, innovations to the real exchange rate have only small effects on innovations to aggregate demand. The estimates of π_1 and π_5 show that for nearly every country innovations to the growth of money and real government expenditure have important effects on unexpected output growth. These are robust results; in many cases the parameter estimates are significant at the one percent level.

Together with the estimated variances of the shocks (reported in Table 3), the parameter estimates are used to derive the estimates of the optimal degree of wage indexation, Θ. These are shown in the first column of Table 4. They range from a low of about 30 per cent for the Austria and the United States to a high of about 90 per cent for Australia, Canada, France and the United Kingdom. In the Australian case, for instance, the reason that Θ takes on such a high value is due to two factors, the relative dominance of demand shocks and the relative flexibility of the exchange rate, as reflected in a low value of α (i.e. innovations to money growth in Australia have been relatively insensitive to innovations in the inflation rate).

The role of the exchange rate regime in determining the optimal degree of wage indexation can be illustrated by comparing, for example, Canada and France. As shown in Table 3, the variance of demand shocks (relative to supply) is relatively greater in France. This would tend to make Θ larger for France than for Canada. However, the Canadian nominal exchange rate is the more flexible of the two (α = 0.137 for Canada versus α = 2.250 for France). The difference in exchange rate regimes offsets the effects of the relative shocks and so the estimated value of Θ is about the same for both countries.

A comparison of the first and third columns of Table 4 shows that in only one country, Austria, did the actual degree of wage indexation exceed the optimum value. In all the other countries, Θ exceeded θ, in many cases by a considerable margin. This implies an excess demand for labour. How can this result be reconciled with the high and generally increasing unemployment that was observed in these countries over the sample period ?

To answer this question one should remember that the estimated values of θ and Θ refer to the indexation of the *innovations* of

TABLE 4

TEST FOR OPTIMAL WAGE INDEXATION

COUNTRY	ESTIMATED PARAMETERS				
	Θ	σ^2_Θ	θ	σ^2_θ	Wald
Australia	0.902	0.023	0.125	0.494	1.165
Austria	0.285	0.579	0.662	9.507	0.014
Canada	0.926	0.005	0.041	0.005	85.947 *
France	0.890	0.008	0.144	0.007	35.713 *
Germany	0.649	0.138	0.117	0.004	2.000
Italy	0.728	0.016	0.391	0.044	1.889
Japan	0.518	0.167	0.253	0.007	0.405
UK	0.904	0.014	0.607	0.083	0.919
USA	0.316	0.591	0.108	0.077	0.065

* indicates rejection of the null hypothesis $\theta = \Theta$ at the five per cent level of significance.

wages to prices; nothing has been said about the indexation of *anticipated* wages to prices. It is possible that real wages in each country were set at the wrong level at the initiation of each wage contract, with wages thereafter being indexed at a rate equal to, or less than, the optimal rate. In this case, classical unemployment (due to real wages being above their market-clearing levels) would still exist, but to a lesser extent than if the degree of indexation exceeded its optimum.

This explanation is consistent with a high level of unemployment. However, it is inconsistent with unemployment levels that are both high and increasing, unless one is willing to entertain the notion that wage setters continually make, and compound, the same miscalculations in determining real wages. These errors would take the form of perpetually setting a real wage level at the beginning of each contract, that is not just excessively high, but increasingly so over time.

A more attractive explanation is that increases in unemployment in these countries were a result of hysteretic effects in the labour market. The idea is essentially that an increase in unemployment propagates itself long after the dissipation of the initial cause of that unemployment, due to such effects as depreciation of the human capital of the long-term unemployed. This train of events might be initiated by an adverse shock (e.g. an oil shock) which lowers the equilibrium real wage. If, following this shock, the actual real wage is not reduced sufficiently, an initial rise in unemployment will result. Even if wages are indexed at rates less than or equal to the optimum thereafter, hysteretic effects will cause continued high (and increasing) unemployment.[16]

The hypothesis of optimal wage indexation is formally tested by constructing the Wald statistic:

$$W \quad = \quad (\theta - \Theta)^2/(\sigma^2_\theta + \sigma^2_\Theta)$$

which is distributed as Chi-square$_1$.[17]

The Wald statistics in Table 3 show that only for Canada and France can the hypothesis of optimal wage indexation be formally rejected. Nevertheless, for all countries, except Austria, Θ appears to be significantly less than θ in an economic sense. There is no evidence, therefore, to support the existence of an "excessive" degree of wage indexation in the major industrial countries over the period 1973 to 1988, given the stance of monetary policy. A corollary to this conclusion is that there is no evidence to suggest that the exchange rate regime (by way of innovations to the growth of the money supply) was insufficiently accommodating to permit real wages to realize their equilibrium levels.

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[16] Blanchard and Summers (1986) provide evidence that hysteresis is an important cause of European unemployment.

[17] To construct the statistic W, one needs to assume a value for cov(θ,Θ), (I assume it is equal to zero) and to calculate the variance of the non-linear term Θ. Linearizing Θ by a Taylor expansion, its variance is obtained as a linear function of the variances of the estimated parameters and shocks. The details of this calculation can be found in Appendix 3.

6. SUMMARY AND CONCLUSIONS

The principal findings of this study are:

(i) the exchange rate regime is an important determinant, in both theory and practice, of the optimal degree of wage indexation;

(ii) over the period 1973 to 1988, innovations to nominal wage growth were indexed to innovations in price inflation in the major industrial economies at considerably *less* than the optimum rate. Thus, the simple explanation that the deterioration of labour market performance can be attributed to excessive wage indexation is not supported by the data;

(iii) equally, one cannot place the blame for the increase in unemployment on systematically restrictive monetary policy. There is no evidence to suggest that monetary policy persistently lowered the price level relative to the nominal wage, thereby creating an excessively high real wage.

These findings do not, however, necessarily preclude a more subtle role for real wages in the creation of labour market disequilibria. An excess supply of labour can co-exist with the optimal indexation of nominal wages to changes in the price level. This will occur if an adverse shock lowers the equilibrium real wage relative to its actual value and an appropriate adjustment is not made to the real wage level which forms the base for subsequent indexation. Hysteretic effects in the labour market are a possible mechanism by which this shock and its effects are propagated.

REFERENCES

Aizenman, Joshua and Frenkel, Jacob A. (1985), "Optimal Wage Indexation, Foreign Exchange Intervention, and Monetary Policy", *American Economic Review*, 75(3), 403-423, June.

Alogoskoufis, George and Alan Manning (1988), "Wage Setting and Labour Market Adjustment in Europe, Japan and the USA", Centre for Economic Policy Research Discussion Paper No.232, June.

Blanchard, Olivier and Lawrence Summers (1986), "Hysteresis and the European Unemployment Problem", in Stanley Fischer (ed), *NBER Macroeconomics Annual 1986*.

Blanchard, Olivier J. and Mark W. Watson (1986), "Are Business Cycles all Alike ?" in Robert J. Gordon. ed., *The American Business Cycle: Continuity and Change*, National Bureau of Economic Research Studies in Business Cycles Vol. 25, University of Chicago Press: Chicago and London.

Bruno, Michael and Jeffrey Sachs (1986), *Economics of Worldwide Stagflation*, Harvard University Press: Cambridge.

DeGroot, Morris H. (1986), *Probability and Statistics*, 2nd Edition, Addison-Wesley: Reading.

Devereaux, Michael (1988), "The Optimal Mix of Wage Indexation and Foreign Exchange Market Intervention", *Journal of Money, Credit and Banking*, 20(3), 381-392, August.

Fischer, Stanley (1977), "Wage Indexation and Macroeconomic Stability", in Karl Brunner and Alan H. Meltzer, (eds), *Stabilization of the Domestic and International Economy*, Vol. 5, Carnegie-Rochester Conferences on Public Policy, *Journal of Monetary Economics*, Suppl. 1977, 107-47.

Gordon, Robert J. (1988), "The Wage and Price Adjustment Process in Six Large OECD Countries", in Robert Z. Aliber, (ed), *The Reconstruction of International Monetary Arrangements*, Macmillan Press: London.

Gray, Jo Anna (1976), "Wage Indexation: A Macroeconomic Approach," *Journal of Monetary Economics*, 2, 221-35, April.

Hansen, Lars Peter (1982), "Large Sample Properties of Generalized Method of Moments Estimators", *Econometrica*, 50(4), 1029-1054, July.

Hausman, Jerry A. and William E. Taylor (1983), "Identification in Linear Simultaneous Equations Models with Covariance Restrictions: An Instrumental Variables Interpretation", *Econometrica*, 51(5), 1527-1549, September.

Hausman, Jerry A., Whitney K. Newey and William E. Taylor (1987), "Efficient Estimation and Identification of Simultaneous Equation Models with Covariance Restrictions", *Econometrica*, 55(4), 849-874, July.

Kaufman, R.T., and Woglom, G. (1987), "Cross-Country Differences in Wage Indexation: A Neoclassical Approach", mimeo.

Metcalf, D. (1987), "Labour Market Flexibility and Jobs - A Survey of Experience from OECD Countries with Special Reference to Great Britain and Europe", in P.R.G. Layard and L. Calmfors (eds) *The Fight Against Unemployment*, MIT Press: Cambridge.

Sargan, J.D. (1958), "The Estimation of Economic Relationships Using Instrumental Variables", *Econometrica*, 26, 393-415.

Turnovsky, Stephen J. (1987), "Optimal Monetary Policy and Wage Indexation Under Alternative Disturbances and Information Structures", *Journal of Money, Credit and Banking*, 19(2), 157-186, May.

Appendix 1

Data Definitions and Sources

Definitions:

y: real GNP(GDP)
m: M1
g: real government consumption
p: GNP(GDP) deflator
w: hourly earnings
e: trade weighted nominal exchange rate
pf: trade weighted GNP(GDP) deflator

The data are seasonally adjusted.

The sources for the data were the International Financial Statistics, published by the International Monetary Fund and the OECD Economic Outlook. The trade weights were calculated from exports and imports data from the IMF's publication, Direction of Trade. The details of these calculations are available from the author on request.

Appendix 2

Testing the Overidentifying Restrictions

The overidentifying restrictions were tested by constructing the following statistic for each estimated equation:

$$Q = TR^2$$

where T is the number of observations and R^2 is the coefficient of determination from a regression of the IV residuals on the available instruments. Q is distributed as Chi-square with degrees of freedom equal to the number of overidentifying restrictions. Its marginal significance level, for each test, is reported in Table A2.1.

The test results show that the overidentifying restrictions in the money supply and wage equations are not rejected at conventional significance levels. However, the evidence points to some correlation between the shocks to aggregate demand and the other shocks.

TABLE A2.1

SIGNIFICANCE LEVELS FOR Q

COUNTRY	EQUATION			
	wage	money supply	aggregate demand	price
Australia	0.540	0.423	0.000	-
Austria	0.714	0.614	0.000	-
Canada	0.775	0.127	0.000	-
France	0.175	0.806	0.000	-
Germany	0.012	0.901	0.000	-
Italy	0.344	0.009	0.000	-
Japan	0.199	0.509	0.000	-
UK	0.034	0.162	0.000	-
USA	0.424	0.845	0.000	0.000

Appendix 3

Calculating the Variance of Θ

Linearizing by a Taylor expansion around the estimated values of the parameters and variances reveals that

$$\sigma^2_\Theta = Z(BC\sigma^2_A + AC\sigma^2_B + AB\sigma^2_C)$$

$$+ Z^2(ABC\sigma^2_D + ABCF\sigma^2_E + ABCE\sigma^2_F),$$

where:

$$A = \beta_4+\beta_1\beta_3,$$

$$B = \beta_4\beta_2 + \beta_1(\alpha + 1),$$

$$C = (1+\varepsilon)\sigma^2_u + \varepsilon\sigma^2_x,$$

$$D = (\beta_4\beta_2)^2(\sigma^2_\xi + \sigma^2_\upsilon) + \beta^2_4(\sigma^2_\kappa + \sigma^2_s) + \beta^2_1(\sigma^2_\delta + \sigma^2_\tau),$$

$$E = A^2,$$

$$F = C - \sigma^2_x,$$

$$Z = (D + EF)^{-1}.$$

Calculation of σ^2_A ... σ^2_F requires knowledge of the variances of ε, β_2, β_3 and β_4, which are not estimated. However, the variances of

γ, π_1, π_2 and π_5 are estimated, and the necessary variances can be approximated by using the "Delta method" (De Groot (1986), pp 429-430) viz. for a random variable x,

$$\mathrm{var}\ f(x) \approx [f'(x)]^2 \mathrm{var}(x),$$

hence

$$\sigma^2_A = \sigma^2_{\pi 1}\beta^2_1/\pi^4_1,$$

$$\sigma^2_B = \beta^2_1\sigma^2_\alpha + \beta^2_2(\sigma^2_{\pi 5}\beta^2_1)/(\pi^4_1\beta^2_3) + \beta^2_4\sigma^2_{\pi 2}/\pi^2_5,$$

$$\sigma^2_C = (1/\gamma)^4\sigma^2_\gamma[(\sigma^2_u)^2 + (\sigma^2_x)^2]^2,$$

$$\sigma^2_D = 16(\sigma^2_\xi + \sigma^2_\upsilon)^2(\beta_4\beta_2)^2[\beta^2_2(\sigma^2_{\pi 5}\beta^2_1)/(\pi^4_1\beta^2_3) + \beta^2_4\sigma^2_{\pi 2}/\pi^2_5]$$

$$+ 4[(\sigma^2_\kappa)^2\beta^2_4(\sigma^2_{\pi 5}\beta^2_1)/(\pi^4_1\beta^2_3) + (\beta^4_1\sigma^2_{\pi 1}/\pi^6_1)\sigma^2_{ud}],$$

$$\sigma^2_E = 4\beta^4_1\sigma^2_{\pi 1}/\pi^6_1,$$

$$\sigma^2_F = (1/\gamma)^4\sigma^2_\gamma[(\sigma^2_u)^2].$$