Irish Inflation in EMS

PATRICK HONOHAN
Department of the Taoiseach, Dublin

JOHN FLYNN
Central Bank of Ireland, Dublin

Abstract: This paper outlines the interaction of Irish prices and wages, and highlights the crucial importance of foreign price movements in determining inflation in Ireland. The discussion is based on quarterly empirical estimates for the period 1972-84, covering both the sterling link and EMS regimes. The potential role of exchange rate policy, within the EMS, in influencing inflation is also analysed at a theoretical level.

I INTRODUCTION

D uring the sterling link period, the textbook view of inflation in a small economy, with fixed exchange rates, worked quite well in terms of explaining the evolution of Irish prices. Studies by P. T. Geary (1976), Geary and McCarthy (1976), Bradley (1977), FitzGerald (1981) and Browne (1983) all confirmed that Irish price inflation was essentially determined by, and more or less equal to, United Kingdom (UK) inflation. By the mid-1970s there were only a few dissenting voices from this view. Among these were proponents of the accounting view of price determination who argued that prices of goods and services not imported were under domestic influence and could not be regarded as determined abroad. This view largely neglected the equilibrium dynamics of the economy and the function of prices in allocating resources. Some other doubts were raised by O'Casaide (1977) and R. C. Geary (1981). O'Casaide pointed out that domestic demand conditions seem to have some influence on the prices of domestic non-traded goods. Geary observed that the money supply was a leading indicator of prices.

So far as wages are concerned there has been a view that some (limited) sensitivity of wages in the non-traded sector to domestic demand conditions existed. However, for neither wages nor prices was the trend rate of inflation thought to be sensitive to domestic factors before Ireland joined the European Monetary System (EMS) in 1979.

In the EMS period we observe wide discrepancies between inflation in Ireland and the UK — or indeed any other country. Realignments of exchange rates have been frequent, and while the currency is not floating, it is clearly not fixed to the same degree as under the sterling link (cf. Walsh, 1983). This could lead one to conclude that the whole purchasing power parity idea, which underlay the external determination of prices, has broken down for Ireland, leaving a conceptual void for the analysis of price determination.

The purpose of this paper is to sketch how this void might be filled with some empirical evidence and with a theoretical model of price determination under fixed but adjustable parities.

II EMPIRICAL EVIDENCE ON SHORT-RUN DETERMINANTS OF PRICES AND WAGES

In this section we present a preliminary and skeletal empirical analysis of price-wage interactions. Our approach is to attempt to isolate the key relationships within an "error correction" framework. Error correction models are suited to processes which have a stable long-term relationship from which more or less enduring deviations can be expected. We followed a couple of non-standard methodological rules in specifying the relationships. It is worth mentioning these together with an indication of their rationale: a similar approach was adopted in Honohan (1984).

> Quarterly data for Ireland are characterised by occasional but very large outliers. We take the view that attempting to explain these outliers within a simple model risks seriously biasing coefficient estimates, as their causes are more likely to be exceptional factors. Accordingly we included intercept dummies for outliers of about three standard deviations or more.

> To minimise the risk of data mining we attempt to err on the side of including too few rather than too many variables. This also helps interpretability, while increasing, of course, the risk of omitted variables bias. We do, however, test explicitly for such bias.

There are similarities and contrasts with the approach adopted by Davidson et al, (1978). The main contrast is that we do not begin with as unrestricted a model as they do.

For each dependent price we model its percentage change as being driven, on the one hand, by current and recent percentage changes in one or more other

prices and on the other hand, by a conservative tendency to restore relative prices to their mean level[1]. The latter effect is obtained by the inclusion of the lagged relative price as an error correction or catching-up term. This term is lagged either one or four quarters, the exact choice being made empirically on the basis of goodness of fit. Schematically the interactions we model are as shown in Figure 1. Each equation was tested for stability across the change in exchange rate regime and none failed this test.

2.1 Import Prices

In the pre-EMS, sterling-link, period, it was axiomatic that Irish pound import prices were more or less completely determined by inflation in the UK. For the EMS period the question arises whether it is fair to assume that Irish pound import prices can be modelled as a convergence to purchasing power parity, with foreign prices (converted to Irish pounds at prevailing exchange rates) still being the ultimate determinant. While we have been able to confirm that this is the case using monthly post-EMS data, the equation presented here is based on quarterly data 1972–1984. Thus Equation A models an error correc-

Figure 1: *Main price-wage interactions*
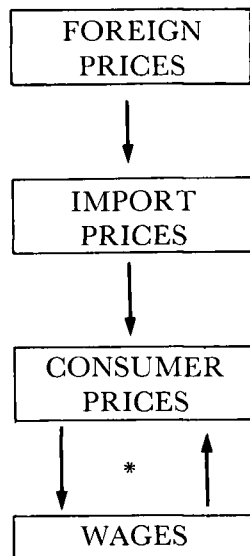
*Lagged effect only from consumer prices to wages.

1. Over periods as long as 15 years, one could also expect changes in equilibrium relative prices. We accept the comment of a referee that long-term structural changes are neglected in our equations. This is partly a function of our preference for erring on the side of underspecification; however, we did experiment with time trends and other variables as described in the Appendix.

tion mechanism, where short-run movements in foreign prices have a less than
one-for-one impact on Irish pound import prices in the first two quarters, but
where no permanent discrepancy between the rate of inflation at home and
abroad can persist in view of the error correction term in lagged relative prices[2].

The convergence towards a long run equilibrium relationship between
import and foreign prices (adjusted for exchange rates) can be seen by rewriting
Equation A as

$$\Delta PM = 0.452 \ (\Delta PF + \Delta PF(-1)) - 0.206 \left\{ \frac{PM \ (-4)}{PF \ (-4)} - 0.98 \right\}$$

The impact effect of a 10 per cent increase in foreign prices or the exchange
rate is thus to increase import prices by 4.52 per cent in each of the current and
following quarters. Whenever the import/foreign price ratio exceeds 0.98 times
its 1975 ratio (1975 is the base year for the price ratios), this equation indicates
that, all other things being equal, 0.206 or one-fifth of the discrepancy will be
closed in one quarter, and a half of the discrepancy within about three quarters.

2.2   Consumer Prices

As shown in Hackett and Honohan (1981) for quarterly data, the short-run
evolution of consumer prices in Ireland is strongly influenced by movements in
Irish pound import prices and in wage rates over the previous few quarters.

Equation B illustrates a more recent implementation of this type of mark-up
model. Instead of estimating in levels, we use first differences and an error
correction mechanism. It is clear that consumer price inflation converges to a
parity with import price changes, although as can be seen from Table 1 domestic
wage inflation has a significant short-run role[3].

2.3   Wages

Up until the recent study by Hughes (1985) (which focuses on the role of
payroll taxes) the determination of inflation had not been econometrically
studied in sub-annual data for many years. We feel that import prices will
ultimately be the dominant factor here too, with the channel of causation
passing with a lag through consumer prices. Some evidence for this is presented
in Equation C though the full story is undoubtedly more complex.

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2. The import price index is partially chain-weighted, with the weights being updated each January: this is a
source of noise, although we found no autocorrelation at lag twelve when we successfully estimated this
equation on monthly data.
3. It seems obvious to us that indirect taxes and subsidies have a strong effect also on the level of consumer
prices. However, attempts to model them in Hackett and Honohan (1981) were unsuccessful and it appears
that quite elaborate data construction will be necessary to capture these effects.

Table 1: *Empirical Results*

Equation A - Import Prices

ΔPM = 0.202 + 0.452 Δ*PF - 0.206 (PM/PF) (-4)
      (3.82) (6.83)   (3.20)

RSQ = 0.542   SER = 0.022   DW = 1.80   Half-life = 3.0 quarters

Equation B - Consumer Prices

ΔP = 0.065 + 0.251 Δ*W + 0.126 Δ*PM - 0.050 (P/PM)(-4) - 0.038D75(3) + 0.038D81(4)
     (2.87) (2.23)   (3.20)   (2.39)   (2.78)   (2.97)

RSQ = 0.459   SER = 0.013   DW = 1.95   Half-life = 13.5 quarters

Equation C - Wages

ΔW = 0.096 + 0.548 ΔP(-2) - 0.074(W/P)(-1) + 0.054D79(3) + 0.042D80(1)
     (3.59) (3.86)   (2.89)   (3.41)   (2.61)

RSQ = 0.475   SER = 0.016   DW = 1.85   Half-life = 9.0 quarters

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Period: Quarterly 1972:2 to 1984:1
t-statistics in parentheses
Note: Δ*x means Δx + Δx(-1).

2.4 Summary of Empirical Results

Of course the empirical results are sketchy, as we have only modelled price–price or wage–price interactions. We do not pretend that they cannot be improved upon but they serve to illustrate the dynamic which we stress. To summarise, foreign prices, converted at the exchange rate, affect import prices immediately and also with a lag. Import prices and wage rates affect consumer prices also, both immediately and with a lag. Consumer prices in turn affect wage rates, with a lag. These processes are convergent, so that an initial foreign price shock will ultimately be transmitted one-for-one onto consumer prices if there is no change in the exchange rate.

Working through the interactions of the three equations it is possible to compute the estimated time path of the response of domestic prices and wages to a 10 per cent increase in foreign prices. Two quarters after the increase, import prices have risen by 9.2 per cent, and consumer prices by 2.5 per cent with little response yet in wages. It takes about 6 quarters for consumer prices to increase by 5 per cent and 10 quarters in the case of wages. Figure 2 illustrates the process. The estimated response times are much longer than those estimated by Bradley for the sterling link period, and a little longer than we would have expected. It should be stressed that less reliance can be placed on the estimated time path beyond the first 2 years or so.

Figure 2: *Timepath of consumer prices and wages following a 10 per cent increase in foreign prices (calculated from Equations A to C).*
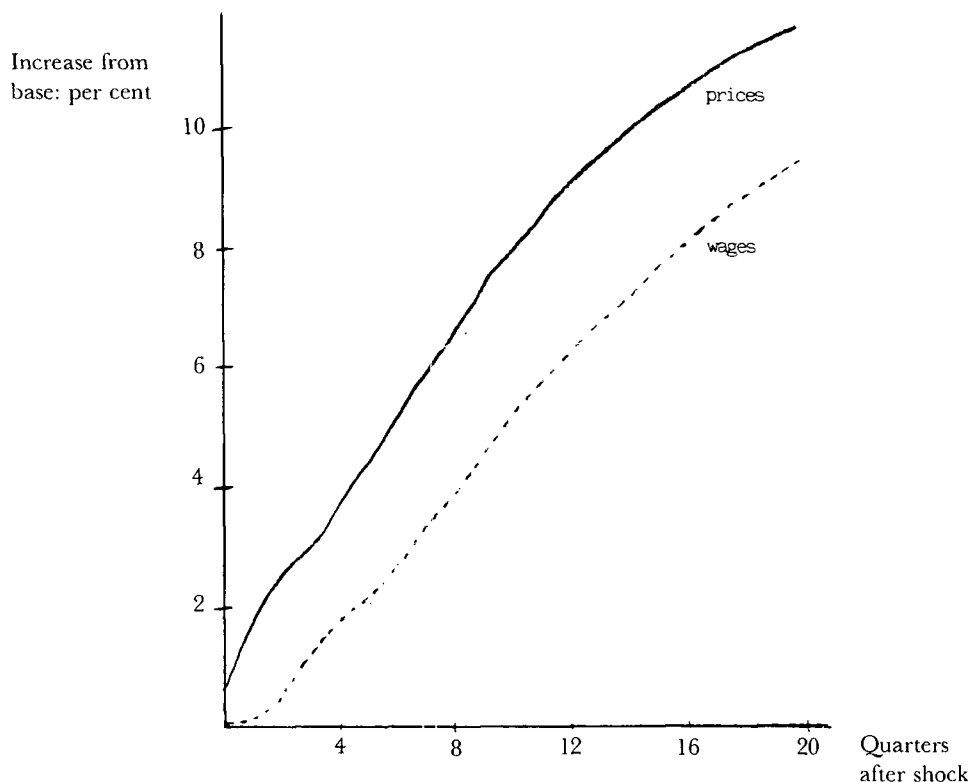
An implication of our model is that exogenous factors such as an exceptionally high wage agreement,[4] although perhaps having short term real effects on output and employment, will not hinder convergence of domestic prices to foreign prices, provided there is no change in the exchange rate.

If the exchange rate does respond, however, then the ultimate impact of foreign price changes could be other than one-for-one. Likewise a positive shock to wage rates could in this case lead to a difference, even in the long run, between foreign and domestic prices. As we have no empirical equation for exchange rates, we must rely on theoretical analysis to flesh out this intuition.

There are standard ways of analysing the long-run response of a price–wage system where the exchange rate is freely floating or responds in a simple linear fashion to unwarranted disturbances (cf. Blejer and Leiderman, 1981). There is also a theoretical literature on the impact on price stability of a policy of adjusting exchange rates continuously in response to emerging competitive pres-

4. i.e., a large positive disturbance in the wage equation.

sures.[5] In the EMS, however, exchange rate movements happen only compara-
tively rarely and in discrete jumps. The recent literature does not address this
situation. The remainder of this paper is, therefore, devoted to analysing, in a
theoretical framework, the impact of an exchange rate regime of discrete
changes, and the authorities' response within this regime, on the long-run rate of
inflation.

III   A SIMPLE MODEL WITH FIXED BUT ADJUSTABLE PARITIES

The empirical work of Section II has stopped short of specifying a model of
exchange rate formation within the EMS. There are several reasons for this, not
least the paucity of data on parity changes. Nevertheless, the possibility of dis-
crete parity adjustments is the essential feature of the EMS from the point of
view of medium-run inflation determination.

Accordingly, it is important to have a theoretical model of how exchange rate
policy in a regime of fixed but adjustable parities might interact with the
remainder of the price–wage system, as already sketched. Naturally we are not
passing judgement on exchange rate policy as practised. Our model, though
simple, is chosen so as to encompass a variety of policy "styles".

To summarise our conclusions in advance, we find that the economy is more
inflation-prone, the faster inflationary expectations respond to experience and
the more the authorities adjust parities in response to changes in competitive-
ness. It is less inflation-prone, the greater the sensitivity of prices to changes in
competitiveness. All of these conclusions are consistent with conventional views,
and that suggests that our model can provide an acceptable framework for
further quantitative analysis.

3.1   The Model

In order to keep things manageable we take only one domestic price or cost
variable, which is denoted p. The exchange rate (price of foreign exchange) is
denoted e. The variables should be thought of as being measured in logarithms.
Drawing on the empirical results in Section II, we propose that the evolution of p
should be governed by

   (i)   an inertial expectations term g and

5. See, for example Dornbusch (1982). A feature of Dornbusch's paper is that he allows the government to
adjust the exchange rate continuously, but only partially, in response to changes in costs and competitiveness.
The next section of this paper has the government choosing probabilistically, and at discrete intervals, to make
an adjustment whenever internal costs or prices move out of line with the exchange rate. An implication of
Section 3.3 below is that the steady state behaviour of the real exchange rate in our model likewise involves
a partial adjustment.

(ii)   a feedback, or catch-up, term $\alpha(p-e)$, depending on the real exchange rate.

In all the empirical equations contemporaneous or recent changes in other prices were important. That is what is to be captured by g, the expectations term, as prices in one market are being adjusted in line with what is happening to other prices.[6] The catch-up term was also a feature of each of our empirical equations. In this case it can be seen as a negative feedback from competitive pressures onto the inflation rate. In addition, there are exogenous shocks, u_t.

Specifically, therefore, the price equation is

$$p_{t+1} = p_t + g_t - \alpha(p_t - e_t) + u_t \tag{1}$$

We assume that the authorities adjust the exchange rate only when domestic costs get out of line, leading to balance of payments and/or employment difficulties at home.

In particular, we represent the decision to change the parity as a probabilistic one. The probability that the parity will be changed is seen as depending on the deviation of domestic costs from foreign prices. The typical realignment in the EMS involves a discrete change in parities of the order of about 5 per cent. We assume that the size of this step is not a choice variable for the authorities. When they change the parities they do so by "one notch".

Notationally, the foreign price in foreign currency is numeraire and an equilibrium is represented by (the log of) domestic prices/costs p equalling the (log) price of foreign exchange e:

$$e_{t+1} = e_t \text{ with probability } 1 - \varphi(|p_t - e_t|)$$
$$\tag{2}$$
$$e_{t+1} = e_t + \text{sgn}(p_t - e_t) \text{ with probability } \varphi(|p_t - e_t|)$$

where φ, the probability of realignment, is an increasing function of the absolute deviation of domestic costs from foreign prices.

We simplify by assuming the functional form for φ as defined by

$$\varphi(x) = \min\{1, \beta x\}, \quad \text{for all } x \tag{3}$$

With this response function, a completely rigid exchange rate policy is $\beta = 0$.

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6. The term g should not be interpreted simply as the expected rate of inflation. It represents the contribution of inflationary expectations to actual price inflation and should be thought of as summarising effects such as those which might result from overlapping contracts and mark-up pricing. That is why we later explore the implications of adaptive specifications of g. With rational expectations, g would only equal expected inflation if p = e.

The larger is β the more responsive the authorities are to competitive pressures. In the next section we present some simulations to indicate the effect of different values of the feedback parameter α and the policy response parameter β. But first it is appropriate to describe some implications of different specifications of the expectations term g.

3.2   g constant, $\beta = 0$

Since the term g drives the inflation process in the absence of shocks, u_t, it is worth asking what the inflation rate will be if g is constant. If the exchange rate is rigid, $\beta = 0$, then a constant value of g does not imply a constant inflation rate, as might be supposed. Instead, for $\beta = 0$ the rate of inflation converges to zero, and the real exchange rate, given by

$$p_t - e = \left(p_0 - e - \frac{g}{\alpha}\right)(1 - \alpha)^t + \frac{g}{\alpha} \tag{4}$$

converges to $\frac{g}{\alpha}$.

3.3   g constant, $\beta > 0$, steady-state inflation

In a steady state, characterised by

$$E(p_{t+1} - p_t) = E(e_{t+1} - e_t) \tag{5}$$

where E denotes the expectations operator, we obtain expressions for the real exchange rate and the steady state rate of inflation

$$E(p_t - e_t) = g/(\alpha + \beta) \tag{6'}$$

and

$$E(p_{t+1} - p_t) = \frac{\beta}{\alpha + \beta} \cdot g \tag{6''}$$

Thus, in the steady state, (i) the real exchange rate is positively related to g and (ii) the steady state inflation rate is not equal to g. Equation 6 also shows the inverse relation between steady state real exchange rate and inflation rate, and the feedback parameter α. The policy response parameter β is positively associated with steady state inflation and negatively with the real exchange rate.

From (5) and (6)

$$E(p_t - e_t) = E(p_{t+1} - p_t)/\beta \tag{7}$$

We conclude that, in this model, different non-zero steady state inflation rates imply different real exchange rates. This casts doubt over the indefinite sustain-

ability of steady inflation in a crawling-peg world, as inflation means a less competitive exchange rate. In effect, the lagged response of exchange rate movements causes a persistent deviation of the real exchange rate from equilibrium.

3.4 Adaptive Specification of g

A consequence of Equation (6) is that a familiar but unsophisticated adaptive specification of g, such as

$$g_t = \lambda(p_t - p_{t-1}) + (1 - \lambda)g_{t-1} \tag{8}$$

with $0 \leqslant \lambda \leqslant 1$, can never converge to a steady state but results in ever spiralling inflation (unless $\beta = 0$).

A more sophisticated adaptive formulation, which allows convergence to the steady state, is given by (9) and (10)

$$g_t = \lambda\{(p_t - p_{t-1}) + h_t\} + (1 - \lambda)g_{t-1} \tag{9}$$

where

$$h_t = \lambda'\alpha(p_t - e_t) + (1 - \lambda')h_{t-1} \tag{10}$$

This formulation envisages some account being taken by agents in their expectations formation of the feedback term.

These two adaptive formulations are used in the simulations of the next section.

IV SIMULATION RESULTS

A variety of simulations was carried out, a representative selection of which is reported here. In Tables 2 to 4 we report the terminal domestic price level in a simulation which begins with p and e at zero and subjects the system to a series of 10 price shocks, each making a direct impact effect on prices of 0.5, totalling 5.0. Of course the negative feedback tends to reduce this total, while the exchange rate response amplifies it. The elasticity of expectations also tends to raise the final price level.

The probabilistic nature of the exchange rate policy means that the time path of prices and exchange rate must be simulated a number of times with a view to estimating the average effect of policy. The simulations involved 20 replications for each experiment and the standard error of the terminal values is shown in parentheses in each case.

4.1   λ = 0: Table 2(a)

The first simulation assumed inelastic expectations, $\lambda = 0$. The results are summarised in Table 2(a). The mean terminal price level is, as expected, negatively related to the size of the feedback coefficient, α, and positively to the exchange rate response parameter, β.

It may be noticed that, for sufficiently high β and low α, the final price level is close to the sum of the direct shocks. Inspection of the time paths, however, reveals that a zero inflation rate has been reached by period 20 in all cases with inelastic expectations, and the real exchange rate e –p has returned to its pre-shock value.

Table 2: *Price level after 20 periods (Standard errors in parentheses)*

(a) Static expectations, $\lambda = 0$

α \ β	0.01	0.1	0.5	1.0
0.1	1.52 (0.29)	2.82 (0.38)	4.21 (0.16)	4.55 (0.20)
0.5	0.10 (0.30)	1.00 (0.95)	2.34 (0.45)	2.50 (0.75)
0.9	0.05 (0.66)	0.60 (0.22)	1.15 (0.73)	1.97 (0.59)

(b) Expectations coefficients, $\lambda = 0.7$, $\lambda' = 0$

α \ β	0.01	0.1	0.5	1.0
0.1	2.04 (0.67)	6.74 (0.99)	14.83 (0.90)	16.50 (0.68)
0.5	0.05 (0.38)	1.19 (1.22)	4.11 (1.24)	8.58 (1.12)
0.9	0.00 (0.00)	0.74 (0.83)	1.36 (0.86)	4.54 (1.71)

4.2   λ = 0.7; λ' = 0: Tables 2(b), 3 and 4(a)

For the simple adaptive expectation scheme, we find that sufficiently low values of α lead to an enduring inflation.[7] Even with $\beta = 0.01$ the shock has not been eliminated after 20 periods. For the more elastic exchange rate responses the price at period 20 greatly exceeds 5. Table 4(a) confirms that p has settled down to an asymptote by period 20 for $\alpha = 0.5$ and 0.9. But for $\alpha = 0.1$, there is still inflation, albeit gradually slowing, at period 50; the rate being about 0.1 per period for $\beta = 0.5$ and more than twice that rate for $\beta = 1.0$.

7. Much the same results were obtained with $\lambda = 0.9$.

Table 3: *Real exchange rate (p − e) after 20 periods*

(a) Expectations coefficients, $\lambda = 0.7$, $\lambda' = 0$

α \ β	0.01	0.1	0.5	1.0
0.1	1.29	1.19	1.03	0.60
0.5	0.10	0.01	0.06	0.23
0.9	0.00	0.01	0.09	0.04

4.3 $\lambda = 0.7$; $\lambda' = 0.7$: Table 4(b)

Finally, we inspect the case where $\lambda' \neq 0$, which, as already shown, is consistent with steady-state inflation. Only combinations of high values of α and low values of β can prevent the postulated shock from producing a lasting inflation. If, for instance, $\alpha = 0.5$ and $\beta = 0.5$, inflation at period 50 is running at a steady 0.6 per period and the real exchange rate is a full unit from equilibrium. In this case, therefore, a shock of 0.5 per period over 10 periods produces an essentially permanent inflation rate in excess of 0.5 per period, due to the response of inflationary expectations and the response of the authorities in adjusting the exchange rate.

Table 4: *Price level after 50 periods*

(a) Expectations coefficients, $\lambda = 0.7$, $\lambda' = 0$

α \ β	0.01	0.1	0.5	1.0
0.1	1.96 (1.03)	5.04 (2.30)	22.15 (1.81)	29.50 (1.56)
0.5	0.05 (0.38)	1.05 (1.07)	4.16 (1.44)	9.71 (1.76)
0.9	0.05 (0.22)	0.65 (0.96)	0.89 (2.40)	5.04 (2.24)

(b) Expectations coefficients, $\lambda = 0.7$, $\lambda' = 0.7$

α \ β	0.01	0.1	0.5	1.0
0.1	11.81 (1.48)	29.66 (0.90)	48.49 (0.51)	49.34 (0.50)
0.5	2.58 (0.77)	8.54 (0.83)	28.28 (1.98)	37.76 (0.56)
0.9	1.38 (0.49)	5.82 (1.39)	15.97 (1.29)	26.93 (0.53)

4.4   Summary of Simulations

The simulations confirm our prior expectation that the regime of fixed but adjustable parities can convert a shock to the price level into permanent inflation. Only if the elasticity of inflationary expectations is zero will this inherent lack of stability be definitely ruled out. The problem is more serious the greater the tendency to adjust the exchange rate. If there is a strong feedback from the real exchange rate to domestic costs, then the problem will be less serious.

V   CONCLUSIONS

In the absence of exchange rate changes, domestic price and wage inflation is largely determined externally. We have presented the outline of an empirical representation of the path and speed of interactions.

If the exchange rate is subject to discretionary change in response to what would, in any event, be transitory changes in competitiveness, then the ultimate response of domestic wages and prices to a shock can be greatly magnified.

Further analysis to elaborate the empirical model and possibly to integrate it more closely with the theoretical discussion should prove fruitful.

REFERENCES

BLEJER, M. I. and L. LEIDERMAN, 1981. "A Monetary Approach to the Crawling-Peg System: Theory and Evidence", *Journal of Political Economy*, Vol. 89, No. 1, pp. 132-151.

BRADLEY, J., 1977. "Lags in the Transmission of Inflation", *The Economic and Social Review*, Vol. 8, pp. 149-154.

BROWNE, F. X., 1983. "The International Transmission of Inflation to an SOE, Under Fixed Exchange Rates and Highly Interest Sensitive Capital Flows — An Empirical Analysis", Central Bank of Ireland, Technical Paper 4/RT/83.

DAVIDSON, J. E., D. F. HENDRY, F. SRBA and S. YEO, 1978. "Econometric Modelling of the Aggregate Time Series Relationships Between Consumers Expenditure and Income in the UK", *Economic Journal*, Vol. 88, p. 670.

DORNBUSCH, R., 1982. "PPP Exchange Rate Rules and Macroeconomic Stability", *Journal of Political Economy*, Vol. 90, pp. 158-165.

ENGLE, R. F., 1982. "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of UK Inflations", *Econometrica*, Vol. 50, pp. 987-1008.

FITZGERALD, J. D., 1981. "A Study of the Determinants of Irish Industrial Output Prices", Mimeo, ESRI.

GEARY, P. T., 1976. "Lags in the Transmission of Inflation: Some Preliminary Estimates", *The Economic and Social Review*, Vol. 7, pp. 391-400.

GEARY, P. T. and C. McCARTHY, 1976. "Wage and Price Determination in a Labour-Exporting Economy", *European Economic Review*, Vol. 12, pp. 163-166.

GEARY, R. C., 1981. "Monetarism in Ireland: A Simple Statistical Approach", *The Economic and Social Review*, Vol. 12, pp. 163-166.

HACKETT, A. and P. HONOHAN, 1981. "Some Determinants of Consumer Prices", Central Bank of Ireland, Technical Paper 10/RT/81.

HONOHAN, P. 1984. "The Evolution of the Rate of Unemployment in Ireland 1962-1983",
     Quarterly Economic Commentary, May, pp. 41-58.
HUGHES, G., 1985. *Payroll Tax Incidence, the Direct Tax Burden and the Rate of Return on State Pension
     Contributions in Ireland*, Dublin: The Economic and Social Research Institute, (Paper 120).
O'CASAIDE, C., 1977. "The International Transmission of Inflation and the Balance of
     Payments Under Fixed Exchange Rates", Unpublished Thesis, University of Manchester.
WALSH, B. M., 1983. "Ireland in the European Monetary System: The Effects of a Change in
     Exchange Rate Regime", in M. de Cecco (ed.), *International Economic Adjustment: Small
     Countries and the European Monetary System*, pp. 160-188, Oxford: Basil Blackwell.

APPENDIX

THE ECONOMETRIC ESTIMATES

Our model, apart from dummies, is

$$\Delta PM = \alpha_1 L\Delta PF - \beta_1 \left(L\frac{PM}{PF} - \gamma_1 \right)$$

$$\Delta P = \alpha_2 L\Delta W + \alpha_3 LPM - \beta_2 \left(L\frac{P}{PM} - \gamma_2 \right)$$

$$\Delta W = \alpha_4 L\Delta P - \beta_3 \left(L\frac{W}{P} - \gamma_3 \right)$$

Where PM, PF and P are import, foreign and consumer prices, and W is wages. Foreign prices are converted to Irish pound prices.

The lag structures L were determined empirically. In the case of the impact effects a lag length test indicated that lag was not needed in the price equations. Imposing equality of coefficient on current and lag 1 was not rejected. For the wage equation only lag 2 was significant. The choice between lag 1 and 4 for the error correction term was based on R^2.

The chosen specification was successfully tested for autoregressive conditional heteroscedasticity up to fourth order. Autocorrelation does not appear to be a problem, based on the Durbin–Watson and Box–Ljung Q statistics.

The implied equilibrium relative prices γ_i could depend on current economic conditions or longer-term trends. The chosen specification was tested against inclusion of unemployment, current and lagged, industrial production and linear and quadratic time trends. Out of 40 diagnostic tests, the expected number (two) only were significant at the five per cent level as indicated in Appendix Table 1.

Test statistics

The Q statistics are Box–Ljung test statistics for serial independence. The 5 per cent limit for Q(12) is 21.03 and for Q(24) = 36.42.

The F and ARCH statistics reported are the results of specification tests for various types of errors including omitted lags, omitted variables and autoregressive conditional heteroscedasticity.

F_1, F_2, F_3:   F-tests for the omission of the contemporaneous value, lag 1 and lag 2 of the explanatory variable respectively.

F_4, F_5, F_6:   F-tests for the omission of unemployment, lagged unemployment and industrial production respectively from the various equations.

F_7, F_8:   F-tests for the omission of linear and quadratic time trends respectively.

At the 5 per cent level the critical values for all F-tests carried out lie between 4.00 and 4.08. An asterisk denotes a significant test.

ARCH: χ^2 test for ith order autoregressive conditional heteroscedasticity (ARCH) using the test developed by Engle (1982). At the 5 per cent level the critical values are

$ARCH_1 = 3.84$
$ARCH_2 = 5.99$
$ARCH_3 = 7.81$
$ARCH_4 = 9.49$

The Chow F-statistic tests the stability of the equations when the sample is split between the pre- and post-EMS periods. The critical value is 3.3.

Definitions

ΔPM: Percentage change in import unit value index. *Source: Trade Statistics of Ireland.*

ΔPF: This variable gives the trade weighted average percentage change of prices and exchange rates in Irish currency terms *vis-à-vis* the UK, US and Germany. The price and exchange rate series were obtained from the OECD tapes while the trade weights were derived from data taken from the *Trade Statistics.*

ΔW: Percentage change in hourly earnings in manufacturing (seasonally adjusted). *Source:* OECD.

ΔP: Percentage change in the Consumer Price Index (seasonally adjusted). *Source:* OECD.

ΔU: Percentage change in the unemployment rate (insured). *Source:* OECD.

D75(3), D79(3), D80(1): Intercept shift dummies for specified year (quarter).

   The error correction term indicates how fast deviations from equilibrium tend to be closed. The "half-life" gives the number of quarters required to close at least half of any emergent gap.

Appendix Table 1: *Test Statistics*

Dependent Variable:	Equation A ΔPM	Equation B ΔP	Equation C ΔW
Statistic			
F_1			0.76
F_2			0.14
F_3	2.28	0.23	
F_4	2.88	4.07*	1.04
F_5	6.74*	3.03	0.94
F_6	1.55	1.60	0.01
F_7	1.52	0.10	0.05
F_8	1.88	0.02	0.39
$ARCH_1$	0.13	1.18	0.31
$ARCH_2$	0.36	5.06	1.85
$ARCH_3$	0.62	5.28	1.64
$ARCH_4$	0.66	5.82	9.26
Q(12)	9.56	17.40	7.24
Q(24)	21.56	29.09	25.32
Chow-F	3.15	0.19	0.48

*Significant at the five per cent level.