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AN EMPIRICAL ANALYSIS OF NOMINAL EXCHANGE RATE

SHOCKS IN A SMALL ECONOMY: IRELAND 1960 to 1983

Rodney Thom

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AN EMPIRICAL ANALYSIS OF NOMINAL EXCHANGE RATE SHOCKS

IN A SMALL ECONOMY: IRELAND 1960-1983

1. INTRODUCTION

The interaction between nominal exchange rate movements, international competitiveness and real output has been a topic of considerable interest since Dornbusch's 1976 paper on expectations and exchange rate dynamics. Dornbusch proposed a model which treats the exchange rate as a forward looking variable determined in an efficient market capable of rapid responses to new information or policy changes. The domestic price level, on the other hand, is viewed as a backward looking variable which produces sluggish responses to the emergence of excess demand in the commodity market. Hence movements in a small economy's price level are assumed to lag changes in nominal exchange rates leading to jumps in competitiveness with subsequent implications for output and employment.

Although most of the literature on overshooting\(^1\) is concerned with the effects of monetary policy under flexible exchange rates, some elements of the analysis are relevant to small economies which participate in a fixed or quasi-fixed exchange rate regime which excludes a major trading partner. Ireland is undoubtedly a classic example of such an economy. Since March 1979 Ireland has participated in the European Monetary System (EMS) while the United Kingdom, which accounts for approximately 40 per cent of Irish trade, has not.\(^2\) A major consequence of this arrangement has
been that movements in the nominal exchange rate against Sterling have, given Ireland's EMS parity, been determined by the value of Sterling against the major participating currencies. To illustrate, consider an appreciation of Sterling against the D-Mark resulting from a UK monetary contraction or a rise in world oil prices for example. As the EMS links the Irish Pound to the D-Mark then the resulting depreciation against Sterling will directly affect the prices of traded goods and the Irish price level will tend to rise as a consequence of the exchange rate shock. However, if domestic output and imports are imperfect substitutes or if the non-traded sector is significant the rise in the price level may not fully reflect the depreciation with the consequence that Ireland will gain in competitiveness against the UK but lose against its EMS partners. Conversely, a depreciation of Sterling against the D-Mark should lead to a loss in Irish competitiveness on UK markets and to gains within the EMS.

It is, of course, important to note that if purchasing power parity (PPP) was the sole explanation for exchange rate movements then changes in nominal exchange rates would be of little consequence for the Irish economy. If, for example, UK inflation fell by 5 per cent relative to inflation rates in EMS countries and, as a consequence, Sterling appreciated by a compensating amount against member currencies, then real exchange rates (or relative prices expressed in a common currency) would remain unchanged. However, most of the evidence from the 1970's and 1980's suggests that PPP may not hold in the short run. Over the first two years of the EMS, for example, the UK wholesale price index rose by
13 per cent relative to the West German index while Sterling appreciated by approximately 20 per cent against the D-Mark and by 18 per cent against the Irish Pound. Given that British and Irish inflation rates were similar during this period the nominal appreciation of Sterling lead to a significant real depreciation of the Irish Pound against Sterling and to a real appreciation against other EMS currencies.

The magnitude of these shifts in competitiveness is illustrated by Figure 1 which shows quarterly movements in three real exchange rates over 1977(1) and 1983(4). The dashed line traces movements in Irish competitiveness against the UK. The dotted line is the real exchange rate against the D-Mark while the solid line illustrates a trade weighted average of real exchange rates against Sterling, the D-Mark and the US Dollar. The real exchange rates are defined as the nominal exchange rate (Irish pound price of foreign currency) times the ratio of the foreign to the domestic wholesale price index.

The volatility of Irish competitiveness since joining the EMS has been noted elsewhere and has lead several authors, especially McCarthy (1982) and Walsh (1983), to explore the possibility of alternative exchange rate policies against non-participating currencies. However little empirical evidence has been produced on the significance of exchange rate movements for domestic output and employment. Although there is general agreement that nominal exchange rate changes are neutral in the "long-run" there is considerable ambiguity concerning their real effects in the short-run. The primary aim of this paper is therefore to investigate the short-run price and output responses to nominal exchange rate movements using
quarterly Irish data over 1960(1) to 1983(4) with particular emphasis on the EMS period since 1979(1). The approach taken in the next Section is to evaluate the responses of industrial production and wholesale prices to random disturbances in the nominal exchange rate using the innovation- accounting techniques developed by Sims (1980). A five variable model consisting of quarterly observations on output, the price level, and interest rate, the wage rate and the exchange rate is estimated as an unconstrained vector autoregression (VAR). The moving average representation of the VAR is then used to undertake two innovation- accounting exercises. First, the VAR is employed to trace impulse responses for each variable to one period shocks in the nominal exchange rate. Second, the moving average representation is employed to decompose the forecast error variances into proportions attributable to each variable's innovations. Section 2 outlines the methods used and reports the innovation-accounting results. Section 3 presents the results of simulations based on alternative paths for the exchange rate. The conclusions are summarised in Section 4.

2. INNOVATION-ACCOUNTING

A vector autoregressive system may be conveniently expressed as

\[ F(L)Y_t = u_t \]  (1)

where \( t \) is time, \( Y \) is an \( nx1 \) vector of endogenous variables, \( u \) is an \( nx1 \) vector of random disturbances (innovations) and \( F(L) \) is an \( nxn \) matrix of polynomials in the backward shift operator \( L \). Converting (1) to the
moving average representation gives,

\[ Y_t = \left[ F(L) \right]^{-1} u_t = \sum_{i=0}^{\infty} C_i u_{t-i} \tag{2} \]

If \( F(L) \) is normalised so that the first entry of each polynomial on the diagonal is unity then \( C_0 \) is an identity matrix and a unit shock to \( u(k)_t \), the \( k \)th component of \( u \), will produce a unit response in \( Y(k)_t \) with the responses of \( Y_{t+j} \) equal to \( C_j u(k)_t \) for \( j \) greater than zero. The columns of \( C_j \) therefore give the impulses responses of each variable at time \( t+j \) to shocks administered at time \( t \). The impulse response functions (IRFs) may then be used to evaluate the system's reaction to random, or unanticipated, disturbances in selected variables.

The second innovation accounting exercise is to decompose the variances of forecast errors into proportions accounted for by each element in the innovation vector. The forecast of \( Y_t \) made at time \( t-k \) is,

\[ \sum_{i=k}^{\infty} C_i u_{t-i}, \quad k > 0. \tag{3} \]

and the error in the \( k \)-step ahead forecast is,

\[ \sum_{m=0}^{k-1} C_m u_{t-m} \tag{4} \]

which, given the estimated coefficients, is attributable to innovations since period \( t-k \). The forecast errors measure the extent to which each element in the \( Y \) vector diverges from its forecast, or expected, path.
moving average representation gives,

\[ Y_t = [F(L)]^{-1} u_t = \sum_{i=0}^{\infty} C_i u_{t-i} \]  

(2)

If \( P(L) \) is normalised so that the first entry of each polynomial on the diagonal is unity then \( C_0 \) is an identity matrix and a unit shock to \( u(k)_t \), the \( k \)th component of \( u \), will produce a unit response in \( Y(k)_t \) with the responses of \( Y_{t+j} \) equal to \( C_j u(k)_t \) for \( j \) greater than zero. The columns of \( C_j \) therefore give the impulses responses of each variable at time \( t+j \) to shocks administered at time \( t \). The impulse response functions (IRFs) may then be used to evaluate the system's reaction to random, or unanticipated disturbances in selected variables.

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\[ \sum_{i=k}^{\infty} C_i u_{t-i}, \ k > 0. \]  

(3)

and the error in the \( k \)-step ahead forecast is,

\[ \sum_{m=0}^{k-1} \sum_{u^t-m} \]  

(4)

which, given the estimated coefficients, is attributable to innovations since period \( t-k \). The forecast errors measure the extent to which each element in the \( Y \) vector diverges from its forecast, or expected, path.
Thus the variance decompositions apportions responsibility for such movements among the innovations of the endogenous variables in the system. If, for example, innovations in variable $Y(1)$ explain a significant part of the forecast error variance for another variable $Y(2)$ then we may conclude that unexpected changes in the former are an important reason why the latter may diverge from its expected path.

The VAR used here defines the $Y$ vector as:

$$Y = [EX, WP, IP, WR, IR]$$ (5)

where, $EX$ is a weighted average of nominal exchange rates for the Irish Pound against Sterling, the D-Mark and the US Dollar. $WP$ is the wholesale price index, $IP$ is an index of industrial production, $WR$ is a money wage rate and $IR$ is a short term interest rate. A full description of the data and sources is given in the Appendix. The only restriction which has to be placed on the model, apart from the choice of variables, is the length of lag in the polynomials. The VAR was estimated using lags from 2 to 12 (by two) and the appropriate length determined by a series of likelihood ratio tests. Table 1 gives the critical levels, or the significance level at which the null hypothesis is just rejected, of the chi-squared tests and suggests a lag of eight quarters.

The five variable VAR was therefore estimated using eight lags together with a constant, trend and trend squared. Table 2 reports the results of Granger causality tests on the hypothesis that all lags
of a particular variable in each equation are zero. Hence the nominal exchange rate affects output and, to a lesser extent, prices but is itself influenced by the latter. That is, changes in EX typically precede changes in output. Or, output can be better predicted from an information set which includes past values of the exchange rate than one which excludes EX.

To compute the impulse responses a shock equal to one standard deviation of the EX innovations was administered to the system and the responses of each variable were scaled by the standard deviation of its own innovations. The shock is therefore equal to the typical variation in the unexplained part of the EX series and the scaling enables us to gauge the responses relative to what is 'normal' for each variable. To judge the significance of the responses their values were compared with the standard errors of their posterior distribution, computed by taking 100 draws from the posterior distribution of the VAR coefficients. The IRFs are presented in Table 3 which gives the responses of each variable over the eight periods following the period in which the shock is administered. In Part A of Table 3 both the shock to EX and the scaling factors are taken from the variance covariance matrix (VCV) of the innovations computed over the entire sample period 1962(1) to 1983(4). The exercise is repeated in Part B but the VCV matrix is computed over the EMS period 1979(1) to 1983(4). For the former the shock equals .0087 or 1.32 per cent of the sample average for EX. In the latter the standard deviation of EX innovations is .0103 or 1.13 per cent of the mean value for EX.
Because the shock is equal to what may be considered typical variation in the EX series the IRFs should be interpreted as the system's reaction to a random disturbance rather than as a means of either evaluating a particular policy or of identifying structural relationships. Table 3 suggests that prices and output both exhibit significant short-run responses to exchange rate shocks, with the former being more persistent. There does not appear to be any radical differences between the two parts of the Table although the responses in Part B, the EMS period, are slightly greater relative to the standard deviations of the innovations. Hence an unanticipated depreciation of the nominal exchange rate is associated with short-run increases in prices and output. The greater persistence of prices together with the initial significance of output is suggestive of an adjustment process within which nominal exchange rate movements lead to output variations via short-run jumps in competitiveness. However, it must be stressed that innovation-accounting is simply a means of summarizing empirical regularities in the data. The fact that the results may be consistent with one particular set of structural, or causal, relationships in no way implies that that structure is identified to the exclusion of all others. Further, it should be noted that although the real effects of nominal exchange rate disturbances are clearly discernible, the size of the output responses tend to be of a low magnitude when compared to the standard deviation of IP innovations. That is, while there is obvious significance in the output responses the empirical significance is small relative to what may be considered normal variation in the IP innovations.
Table 4 gives the variance decompositions for 4, 8, 12 and 16 periods ahead. Almost 20 per cent of the four quarter forecast error in output can be attributed to EX innovations as compared to only 7 per cent of the error in the price index. In the longer run exchange rate disturbances explain nearly 40 per cent of the price series thus suggesting sluggish price adjustment to nominal exchange rate shocks. Hence the variance decompositions are broadly consistent with the hypothesis that nominal exchange rate disturbances are associated with jumps in competitiveness and movements in real output. However as with the IRFs, the influence of EX innovations on output deviations are relatively small with IP innovations explaining most of the variation in the output series.

3. SIMULATIONS

Innovation-accounting is a means of evaluating the extent to which random disturbances in selected variable cause other variables to diverge from the paths they might otherwise be following. Hence the technique is silent on the effects of anticipated, or systematic, changes in the endogenous variables. For example, would the behaviour of prices and output have been significantly different if Ireland had stayed out of the EMS and maintained the no margins parity link with Sterling? Or, would a different policy towards EMS realignments have produced a more favourable domestic growth rate? This Section attempts to address these questions by simulating the model with alternative paths for the
for the nominal exchange rate over the EMS period.

(a) Continuing the Sterling Link

In Section 2 the weighted average nominal exchange rate was defined as:

\[ EX = w_1E_{is} + w_2E_{im} + w_3E_{id} \]  \hspace{1cm} (6)

where \( E_{is}, \ E_{im} \) and \( E_{id} \) are nominal exchange rates against Sterling, the D-Mark and the Dollar and \( w_i \) are the weights. Letting \( E_{ms} \) and \( E_{ds} \) denote the D-Mark and Dollar prices of Sterling then,

\[ E_{im} = E_{is}/E_{ms} \text{ and } E_{id} = E_{is}/E_{ds} \]  \hspace{1cm} (7)

so that we can express (6) as,

\[ EX = E_{is}[w_1 + w_2E_{ms} + w_3E_{ds}] \]  \hspace{1cm} (8)

Setting \( E_{is} \) equal to one and using the actual observations on \( E_{ms} \) and \( E_{ds} \) therefore gives a hypothetical series for \( EX \) computed on the assumption that Ireland had not joined the EMS and continued the parity link with Sterling over 1979(1) to 1983(4). This series was used to simulate the model over these 20 quarters with \( EX \) treated as exogenous and the other variables as endogenous.
Figures 2A and 2B give the forecast values for IP and WP on the assumption that the Sterling link was continued. In each case the solid line is the actual series, the dashed line is the simulated Sterling link series and the dotted line shows the forecast using the actual values of EX. The simulation results suggest that continuing the Sterling link would have prolonged the recession in output which occurred in the second half of 1980 with production declining for another four quarters. Against this the price level would have risen along a lower path from 1980(4) reflecting the slowdown in UK inflation. These results appear to be plausible. Had the Sterling link been maintained then Ireland would not have enjoyed competitive gains against the UK in 1979-80 and, given Sterling’s appreciation against other currencies, would probably have experienced a greater competitive loss against the EMS.

(b) EMS Realignment

The second simulation exercise assumes a 10 per cent devaluation of EX in 1981(4) - an amount equal to the excess of Irish inflation over the weighted average of British, German and American inflation rates during the previous four quarters. The actual value of EX for 1981(4) was increased by 10 per cent and the values for 1982(1) to 1983(4) were computed on the assumption that the once off devaluation would not affect the rates of depreciation/appreciation of the Irish Pound against Sterling, the D-Mark and the Dollar over the next eight quarters. The last quarter of 1981 was selected as an appropriate base period because Sterling tended to depreciate against the EMS currencies over 1982 and
1983. Hence the simulation assumes a realignment within the EMS at a
time when Ireland's competitiveness position relative to the UK was
beginning to deteriorate. 6

Table 5 gives the actual values for IP and WP over the forecast
period together with the simulated values based on the assumed path
for EX. The results suggest that the devaluation would have yielded a
7.6 per cent growth rate in 1982 compared to the modest 1 per cent
increase in IP which was actually achieved. The 1983 forecast for
output is 5.6 per cent while the actual growth rate was 8 per cent.
The observed inflation rates in 1982 and 1983 were 8.3 and 7.7 per
cent while the simulated rates are 13.4 and 6.8 per cent respectively.
Hence even though the devaluation would have produced a rise in the
inflation rate it would also have yielded substantial real gains with
the forecast quarterly index of production being, on average, 3 per
cent above the recorded index over 1981(4) to 1983(4).

4. Conclusions

The principal objective of this paper was to evaluate empirical
relationships between movements in output, prices and the nominal
exchange rate. The results suggest the presence of discernible
regularities in the data and that the short-run behaviour of prices
and output may be related to prior exchange rate movements. The
evidence presented in Section 2 must, however, be tempered by the
recognition of several limiting features of VAR systems. First,
innovation-accounting cannot be used to either identify a particular
structural system or to give a behavioural interpretation of the
relationships among the variables in the VAR. Second, impulse
responses and variance decompositions indicate how the system responds
to random disturbances in selected variables and cannot be used to
evaluate alternative policies. Thus the results presented in Section
2 suggest that random movements in nominal exchange rates may be an
important source of price and output variation, but they do not imply
that a different exchange rate policy would have produced a different
macro economic performance.

The simulation experiments in Section 3 do indicate that the
behaviour of output may have been influenced by exchange rate policy
with EMS membership acting as a stabilizing influence over the initial
years of Irish participation. Although we may not wish to draw any
strong policy conclusions from these historical simulations they
nonetheless suggest that a more detailed, and structural, assessment
of exchange rate policy may prove rewarding.
### TABLE 1

Test of Lag Length. Critical Levels of Chi-Square

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### TABLE 2

F-Tests: Critical Levels of F

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<th>Dependent Variable</th>
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<td>.252</td>
<td>.074</td>
<td>.094</td>
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Note: * Indicates less than 0.01
TABLE 3

Impulse Responses

A. VCV 1962(1) to 1983(4)

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<th>Period</th>
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B. VCV 1979(1) to 1983(4)

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Note: An (a) indicates greater than but less than twice the estimated standard error of response.

A (b) indicates more than twice the estimated standard error of responses.
## TABLE 4

Variance Decompositions

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<th>Variable</th>
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### TABLE 5

Simulation Results

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Figure 1: Irish Pound Real Exchange Rates 1977–1983

Key:
--- Against Sterling
••• Against D-Mark
_____ Weighted average of Sterling, D-Mark and Dollar
Figure 2: Simulations, Continuing the Sterling Link 1979–1983

(a) Output (IP)

(b) Prices (WP)

Key for (a) and (b):

— Actual Series

--- Forecast on Continuing the Sterling Link

... Forecast on Actual Values of EX
FOOTNOTES

1. See, for example, Buiter and Miller (1981).

2. Prior to March 1979 Ireland operated a no margins parity link with Sterling.

3. The weights and data are described in the Appendix.

4. The RATS time series package was used for all computations. See Doan and Litterman (1981).

5. Dean and Litterman (1981), Ch. 11.

6. A 10 per cent devaluation of EX implies a relatively large realignment within the EMS. However, it is just sufficient to compensate for the difference between Irish and foreign inflation rates over 1980(3)-1981(3).
LITERATURE CITED


DATA

IP  Index of industrial production 1980 = 100, seasonally adjusted.  
    Source OECD Main Economic Indicators.

WP  Index of wholesale prices 1980 = 100, seasonally adjusted.  
    Source Irish Statistical Bulletin.

WR  Index of hourly earnings in manufacturing 1980 = 100, seasonally 
    adjusted.  Source OECD Main Economic Indicators.

IR  Central Bank of Ireland discount rate.  Source OECD Main 
    Economic Indicators.

EX  Weighted average of nominal exchange rates against Sterling, the 
    D-Mark and the Dollar.  Exchange rates are quarterly averages 
    of spot rates.  The weights for each country are equal to the 
    value of Irish trade with that country divided by the total 
    value of Irish trade.  The residual is allocated evenly to the 
    D-Mark and Dollar.