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# The Exchange Rate as an Adjustment Mechanism: A Structural VAR Approach to the Case of Ireland

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*Abstract:* Ireland's participation in stage three of Economic and Monetary Union precludes exchange rate adjustment in response to asymmetric shocks. A Structural VAR model is used to decompose the effects of asymmetric supply, demand and nominal disturbances on macroeconomic imbalances between Ireland and the UK and on the Irish pound-sterling exchange rate. The results indicate that supply shocks account for a significant degree of the fluctuation in both variables. This lends weight to the view that the loss of autonomous control over the nominal exchange rate in the face of asymmetric shocks is a significant one, thus increasing the importance of alternative adjustment mechanisms for the Irish economy.

## I INTRODUCTION

In January 1999 Ireland joined the third and final stage of Economic and Monetary Union (EMU) without its single largest trading partner, the United Kingdom (UK). Since Ireland is one of the smallest members of the euro zone, macroeconomic imbalances between the Irish and UK economies alone are unlikely to alter the nominal exchange rate between the euro and sterling. To respond to such asymmetric shocks Ireland must seek other mechanisms of adjustment (Baker, Fitz Gerald and Honohan, 1996).

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Ireland's adjustment dilemma has been heightened by the fact that entry to EMU coincided with the peak in an economic boom, which produced faster growth rates, lower unemployment and eventually higher inflation than in the rest of the euro zone (MacCoille and McCoy, 2002). Whilst an appreciation of the nominal exchange rate would have helped to curb this overheating, a 6.5 per cent depreciation of the euro against sterling between 1999 and 2000 served only to exacerbate the situation (CEC, 2000). The matter came to a head in February 2001 when the Council of Economic and Finance Ministers of the European Union (ECOFIN) issued a formal recommendation against the Irish government on the grounds that it had failed to use budgetary policy to ensure economic stability in the face of overheating (ECOFIN, 2001; Hodson and Maher, 2001). Although inflationary pressures subsequently abated as a result of the global economic slowdown, the experience of overheating serves as a sharp reminder that Irish macroeconomic policy must adjust to the constraints of being a small regional economy within a larger monetary union (Krugman, 1997).

According to Alesina *et al.* (2001) the optimal policy response for Ireland lies in some combination of fiscal policy and relative wage and price adjustment. In the face of overheating, fiscal restraint would constrain domestic demand, whilst an appreciation of the real exchange rate (through, for example, wage inflation) would diminish the economy's external competitiveness and thus provide a check on external demand. Blanchard (2001) argues in favour of some degree of wage inflation in Ireland's case since the rate of economic growth and investment demand at the time made a current account deficit permissible. A tighter fiscal policy on the other hand could have acted as a deterrent to investment. Leddin (2001) calls for a "re-evaluation" of macroeconomic policy in Ireland before such adjustment can be realised. He suggests in particular that the recent pro-cyclical tendency of fiscal policy makes it unsuitable as an adjustment mechanism against asymmetric shocks.

The debate about macroeconomic policy under EMU raises crucial questions concerning the relative importance of various adjustment mechanisms within the Irish economy prior to the euro zone's creation. Baker, Fitz Gerald and Honohan (1996) find that relative consumer and wholesale prices have traditionally played a significant role in response to macro-economic imbalances between the Irish and UK economies. Lane (1998) identifies strong pro-cyclical tendencies over the last twenty years, implying that the contribution of fiscal policy to the adjustment process in recent years has been limited.

What contribution then has been made by the nominal exchange rate in adjusting to asymmetric shocks? This paper employs Structural Vector

Autoregression (SVAR) analysis to examine the extent to which macroeconomic imbalances between the Irish and UK economies are motivated by the same category of shock that drives movements in the Irish pound-sterling exchange rate. A high degree of coincidence in this respect would suggest that the nominal exchange rate responded to asymmetric shocks. A low degree of coincidence, on the other hand, would suggest that macroeconomic imbalances and movements in the exchange rate were driven by other factors. The empirical results indicate a high degree of coincidence for the case of Ireland and the UK over a sample period from 1981 to 1998, with supply shocks playing a crucial role with respect to fluctuations in both relative output and the Irish pound-sterling exchange rate. This suggests not only that the nominal exchange played an important adjustment role in the Irish economy prior to EMU but that the order of importance is significantly greater for Ireland than it is for other key EU members.

The balance of this paper begins with a brief introduction to SVAR analysis followed by a formal model of the macro economy. The proceeding sections deal with data description and then model formulation and estimation. This is followed by the results of the dynamic analysis and a critical appraisal of the model's underlying assumptions. The final section concludes with a re-examination of Ireland's adjustment dilemma in the light of the preceding empirical analysis.

## II METHODOLOGY

A Vector Autogression (VAR) model is a method of multivariate time series analysis which can be used to investigate the relationship between endogenously determined economic variables and their response to exogenously formed disturbances. In practice, when endogenous variables are contemporaneously correlated, the parameters of a primitive system of variables cannot be uniquely identified from the estimated model (Enders, 1995). The traditional response to this problem is to impose atheoretical identifying assumptions which restrict the contemporaneous interaction between certain key economic variables (Charemza and Deadman, 1997, p.160). The SVAR approach departs from tradition by grounding the choice of identifying restrictions in some underlying economic theory. SVAR analysis thus provides "a bridge between economic theory and multiple time-series analysis in order to determine the dynamic responses of variables to variance disturbances or shocks that occur in the economy" (McCoy, 1997, p. 1). Seminal contributions to the literature include Bernanke (1986), Blanchard and Quah (1989), Blanchard and Watson (1986) and Shapiro and Watson (1988). Two recent studies have applied the SVAR methodology to the study of the Irish economy. Gallagher (2000) examines the effect of ERM membership on the incidence of demand and supply shocks and on the correlation of these shocks across the Irish, UK and German economies. Bredin and O'Reilly (2001) examine the impact of temporary interest rate changes on output, prices and the exchange rate in the Irish economy over the period 1980 to 1996.

The SVAR approach has also been employed by a number of authors to explore the response of the nominal exchange rates of EU member states to a variety of exogenous disturbances in the lead up to EMU. A variety of identification schemes have been employed within this literature. A widespread approach is based on Clarida and Gali (1994), which in turn is based on a stochastic version on the classic Mundell-Fleming model (Canzoneri *et al.* 1996; Thomas, 1997; and Funke, 2000). An alternative identification scheme is commonly derived from a dynamic general equilibrium (DGE) representation of the open economy (Smets, 1997), which allows a distinction to be drawn between money and exchange rate shocks (Artis and Ehrmann, 2000).

This paper adopts the first of these identification schemes. Two caveats must accompany this choice. First, SVAR estimates may be sensitive to the assumptions that underpin the Clarida and Gali (1994) model of the macro economy (Labhard and Westaway, 2001). Second, the Clarida and Gali (1994) model examines the impact of asymmetric shocks only and thus gives no indication of the relative importance of symmetric disturbances to the economy (Artis and Ehrmann, 2000).

## III THEORETICAL MODEL

Clarida and Gali (1994) derive their identifying schema from a stochastic, two-country, rational expectations model of the open economy. Since the proceeding analysis is concerned with long-run restrictions only, the short-run dynamics of the model are not directly relevant on this occasion. It is sufficient to note that prices are sticky in the short run, thus giving the dynamics a familiar Mundell-Fleming-Dornbusch flavour. The bare bones of the model can be represented by four main equations and three rules of motion. All variables are expressed in terms of home relative to foreign levels and, with the exception of interest rates, all are expressed in logarithmic form.

$$y_t^d = d_t - \eta(s_t - p_t) - \sigma(i_t - E_t(p_{t+1} - p_t)) \tag{1}$$

$$m_t^s - p_t = y_t - \lambda i_t \tag{2}$$

$$p_t = (1 - \theta)E_{t-1}p_t^e + \theta p_t^e \tag{3}$$

$$i_t = E_t(s_{t+1} - s_t) \tag{4}$$

$$y_t^s = y_{t-1}^s + z_t \tag{5}$$

$$m_t = m_{t-1} + v_t \tag{6}$$

$$d_t = d_{t-1} + \delta_t - \gamma\delta_{t-1} \tag{7}$$

Equation (1) states that the demand for home output relative to foreign output ($y_t^d$) is an increasing function of relative demand shocks ($d_t$) and a decreasing function of both the real exchange rate and the real interest rate differential. The real exchange rate is defined as the difference between the nominal exchange rate ($s_t$) and relative prices ($p_t$). In both this and the empirical section which follows the nominal exchange rate is quoted indirectly i.e. as the price of an Irish pound in terms of sterling. Thus a depreciation (appreciation) of the domestic currency is recorded by a fall (rise) in the value of its exchange rate. The real interest rate differential is defined as the difference between home and foreign interest rates ($i_t$), on one hand, and the expected change in relative prices ($E_t(p_{t+1} - p_t)$), on the other. Equation (2) states that the home supply of real money balances relative to the foreign supply ($m_t^s - p_t$) is an increasing function of relative output ($y_t$) and a decreasing function of the interest rate differential ($i_t$). The parameter $\lambda$ measures the interest rate sensitivity of money. Equation (3) describes the process of price adjustment. The difference between the home and foreign price level in period $t$ ($p_t$) is given by the average of the expected ($E_{t-1}\ p_t^e$) and actual ($p_t^e$) market clearing prices. The parameter $\theta$ is interpreted by Clarida and Gali (1994) as a measure of price flexibility. At the upper bound a value of unity denotes full flexibility, while at the lower bound a value of zero means that prices are irrevocably fixed one period in advance. Equation (4) denotes interest rate parity. This states that the difference between home and foreign interest rates ($i_t$) is determined by the expected change in the nominal exchange rate ($E_t(s_{t+1} - s_t)$.

Equations (5) and (6) describe relative supply shocks ($y_t^s$) and relative money shocks ($m_t$) as being generated by their past values, ($y_{t-1}^s$) and ($m_{t-1}$), and stochastic components ($z_t$) and ($v_t$), respectively. Whilst supply and money shocks in this model follow a random walk, demand shocks are considered to have both transitory and permanent effects. Equation (7) states that while demand shocks ($d_t$) are determined by past values ($d_{t-1}$) and a stochastic component ($\delta_t$), the effect of the former will be partially reversed in the proceeding period. The magnitude of this reversal is denoted by the parameter $\gamma$.

Adjustment in the long run when prices are fully flexible is characterised by equations (8) to (10). A full derivation of these equations and an account of short-run dynamics is presented in Clarida and Gali (1994).

$$y_t^e = y_t^s \tag{8}$$

$$s_t^e = \eta^{-1}d_t - \eta^{-1}(1 - \eta)y_t^s - m_t - (\gamma\delta_t)(\eta + \sigma)^{-1}(\eta^{-1}\sigma + \lambda(1 + \lambda)^{-1}) \tag{9}$$

$$p_t^e = m_t - y_t^s + \lambda(1 + \lambda)^{-1}(\eta + \sigma)^{-1}\gamma\delta_t \tag{10}$$

Equation (8) states that a positive supply shock alone will raise the long run level of relative output. Thus, neither demand nor money shocks have any effect here. As can be seen in Equation (9), the nominal exchange rate will appreciate in the face of a positive demand shock and depreciate following a positive supply shock. In the Clarida and Gali (1994) model the second of these effects relies on a reduction in the terms of trade following an output expansion, which is an unrealistic assumption for a small open economy such as Ireland. By way of an alternative explanation, Benigno and Thoenissen (2002) find that a positive supply shock, which has an immediate impact on output (such as a reduction in the degree of monopolistic distortion in the labour market) will cause a depreciation in the real exchange rate. Finally, by Equation (10), prices will rise in response to either a positive money shock or a temporary positive demand shock and fall in the wake of a positive supply shock. A permanent demand shock, in contrast, will drive up both home and foreign prices in the long run, thus leaving relative prices unchanged.

## IV THE DATA

Following the work of Canzoneri *et al.* (1996) the SVAR model contains three endogenous variables. The first (e) is the quarterly average bilateral exchange rate between the Irish pound and sterling. The second (g) is quarterly Irish government expenditure as a ratio of UK government expenditure.[1] The third (y) is quarterly Irish real GDP as a ratio of UK real GDP. All variables are expressed in logarithmic form and the sample covers from 1980Q1 to 1998Q1.

A full description of each variable is presented in the Data Appendix. Two points warrant further discussion however. The first concerns the construction of the real output measure and the second concerns the choice of sample size.

[1] Canzoneri *et al.* (1996) experiment with alternative measures for the demand variable but government expenditure appears to be the most robust.

With regard to the former, the Central Statistics Office of Ireland has published a quarterly measure of GDP since 1997 only. In its place we employ the Central Bank of Ireland's own measure of quarterly GDP. The series was interpolated from an annual frequency to a quarterly one and is consistent with the historical statistics of the European System of Accounts (ESA79).[2] This particular data set contain no measure of quarterly UK GDP so a series that is compatible with ESA95 is employed in its place. The desired sample would cover from 1979Q1 to 1998Q4, thus beginning just after the Irish pound's break from sterling parity and ending just before Ireland's entry to stage three of EMU. In 1987 the ERM moved to the hard ECU phase during which national currencies were re-aligned less frequently. A policy regime change of this magnitude creates the potential for parameter instability within the model (Favero, 2001). While this possibility is borne in mind it should be noted that Gallagher (2000) finds little evidence to suggest that ERM altered the correlation of Irish demand and supply shocks with those of the UK.

A number of observations are unavoidably lost at either end of the desired sample range. The period between 1979Q1 and 1979Q4 is not recorded in our measure of Irish GDP, while a consistent measure of UK government expenditure is unavailable for the period between 1998Q2 and 1998Q4. The available sample size thus covers from 1980Q1 to 1998Q1. Augmented Dickey Fuller Tests, the results of which are presented in Tables A1 and A2 in the Statistical Appendix, reveal that each variable is integrated of order one. The variables are consequently rendered stationary with the aid of first differencing, while recognising that this process could lead to a loss of low frequency information or long-run characteristics of the series data. On the basis of their behaviour over time, seasonal differencing was considered to be more appropriate in the case of government expenditure and real output.

## V IMPOSING THE IDENTIFICATION RESTRICTIONS

The trivariate VAR can be represented in short-hand form by the following expression.

$$\Delta x_t = C(L) \in_t \tag{11}$$

where $\Delta x_t = [\Delta e_t, \Delta g_t, \Delta y_t]'$, $\Delta$ is the difference operator, $L$ is the lag operator and $\in_t = [\in_{mt}, \in_{dt} \in_{st}]'$ is a vector of structural shocks; $\in_{mt}$ is the money shock, $\in_{dt}$

[2] A similar method is employed by Funke (2000). For a discussion of the quadratic linear form of the dynamic programming algorithm see Bertsekas (1976).

is the demand shock and $\in_{st}$ is the supply shock. It is assumed that $\in_t$ is serially uncorrelated and that its variance-covariance matrix is normalised to the identity matrix.

If we estimate this model at this stage then our results will take on the following form.

$$\Delta x_t = A(L)u_t \tag{12}$$

where $A(L)$ is an identity matrix and $u_t$ is a reduced form matrix of our structural disturbances. The problem of identification arises here because we do not directly observe the vector of disturbances $\in_t$. The reduced form disturbances are related to their structural counterparts in the following manner, however.

$$u_t = C_0 \in_t \tag{13}$$

We can exploit this relationship to recover the vector $\in_t$ by imposing two sets of restrictions. In the first place, we turn to the variance covariance matrix of the reduced form disturbances (Σ). By assuming that this matrix is symmetric in form we derive three restrictions and face a system of nine equations in six unknowns. This leaves us in search of three further identifying restrictions, for which we turn to the economic model described in the preceding section.

Consider the following long-run representation of the structural model.

$$\begin{bmatrix} \Delta e_t \\ \Delta g_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} C_{11}(1) & C_{12}(1) & C_{13}(1) \\ C_{21}(1) & C_{22}(1) & C_{23}(1) \\ C_{31}(1) & C_{32}(1) & C_{33}(1) \end{bmatrix} \begin{bmatrix} \in_{mt} \\ \in_{dt} \\ \in_{st} \end{bmatrix} \tag{14}$$

According to the model of Clarida and Gali (1996), a money shock, will effect neither relative demand nor relative output (real GNP). In terms of Equation (17) this implies that $C_{21}(1) = 0$ and $C_{31}(1) = 0$ respectively. In addition, our adopted view of adjustment would suggest also that demand shocks have no long-run effect on relative output. In terms of the above, this implies that $C_{32}(1) = 0$. By imposing these three extra restrictions the model is now fully identified and we can proceed to the stage of estimation and dynamic analysis.

## VI ECONOMETRIC ANALYSIS

The estimated VAR includes a constant, trend and two significant lags. The results of the estimation and a selection of mis-specification tests are presented in the Statistical Appendix. Once the identification restrictions have been imposed we are now in a position to measure the relative importance of demand, supply and nominal shocks in explaining fluctuations in the endogenous variables or Forecast Error Variance Decomposition (FEVD) as it is more commonly known. Table 1 presents the FEVD over a forecast horizon of twenty quarters.

As can be seen from the lower half of the table, supply shocks predominate when it comes to fluctuations in relative output. In the first quarter of the forecast horizon 84.0 per cent of the fluctuation in relative output can be attributed to supply shocks as compared with 6.7 per cent for money shocks and just 9.3 per cent for demand shocks. By the fourth quarter of the horizon 93.4 per cent of fluctuations in real output continue to be explained in terms of supply shocks. When we turn to fluctuations in the nominal exchange rate a similar pattern emerges. In the first quarter of the forecast horizon approximately 59.1 per cent of fluctuations in the exchange rate can be attributed to supply shocks as compared with 40.8 per cent for money shocks and just 0.1 per cent for demand shocks. By the fourth quarter of the forecast horizon the importance of demand shocks has increased to 4.4 per cent but 58.1 per cent of fluctuations in the exchange rate continues to be explained in terms of supply shocks. Although the importance of nominal shocks should not be underestimated, neither should the significance of supply shocks as a driving factor behind macroeconomic imbalances and exchange rate fluctuations.

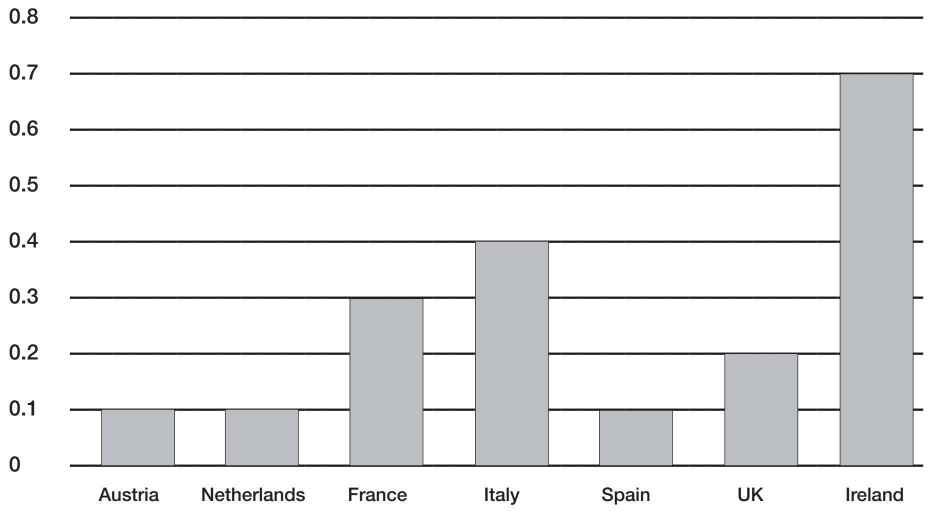
Table 1: *Forecast Error Variance Decompositions*

| | | | *Disturbances* | | |
|---|---|---|---|---|---|
| *Variable* | *Forecast Step* | *S.E.* | *Nominal Shock* | *Demand Shock* | *Supply Shock* |
| DE | 1 | 0.04 | 40.8 | 0.1 | 59.1 |
| | 2 | 0.04 | 38.1 | 3.0 | 58.9 |
| | 4 | 0.04 | 37.5 | 4.4 | 58.1 |
| | 6 | 0.04 | 37.6 | 4.4 | 58.0 |
| | 8 | 0.04 | 37.6 | 4.4 | 58.0 |
| | 20 | 0.04 | 37.6 | 4.4 | 58.0 |
| DY | 1 | 0.05 | 6.7 | 9.3 | 84.0 |
| | 2 | 0.07 | 3.2 | 4.3 | 92.5 |
| | 4 | 0.09 | 3.3 | 3.3 | 93.4 |
| | 6 | 0.09 | 3.3 | 3.4 | 93.3 |
| | 8 | 0.09 | 3.3 | 3.4 | 93.3 |
| | 20 | 0.09 | 3.3 | 3.4 | 93.3 |

How do these results compare with the findings of other authors? Previous studies in the Clarida and Gali (1994) vein corroborate the importance of supply shocks in determining fluctuations in relative output for the case of the UK (Canzoneri *et al.* 1996; Funke, 2000), Austria, the Netherlands, France, Italy, Spain (Canzoneri *et al.* 1996) and Sweden (Thomas, 1997). These studies also reveal, however, that supply shocks play a comparatively small role when it comes to the evolution of the exchange rate. Some two-thirds of the fluctuations in the (synthetic) sterling-euro real exchange rate over the period 1980 to 1997, for example, can be attributed to demand shocks (Funke, 2000). The results of Astley and Garratt (1998) largely concur with this analysis. Using a sample period from 1970 to 1994 roughly one-fifth of the fluctuations in the real exchange rate can be contributed to supply shocks. The remainder can be attributed almost entirely to demand shocks. In the case of Sweden, demand shocks account for up to 62 per cent of the fluctuation in the real effective exchange rate over the period 1979 to 1995 as compared with a figure of no greater than 10 per cent in the case of supply shocks (Thomas, 1997). In the study of Canzoneri *et al.* (1996) supply shocks are most prominent in the case of the lira-deutschmark exchange rate and yet in the fourth quarter of the forecast horizon they account for just 36.6 per cent of total fluctuations as compared with a figure of 53.8 per cent for money shocks and 11.5 per cent for demand shocks. Smets (1997) employs an alternative theoretical model to Clarida and Gali (1994), that takes explicit account of the response of monetary policy to changes in the exchange rate. Using a sample period, which ranges from 1979-1996 the author finds that fluctuations in industrial output in France, Italy and Germany are driven primarily by supply shocks. Fluctuations in the ECU exchange rate, on the other hand, are driven more by exchange rate shocks than they are by supply shocks. Using a similar approach to a study of Denmark and the UK over the period 1974-1998 Artis and Ehrmann (2000) find that supply shocks account for a majority of fluctuations in output and a minority of fluctuations in the ECU exchange rate. In the case of Sweden, demand shocks are more important than supply shocks with respect to fluctuations in output. In all three countries, exchange rate shocks predominate when it comes to fluctuations in the ECU exchange rate.

To understand our findings in a comparative context it is instructive to consider the findings of Canzoneri *et al.* (1996) in closer detail. While the authors' results are based on a different sample period than our own (and hence on a different exchange rate regime), they nonetheless provide a rough benchmark against which to judge the significance of the Irish result. In Figure 1 the vertical axis draws from the two sets of variance decompositions to construct a ratio of the explanatory power of supply shocks with regard to the nominal exchange rate and relative output respectively. If the exchange rate and relative output are motivated by a completely different variety of disturbances, the measure of coincidence will be zero. If, at the other extreme, both variables are driven entirely by supply shocks, the measure of coincidence will be one. As we can see, the measure of coincidence for the first quarter of the forecast horizon varies from one Member State to another. In the Canzoneri *et al.* (1996) study, Spain and Austria exhibit the lowest degree of coincidence (0.06), while Italy (0.5) exhibits the highest. In comparison, the coincidence index is highest of all for the case of Ireland (0.7). This reflects the fact that supply shocks account for a higher proportion of fluctuations in the Irish pound-sterling exchange rate than they do in the case of any other exchange rate that is under investigation here.

Figure 1: *A Measure of Coincidence*




*Note:* The measure of coincidence represents the ratio of fluctuations in relative output attributed to supply shocks to fluctuations in the nominal exchange rate attributed to the same variety of disturbance.

Three key empirical findings thus emerge from this analysis of macroeconomic adjustment in Ireland. First, fluctuations in relative output between Ireland and the UK between 1980 and 1998 can be attributed primarily to supply shocks. Second, although a significant degree of fluctuations in the Irish pound-sterling exchange rate can be attributed to nominal and demand shocks over the period, supply shocks play a predominant role. Third, the degree of coincidence, according to which macroeconomic imbalances and exchange rate fluctuations are driven by the same variety of disturbances, is significantly higher in the case of Ireland than it is for other key EU economies.

How then are we to interpret these results? The central conclusion of Canzoneri *et al.* (1996), Thomas (1997) and Funke (2000) is that nominal exchange rates do not move to redress macroeconomic imbalances. Relative output and exchange rates on the contrary are subject to differing varieties of macroeconomic disturbance. The opposite would appear to hold true in the case of Ireland. The fact that macroeconomic imbalances *vis-à-vis* the UK are motivated by the same category of disturbance as the Irish pound-sterling exchange rate, lends weight to the view that the exchange rate acted as a shock absorber between the two economies. This methodology, it must be stressed, does not claim to draw a causal link between fluctuations in the exchange rate and macroeconomic imbalances. Its more modest contribution is to highlight a recurring coincidence in the evolution of both variables that, at best, alludes to the significance of exchange rate adjustment in the Irish economy prior to EMU.

## VII THE VALIDITY OF IDENTIFICATION RESTRICTIONS

In following an SVAR approach to this investigation, we have derived identifying restrictions from economic theory. In so doing the model may achieve an internal consistency but doubts still remain about its empirical validity. To address such concerns, it is useful to consider whether the impulse responses of variables to shocks conform to our theoretical preconceptions.

The model reveals generally positive although occasionally ambiguous results. In the first place the restrictions imply that nominal shocks will raise output in the short run and cause the exchange rate to depreciate over the long run. As can be seen from Figure A1 in the Appendix, after an initial fall following the (positive) nominal shock output rises between the third and tenth quarters. As regards the exchange rate, the nominal shock is followed by a sustained depreciation between the first and third quarters, albeit after an initial appreciation. The exchange rate finally returns to its baseline after eight quarters. Turning to the (positive) supply shock, the earlier restrictions lead us to expect a short run increase in relative output accompanied by a depreciation of the exchange rate. Relative output rises sharply in response to the shock, and returns to its base line ten quarters later. As can also be seen from Figure A1, the exchange rate depreciates in the short run after the supply shock and returns to the base line after nine quarters. Finally, when it comes to (positive) demand shocks our restrictions imply that in the short run output should increase while the exchange rate appreciates. As can be seen from Figure A1, the appreciation of the exchange rate is forthcoming, although the increase in relative output is less than we might expect *a priori*.

In summary, the impulse response analysis of our identifying restrictions points towards their general validity. Some doubts over our description of demand shocks remain but the overall evidence is inconclusive. In short we offer our chosen models as a reasonable approximation to reality, while accepting that strict causal inference is likely to remain beyond our grasp.

A more general criticism of this methodology concerns the assumption that the Irish and UK economies will continue to move together in response to demand shocks and move apart in the face of supply shocks. This tends to discount the possibility that EMU will alter the fundamental relationships between the two economies. Frankel and Rose (1997) find evidence of a strong positive relationship between the intensity of bilateral trade relations and the correlation of business cycles, while Rose (1999) observes a positive correlation between membership of a currency union and trade integration. The implication for Ireland is that EMU could alter the synchronicity of the Irish and UK business cycles, thus making past demand and supply shocks ad unreliable predictor for future disturbances. Sims (1999) has responded to the problem of regime changes with the aid of a switching model. The application of this method to the case of Ireland is likely to be constrained by insufficient data, however.

## VIII CONCLUSIONS

As a member of EMU, Ireland can no longer rely on the nominal exchange rate to adjust to asymmetric shocks. The full bearing of this decision depends in part on the incidence of asymmetric shocks, as well as on the traditional role of the exchange rate and finally on the efficiency of alternative adjustment mechanisms. The focus of this paper concerned the second of these three conditions. SVAR analysis was used to decompose the effect of supply, demand and nominal shocks on fluctuations in output relative to the UK and the Irish pound-sterling exchange rate.

Three main findings emerge from the empirical analysis. First, fluctuations in relative output between Ireland and the UK are driven primarily by supply shocks. Second, supply shocks also play a crucial role with regard to fluctuations in the Irish pound-sterling exchange rate. Third, the degree of coincidence between relative output and exchange rate movements is higher in the case of Ireland than it is for other key EU economies.

Three main conclusions may be drawn from these results. First, although the SVAR methodology does not, by itself, prove that the exchange rate responded to relative output fluctuations between the two countries, it does provide strong evidence that the exchange rate played an important role in the adjustment process. Second, nominal exchange rate adjustment was comparatively more important in Ireland than in other parts of the EU. As a consequence, the need for alternative adjustment mechanisms will be all the greater in Ireland if it is to maintain macroeconomic stability under EMU.

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## DATA APPENDIX

| *Variable* | *Sample* | *Source* | *Code* | *Seasonally Adjusted* | *Description* |
|---|---|---|---|---|---|
| Quarterly nominal exchange rate between the Irish pound and sterling | 1980:1 1998:1 | Central Bank of Ireland | N/A | No | The average of the daily spot rate of the Irish pound in terms of pounds sterling |
| Quarterly Irish government expenditure | 1980:1 1998:1 | Central Statistics Office of Ireland | FIBQ011 | No | Total exchequer expenditure |
| Quarterly UK government expenditure | 1980:1 1998:1 | DATASTREAM | UK182….A | No | Total exchequer expenditure |
| Quarterly real Irish gross domestic product | 1980:1 1998:1 | Central Bank of Ireland | N/A | No | This series is measured in terms of constant market prices and is consistent with the European System of Accounts Quarterly National Accounts (ESA79) |
| Quarterly real UK gross domestic product | 1980:1 1998:1 | DATASTREAM | ESGD95.C | No | This series is measured in terms of constant market prices and is consistent with the European System of Accounts Quarterly National Accounts (ESA95) |

## TECHNICAL ANNEX

Table A1: *Augmented Dickey Fuller Tests for the Levels E, G and Y*

*Nominal Exchange Rate*
*Critical values: 5%=-3.477 1%=-4.099; Constant and Trend included*

| | t-adf | Beta Y_1 | \sigma | lag | t-DY_lag | t-prob | F-prob |
|---|---|---|---|---|---|---|---|
| E | –1.84 | 0.70 | 0.04 | 5.00 | 0.44 | 0.66 | |
| E | –1.82 | 0.73 | 0.03 | 4.00 | 0.59 | 0.56 | 0.66 |
| E | –1.74 | 0.76 | 0.03 | 3.00 | 0.73 | 0.47 | 0.77 |
| E | –1.58 | 0.81 | 0.03 | 2.00 | –1.10 | 0.28 | 0.79 |
| E | –2.54 | 0.74 | 0.03 | 1.00 | 1.88 | 0.07 | 0.70 |
| E | –1.86 | 0.83 | 0.04 | 0.00 | | | 0.36 |

*Relative Government Expenditure*
*Critical values: 5%=-3.477 1%=-4.099; Constant and Trend and Seasonals included*

| | t-adf | Beta Y_1 | \sigma | lag | t-DY_lag | t-prob | F-prob |
|---|---|---|---|---|---|---|---|
| G | –2.80 | 0.65 | 0.07 | 5.00 | 0.85 | 0.40 | |
| G | –2.68 | 0.68 | 0.07 | 4.00 | 1.45 | 0.15 | 0.40 |
| G | –2.36 | 0.73 | 0.07 | 3.00 | –0.82 | 0.42 | 0.25 |
| G | –2.63 | 0.70 | 0.07 | 2.00 | –0.95 | 0.34 | 0.33 |
| G | –2.97 | 0.68 | 0.07 | 1.00 | –1.13 | 0.26 | 0.36 |
| G | –3.59 | 0.63 | 0.07 | 0.00 | | | 0.35 |

*Relative Gross Domestic Product*
*Critical values: 5%=-3.477 1%=-4.099; Constant and Trend and Seasonals included*

| | t-adf | beta Y_1 | \sigma | lag | t-DY_lag | t-prob | F-prob |
|---|---|---|---|---|---|---|---|
| Y | 0.31 | 1.02 | 0.04 | 5.00 | –0.83 | 0.41 | |
| Y | 0.02 | 1.00 | 0.04 | 4.00 | 0.40 | 0.69 | 0.41 |
| Y | 0.19 | 1.01 | 0.04 | 3.00 | –0.27 | 0.79 | 0.66 |
| Y | 0.08 | 1.00 | 0.04 | 2.00 | –0.87 | 0.39 | 0.82 |
| Y | –0.27 | 0.99 | 0.04 | 1.00 | 1.25 | 0.22 | 0.80 |
| Y | 0.15 | 1.01 | 0.04 | 0.00 | | | 0.68 |

Table A2: *Augmented Dickey Fuller Tests for the Differences DE, DG and DY*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Nominal Exchange Rate* | | | | | | |
| | *Critical values: 5%=-3.481 1%=-4.108; Constant and Trend included* | | | | | | |
| | t-adf | beta Y_1 | \sigma | lag | t-DY_lag | t-prob | F-prob |
| DE | –3.14 | –0.26 | 0.04 | 5.00 | 0.48 | 0.63 | |
| DE | –3.42 | –0.16 | 0.04 | 4.00 | 0.28 | 0.78 | 0.63 |
| DE | –3.89 | –0.11 | 0.04 | 3.00 | 0.21 | 0.83 | 0.86 |
| DE | –4.62 | –0.07 | 0.04 | 2.00 | –0.18 | 0.86 | 0.95 |
| DE | –6.34 | –0.10 | 0.04 | 1.00 | 1.75 | 0.08 | 0.98 |
| DE | –6.85 | 0.10 | 0.04 | 0.00 | | | 0.66 |
| | *Relative Government Expenditure* | | | | | | |
| | *Critical values: 5%=-3.481 1%=-4.108; Constant and Trend and Seasonals included* | | | | | | |
| | t-adf | beta Y_1 | \sigma | lag | t-DY_lag | t-prob | F-prob |
| DG | –2.74 | 0.50 | 0.08 | 5.00 | 0.37 | 0.71 | |
| DG | –2.84 | 0.53 | 0.08 | 4.00 | –1.23 | 0.22 | 0.71 |
| DG | –4.02 | 0.42 | 0.08 | 3.00 | 1.79 | 0.08 | 0.45 |
| DG | –3.53 | 0.53 | 0.09 | 2.00 | 0.83 | 0.41 | 0.20 |
| DG | –3.50 | 0.57 | 0.09 | 1.00 | –0.17 | 0.87 | 0.25 |
| DG | –4.02 | 0.56 | 0.08 | 0.00 | | | 0.37 |
| | *Relative Gross Domestic Product* | | | | | | |
| | *Critical values: 5%=-3.481 1%=-4.108; Constant and Trend and Seasonals included* | | | | | | |
| | t-adf | beta Y_1 | \sigma | lag | t-DY_lag | t-prob | F-prob |
| DY | –2.88 | 0.65 | 0.05 | 5.00 | 1.73 | 0.09 | |
| DY | –2.44 | 0.71 | 0.05 | 4.00 | –1.83 | 0.07 | 0.09 |
| DY | –3.37 | 0.62 | 0.05 | 3.00 | 0.06 | 0.95 | 0.05 |
| DY | –3.88 | 0.63 | 0.05 | 2.00 | 1.09 | 0.28 | 0.11 |
| DY | –3.85 | 0.68 | 0.05 | 1.00 | 3.28 | 0.00 | 0.12 |
| DY | –2.64 | 0.78 | 0.06 | 0.00 | | | 0.00 |

Table A3: *Vector Autoregression Estimates*

| | *DE* | *DG* | *DY* |
|---|---|---|---|
| *Sample(adjusted): 1981:3 1998:1* | | | |
| *Standard errors in ( ) & t-statistics in [ ]* | | | |
| DE(-1) | 0.06 | 0.15 | –0.31 |
| | –0.14 | –0.34 | –0.19 |
| | [0.39] | [0.43] | [–1.61] |
| DE(-2) | –0.28 | –0.03 | –0.36 |
| | –0.13 | –0.32 | –0.18 |
| | [–2.06] | [–0.09] | [–1.98] |
| DG(-1) | 0.10 | 0.38 | –0.19 |
| | –0.06 | –0.14 | –0.08 |
| | [1.75] | [2.78] | [–2.47] |
| DG(-2) | –0.11 | 0.17 | 0.08 |
| | –0.06 | –0.14 | –0.08 |
| | [–1.87] | [1.25] | [0.99] |
| DY(-1) | 0.00 | –0.40 | 0.76 |
| | –0.11 | –0.25 | –0.14 |
| | [–0.04] | [–1.57] | [5.35] |
| DY(-2) | –0.02 | 0.57 | –0.18 |
| | –0.09 | –0.21 | –0.12 |
| | [–0.28] | [2.68] | [–1.53] |
| C | 0.01 | 0.02 | –0.03 |
| | –0.01 | –0.02 | –0.01 |
| | [1.3] | [1.00] | [–2.08] |
| @TREND | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 |
| | [–1.18] | [–1.15] | [3.05] |
| R-squared | 0.18 | 0.42 | 0.80 |
| Adj. R-squared | 0.08 | 0.35 | 0.78 |
| Sum sq. resids | 0.07 | 0.41 | 0.13 |
| S.E. equation | 0.03 | 0.08 | 0.05 |
| F-statistic | 1.80 | 6.17 | 34.53 |
| Log likelihood | 134.15 | 75.80 | 114.52 |
| Akaike AIC | –3.77 | –2.02 | –3.18 |
| Schwarz SC | –3.50 | –1.76 | –2.92 |
| Mean dependent | 0.00 | 0.00 | 0.02 |
| S.D. dependent | 0.04 | 0.10 | 0.10 |
| Determinant residual covariance | | 9.87E-09 | |
| Log Likelihood (d.f. adjusted) | | 332.32 | |
| Akaike Information Criteria | | –9.20 | |
| Schwarz Criteria | | –8.41 | |

*Note:* Included observations: 67 after adjusting endpoints.

Table A4: *VAR Residual Normality Tests*

| *Component* | *Skewness* | *Chi-sq* | *df* | *Prob.* |
|---|---|---|---|---|
| 1 | 0.07 | 0.05 | 1.00 | 0.82 |
| 2 | –0.02 | 0.00 | 1.00 | 0.95 |
| 3 | 0.01 | 0.00 | 1.00 | 0.97 |
| Joint | | 0.06 | 3.00 | 1.00 |
| *Component* | *Kurtosis* | *Chi-sq* | *df* | *Prob.* |
| 1 | 3.41 | 0.47 | 1.00 | 0.49 |
| 2 | 2.30 | 1.36 | 1.00 | 0.24 |
| 3 | 1.59 | 5.53 | 1.00 | 0.02 |
| Joint | | 7.36 | 3.00 | 0.06 |
| *Component* | *Jarque-Bera* | *df* | *Prob.* | |
| 1 | 0.52 | 2.00 | 0.77 | |
| 2 | 1.36 | 2.00 | 0.51 | |
| 3 | 5.53 | 2.00 | 0.06 | |
| Joint | 7.42 | 6.00 | 0.28 | |

*Note:* Orthogonalization: Cholesky (Lutkepohl)
H0: residuals are multivariate normal
Sample: 1981:1 1998:1
Included observations: 67

Table A5: *VAR Residual Heteroskedasticity Tests*

| *Joint test:* | | | | | |
|---|---|---|---|---|---|
| Chi-sq | | df | | Prob. | |
| 103.1331 | | 84 | | 0.08 | |
| Individual components: | | | | | |
| *Dependent* | *R-squared* | *F(14,52)* | *Prob.* | *Chi-sq(14)* | *Prob.* |
| res1*res1 | 0.29 | 1.53 | 0.13 | 19.59 | 0.14 |
| res2*res2 | 0.22 | 1.06 | 0.41 | 14.92 | 0.38 |
| res3*res3 | 0.29 | 1.53 | 0.13 | 19.53 | 0.15 |
| res2*res1 | 0.29 | 1.53 | 0.13 | 19.56 | 0.14 |
| res3*res1 | 0.20 | 0.91 | 0.55 | 13.23 | 0.51 |
| res3*res2 | 0.22 | 1.08 | 0.40 | 15.05 | 0.37 |

*Note:* No Cross Terms (only levels and squares)
Sample: 1981:1 1998:1
Included observations: 67

Table A6: *VAR Residual Portmanteau*

*Sample: 1981:1 1998:1*
*Included observations: 67*

| *Lags* | *Q-Stat* | *Prob.* | *Adj Q-Stat* | *Prob.* | *df* |
|---|---|---|---|---|---|
| 1 | 2.51 | NA* | 2.55 | NA* | NA* |
| 2 | 3.63 | NA* | 3.70 | NA* | NA* |
| 3 | 12.20 | 0.20 | 12.67 | 0.18 | 9.00 |
| 4 | 27.31 | 0.07 | 28.74 | 0.05 | 18.00 |
| 5 | 36.84 | 0.10 | 39.04 | 0.06 | 27.00 |
| 6 | 42.86 | 0.20 | 45.65 | 0.13 | 36.00 |
| 7 | 49.55 | 0.30 | 53.13 | 0.19 | 45.00 |
| 8 | 61.53 | 0.22 | 66.73 | 0.11 | 54.00 |
| 9 | 67.42 | 0.33 | 73.53 | 0.17 | 63.00 |
| 10 | 79.14 | 0.26 | 87.31 | 0.11 | 72.00 |
| 11 | 86.23 | 0.32 | 95.79 | 0.13 | 81.00 |
| 12 | 94.89 | 0.34 | 106.35 | 0.11 | 90.00 |

*The test is valid only for lags larger than the VAR lag order.
*df* is degrees of freedom for (approximate) chi-square distribution

*Note:* H0: no residual autocorrelations up to lag h

Figure A1: *Impulse Response Functions*
*(Response to One S.D. Innovations)*