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An Analysis of the Transmission Mechanism of Monetary Policy in Ireland

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Abstract

This paper examines the impact of monetary policy shocks on a number of key economic variables, including output, prices and the exchange rate. The paper draws on recent techniques used in the structural vector autoregression literature. Our results suggest that an exogenous temporary increase in the short-term interest rate leads to a decline in output and prices with the latter responding more sluggishly. In addition, a higher interest rate leads to an immediate appreciation of the domestic exchange rate and a subsequent depreciation of the currency. Hence, there is an absence of an exchange rate or forward bias puzzle, which are prevalent in other studies. Overall the response of macroeconomic variables to a change in the interest rate are very small in magnitude.

1. Introduction

With the advent of EMU, there has been substantial debate on how a single monetary policy will affect the economy in the euro area. This debate has led to a number of studies examining the subject of the transmission of monetary policy.[1] Important issues examined in this literature include the effects on output and prices with respect to interest rate changes, the length of time it takes for these effects to materialise and finally what is the shape of the response of these and other key macroeconomic variables to a monetary policy shock? These issues are important with the advent of EMU and the move to a one policy fits all sizes.

Increasing attention has been paid to delineating the transmission mechanism in individual countries and comparing possible differences across countries.[2] If differences exist this could have important consequences, in terms of asymmetric effects of monetary policy across Euroland. To date there has been very little work done in this area in an Irish context.[3] One of the primary problems confronting researchers in an Irish context is the lack of quarterly national income account data.[4] In our study, we attempt to circumvent this problem by using an interpolated quarterly series developed at the Central Bank of Ireland.[5]

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[1] For example, Monticelli & Tristani (1999) examine monetary policy transmission at the aggregate euro area level.

[2] See Gerlach & Smets (1995), Ramaswamy & Sloek (1997), Ehrmann (2000) and McCoy & McMahon (2000) for cross-country comparisons in terms of the effects of monetary policy. shocks.

[3] Two exceptions to this are Ehrmann (2000) and McCoy & McMahon (2000). Both of these studies include Ireland as part of a multicountry comparison of the transmission of monetary policy. Our results are consistent with those of Ehrmann (2000) even though we use different data and a somewhat different econometric approach to his.

[4] For example, Ehrmann (2000) uses industrial production in his study.

[5] We find qualitatively similar results if we use industrial production instead of our interpolated output series.

In this paper we examine the effect of an exogenous monetary contraction on various macroeconomic variables in an attempt to assess the timing and magnitude of the transmission mechanism of monetary policy in an Irish context. In particular, within a vector autoregressive framework, we analyse the effect of an exogenous temporary change in the short-term interest rate on output, prices and the exchange rate. The period of study runs from 1980 to 1996 using quarterly data. During this period Ireland was a member of the European Monetary System with the result that the main goal of monetary policy was to maintain this exchange rate commitment. Since EMS was a quasi-fixed exchange rate regime there was still some scope for limited domestic monetary policy. In addition, our work can be considered a first step in elucidating how monetary shocks are propagated whether these shocks are domestic or foreign in origin.

Overall our results are consistent with the qualitative predictions of economic theory regarding the impact of a change in monetary policy in an open economy setting. In particular, we find that a temporary monetary contraction leads to a decline in both output and prices, with the latter being somewhat slower to adjust. Secondly, a rise in the interest rate leads to an immediate appreciation of the exchange rate, which is a prelude to a subsequent depreciation of the currency. The exchange rate behaviour is consistent with theory and is in marked contrast to the difficulty of other studies in finding plausible exchange rate responses to interest rate changes (Sims 1992 and Eichenbaum & Evans 1995).

Finally, while the effect of monetary policy changes accords qualitatively with economic theory, the magnitude of the effect of interest rate changes on macroeconomic variables is very small in quantitative terms. The latter is not surprising given Ireland's membership during the period in question of a quasi-fixed exchange rate regime. Thus, the scope for an independent monetary policy was limited.

The remainder of the paper is structured as follows. Section 2 gives a detailed discussion on the empirical evidence regarding monetary transmission. This includes both large and small open economy reviews. The following section deals with the econometric methodology and the issues associated with identification. Section 4 outlines the data used in the study and the empirical results. Finally, section 5 concludes and discusses possible future work.

2. Literature

From a theoretical point of view, there is a long literature suggesting how exogenous changes in interest rates will impinge on the economy. This analysis runs from the traditional IS-LM framework to the recent new neoclassical synthesis. Common to a number of these models is the belief that monetary policy can have short run effects on real variables such as output, as a result of the presence of nominal rigidities such as sticky prices or wages. However in the long run, monetary policy has no effect on output but merely on prices. Surprisingly, it is only in recent times that empirical macroeconomists have found support for such an idea in the data (Leeper et al 1996).

2.1 Identification of Monetary Policy Changes

A major problem in estimating the effects of monetary policy is clearly identifying monetary policy shocks. Identification refers to the ability to attribute the response of a certain variable to an economically interpretable change in another variable. Variables that capture monetary policy such as short-term interest rates or monetary aggregates are endogenous variables that partially reflect shifts in monetary policy and partially reflect the state of the economy.

In order to assess the effects of monetary policy on the economy, one consequently needs to disentangle changes in policy variables into the part reflecting exogenous shifts in the stance of policy and the part reflecting endogenous responses to the state of the economy. The latter can be formalised with the concept of a monetary authority's reaction function, which summarises how the central bank's instruments systematically respond to activity in the economy.[6] The unsystematic change in instruments can then be used as an indicator of exogenous shifts in monetary policy (Leeper et al 1996 and Christiano et al 1998).

In this study we choose to focus on the short-term money market interest rate as our indicator of monetary policy. This can be motivated in part by the fact that most central banks in recent times use short-term interest rate as their instrument in conducting monetary policy (Bernanke & Blinder, 1992). In addition, monetary aggregates on the other hand are more susceptible to changes reflecting demand pressures (Leeper et al 1996).

There is a large literature examining the effects of exogenous monetary policy changes on macroeconomic variables in a VAR framework. Initially, most work focused on the U.S. where a closed economy model was deemed appropriate. Various identification schemes to isolate monetary shocks relied on alternative recursive ordering of variables based on assumptions regarding the presence or absence of information lags or policy lags. For example, Sims (1980) argued that the policy instrument could be ordered first ahead of output and prices since contemporaneous measures of output and prices were not available to the monetary authorities when making decisions regarding the appropriate rate for the monetary policy variable.[7] On the other hand, Bernanke & Blinder (1992) and Christiano & Eichenbaum (1992) order the policy instrument after output and prices based on the

[6] Instruments that the monetary authority traditionally use are some short term interest rate or narrow money aggregate.

[7] This could be justified if the frequency of the data was short i.e. monthly.

assumption that interest rate changes will only affect these variables with a lag.[8]

After some refinements a consensus arose with studies finding a stylised set of facts with a monetary contraction leading to a negative response of output and a sluggish decline in the price level. The standard variables used in these studies included real output, prices, a monetary policy instrument and some measure of commodity or oil prices. The latter variable was included, to take into account the forward looking behaviour of monetary authorities in setting interest rates and so affect both present and future inflation. When this variable was omitted prices initially rose after a monetary contraction and this became known as the price puzzle (see Sims 1992, Bernanke & Blinder 1992 and Christiano & Eichenbaum 1992).

The above analysis has been extended to an open economy setting where exchange rate considerations are critical in the setting of monetary policy. Initially, studies continued to impose a recursive structure in identifying monetary policy shocks. A number of studies find the existence of a price puzzle, exchange rate puzzle and forward bias puzzle associated with domestic monetary tightening for open economies (Sims, 1992, Eichenbaum & Evans 1995 and Grilli & Roubini 1995). The exchange rate puzzle refers to the observed exchange rate initially depreciating when the domestic interest rate rose, while the forward bias puzzle refers to the lack of a subsequent depreciation of the domestic currency in accordance with uncovered interest parity holding.

These findings suggest that a recursive identification scheme with respect to the interest rate and the exchange rate are inappropriate in a small open economy. With capital mobility, changes in the policy rate will have an immediate effect on the exchange rate. Therefore, an ordering of exchange rate innovations before interest rate innovations is thus inappropriate. The

[8] This is consistent with the predictions of a number of theories (see Christiano et al 1997).

reverse ordering doesn’t seem justified for a small open economy where exchange rate considerations will likely affect interest rate changes.

In response to this, researchers have moved away from a recursive scheme to allow simultaneity between contemporaneous values of the interest rate and exchange rate (Cushman & Zha 1998 and Kim & Roubini 2000). The latter allow contemporaneous interaction between domestic monetary policy variables and the exchange rate for G7 countries. Other identification schemes used in an open economy setting include Bagliano & Favero (1998) and Smets & Wouters (1999). The former attempt to solve this simultaneity problem between the exchange rate and the interest rate by using information extracted from financial markets independently from the VAR while the latter imposes a combination of short and long run restrictions to identify monetary shocks.

In this paper we attempt to characterise the effect of an exogenous interest rate change on output, prices and the exchange rate under a number of different identification schemes. Initially, we start with a recursive structure and conduct a robustness check of our results for different ordering schemes. We next adopt a structural VAR, which leads to a more flexible approach by allowing simultaneous contemporaneous response of variables to shocks in other variables. The restrictions imposed are in the spirit of Kim & Roubini (2000), but are altered to take account of specific aspects germane to the conduct of Irish monetary policy.

3. Vector Autoregressions (VAR'S)

Vector autoregression (VAR) models are multivariate time series models and can be seen as extensions of the univariate autoregressive moving average (ARMA) models of Box and Jenkins (1970). Let x_t be an $n \times 1$ vector of variables and ε_t be an $n \times 1$ vector of mean zero structural innovations. The ρ^{th} order structural VAR model is written as;

$$B(L)x_t = e_t$$

$$Ee_t e_t^{'} = \Lambda \qquad (1)$$

$$\mathrm{E}e_t e_{t+s}^{'} = 0, \quad \forall s \neq 0$$

For t = -(ρ-1)…T. B(L) is the ρ^{th} order matrix polynomial in the lag operator L, $B(L) = B_0 – B_1L – B_2L^2 - …- B_PL^P$. B_0 is a non-singular matrix and is normalised to have ones on the diagonal. This matrix summaries the contemporaneous relationships between the variables of the model. [9]

The problem with equation (1) is given that the coefficients are unknown and the variables have contemporaneous effects on each other, it is not possible to uniquely determine the values of the parameters in the model. However, the parameters can be estimated if we transform equation (1) into

[9] Since the publication of Sims's early work (1972, 1980a, 1980b, 1982) on the methodology, the VAR approach has caused much debate. Critics of the approach claim that it bears little relationship with economic theory and relies on unsustainable assumptions, Canova (1995). However, the VAR methodology has proved to be a popular tool in the applied economics literature.

its reduced form. Hence, associated with the structural model is the reduced form VAR representation;

$$A(L)x_t = e_t$$

$$Ee_t e_t^{'} = \sum \qquad (2)$$

$$Ee_t e_{t+s}^{'} = 0, \forall s \neq 0$$

where $\mathrm{A(L)} = \mathrm{B}_0^{-1} B(L) = I - AL - A_2 L^2 - ... - A_P L^P$ and $e_t = B_0^{-1} \varepsilon_t$

The error terms (e_t) are composites of the underlying shocks (ε_t). The model must be exactly identified or over-identified in order to estimate the structural model. In order to recover the structural parameters from the reduced form model, there must be the same number of parameters in B_0 and Λ as there are in $\sum$, the covariance matrix of the reduced form. This is referred to as the order condition (Hamilton, 1994).

Using equation 1 and 2, we can express the variance covariance matrix, $\sum$, as;

$$\sum = (B_0^{-1})\Lambda(B_0^{-1})' \qquad (3)$$

Maximum likelihood estimation of Λ and B_0 can only be obtained through the sample estimation of Σ. In equation 3, $\sum$ has $n(n+1)/2$ parameters, while the right hand side has $n(n+1)$ free parameters to be estimated. Hence we need at least $n(n+1)/2$ restrictions. If the n diagonal elements of Λ are set to 1, all that is required is a further $n(n-1)/2$ restrictions on B. There are a number of different methods to recover the parameters of the structural form from the parameters in the reduced form. The most widely used approach is the Cholesky decomposition, Sims (1980).[10] This could be accomplished if we assume B_0 is lower triangular, i.e. the standard Cholesky decomposition. Since the model is just identified, the full-information maximum likelihood (FIML) procedure can be employed. First we maximise the likelihood function with respect to the reduced form parameters and then the structural parameters are found from unique mapping of the reduced form parameters.

In reality, the Cholesky approach has been found to produce many of the empirical puzzles discussed in the literature section. Given that the Cholesky decomposition restricts the B_0 matrix to be triangular, this means that there is no simultaneous interaction among the variables. This would imply that policy does not respond to contemporaneous changes in the exchange rate.[11] However, in the case of Ireland and other small open economies, it is likely that the monetary authority would react extremely quickly to movements in exchange rates and foreign interest rates.

However, in the structural VAR approach economic theory guides the structural restrictions on the B_0.[12] All that is required is that there ares

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[10] An important issue when estimating the VAR is the appropriate lag length, *p*. If the lag length is too large, the VAR is more likely to 'pick-up' within sample random variation as well as any systematic relationship, due to the greater number of parameters that need to be estimated. Abadir, Hardi and Tzavalis (1999) noted that even moderate values of *p* will lead to substantial biases in the VAR. If the lag length is too small, important lag dependencies may be omitted from the VAR and if serial correlation is present the estimated coefficient will be inconsistent. The applied econometrician is left with 2 options; choose a particular lag length and verify the results are independent of this auxiliary assumption or let the data choose a particular lag length using some optimal statistical criteria, Canova (1995). Examples are the Akaike Information Criteria (AIC), Akaike (1974), Hannan and Quinn (H-Q) (1979) or the Swartz Bayesian Criterion (SBC), Schwartz (1978). It has been noted by a number of studies that little is known about the small sample properties of these selection procedures, and that in many cases they may give conflicting conclusions, Pesaran and Smith (1998).

[11] Studies that use the Cholesky ordering include, Sims (1992), Grilli and Roubini (1995), and Eichenbaum and Evan (1995).

[12] Long-run restrictions could also be imposed on B(L). Gali (1992) is an example of a study that imposes the two types of restrictions, i.e. on B_0 and B(L). In general the identification restrictions will

sufficient restrictions. If the model is over identified, the 2 step procedure is not the FIML estimator for the SVAR model.

4. Data and Empirical Results

4.1 Data

Our data set consists of quarterly series spanning the period 1980:Q1-1996:Q3.[13] Variables used in the study are plotted in figure 1. The data is taken from a number of sources including, the International Financial Series (IFS), the Central Bank of Ireland Database and the Central Statistics Office (CSO) data bank. The interest rate used is the inter-bank money market rate and prices are proxied by the consumer price index (CPI). All exchange rates are defined as the foreign currency price per unit of Irish punts. All exchange rates are taken form the IFS. Industrial production series was taken from the CSO database, and is seasonally adjusted series at 1995 prices.

Real GDP series is obtained from the Central Bank of Ireland. Given that the GDP figures for Ireland are only available annually, we use an interpolated series based on the Chow-Lin procedure.[14] The data for interest rates was taken from the IFS database using short-term money market rates. The money market rate is used for both the UK and Germany.

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be imposed on the B_0 matrix. It is also possible to impose identification restrictions on the cointegration matrix of a vector error correction model see for example Garrant (1998), Mitchell (2000) and Ehrmann (2000). Pagan and Robertson (1998) provide a detailed discussion on the various types of restrictions used in the SVAR literature.

[13] A detailed list of all data used in the study is reported in appendix 1.

[14] The interpolation procedure was carried out by the Research Department at the Central Bank of Ireland.

4.2 Empirical Results

The initial choice of variables is what we refer to as the standard model; *model 1*. The variables used are real GDP (*y*), prices (*p*), a short-term money market rate for Ireland (*i*) and the DM/punt exchange rate(dm).[15] The latter is included given Ireland's membership of the European Monetary System during the sample period. Finally, we include a short-term German money market rate (i^G) since one needs to control for changes in the domestic interest rate that are responses to changes in the German interest rate. Otherwise, such changes may be associated with changes in the domestic exchange rate.

[15] All variables are logged, except for interest rates.

4.2.1 Model 1

The first specification involves a Cholesky decomposition with the following ordering of variables *y*, *p*, dm, *i* and a constant.[16] The German interest rate (i^G) is assumed exogenous since domestic variables are unlikely to affect its value. This ordering of the variables implies that B_0 is given by

$$B_0 X_t = \begin{bmatrix} 1 & & & \\ B_{21} & 1 & & \\ B_{31} & B_{32} & 1 & \\ B_{41} & B_{42} & B_{43} & 1 \end{bmatrix} \begin{bmatrix} y \\ p \\ i \\ dm \end{bmatrix}$$

and imposes the condition that innovations to the policy instrument have no immediate effect on prices and output. Hence, monetary policy does not have any contemporaneous effect on these variables. Sticky prices would be one justification for the above ordering. Current prices and output also enter the central banks' decision making process.

The impulse responses to a one standard deviation rise in the interest rate are graphed in figure 2.[17] The innovation in the interest rate leads to a fall in output and the price level. Output has a typical U-shaped profile with the decline in output reaching its peak within 2 quarters of the interest rate rise (see Sims 1992, Bernanke & Blinder 1992 and Christiano and Eichenbaum 1992). Prices fall more slowly and don't reach a trough until later in the first year. An anomalous result found here is that the exchange rate depreciates when the domestic interest rate rises which is counter to what one would expect from economic theory. Thus, the above specification gives rise to an

[16] All models estimated include a constant and 1 lag. The appropriate lag length was selected using the standard selection criteria, i.e. AIC, SBC and H-Q.

[17] As can be seen from figure 2, a one standard deviation shock to interest rates is equivalent to a 2.5% change.

exchange rate puzzle.[18] This result casts doubt regarding the validity of *model 1* and may suggest that the reaction function for the Irish monetary authorities is misspecified.

While Ireland was a member of the European Monetary System, the UK, who was our major trading partner, remained outside the exchange rate system, apart from a short period between October 1990 and September 1992. Irish monetary authorities attempted to maintain an exchange rate compatible with membership of EMS while simultaneously trying to ensure a competitive Irish sterling exchange rate. This led to the possibility of potential conflicts arising in the determination of Irish monetary policy. These conflicts in turn manifested themselves and were the primary reason for the three devaluations witnessed during this period in 1983, 1986 and 1993.

4.2.2 Model 2

Given the above considerations, it would seem appropriate to also include the sterling/punt exchange rate (st) as well as the DM/punt exchange rate (dm) in the Irish monetary authority's reaction function.[19] In addition, the UK short-term interest rate (i^{uk}) is also included for the same reasons as outlined for including the German interest rate. Both German and UK interest rates are treated as exogenous variables.

[18] The existence of an exchange rate puzzle is a common finding in the literature and is discussed in detail in section 2.

[19] Ehrmann (2000) also includes both the German and UK exchange rate but excludes their respective interest rates.

A systematic search of the different possible ordering of variables was undertaken imposing a Cholesky decomposition. Our results indicate that under certain conditions an exogenous increase in the interest rate can generate stylised responses in accordance with theoretical predictions, regarding the impact of an innovation in the short-term policy rate to output, prices and the exchange rate.

In particular, we find restrictions necessary for plausible responses are twofold: (i) the interest rate is ordered prior to the two exchange rates and (ii) the price level is ordered before the interest rate. When these two conditions are imposed, we find that a temporary monetary contraction will lead to a negative response of output to the policy instrument, a more gradual decline in prices and an initial rise in the DM/punt and sterling/punt exchange rates. Subsequently, the exchange rates decline in value. These exchange rate movements are consistent with the predictions of uncovered interest parity. Moreover, one doesn't observe the phenomenon of delayed overshooting, which seems to plague other studies of monetary policy in other countries (Eichenbaum and Evans, 1995 and Sims, 1992).

To illustrate the above findings we graph the impulse responses when the variables are ordered with the price variable first, next followed by the short-term interest rate, both exchange rates and finally output. In figure 3 we see that output and prices fall due to the tightening of monetary policy with latter's decline being more gradual. In addition, both exchange rates appreciate immediately and then subsequently decline after the initial rise in the interest rate. Thus, this specification seems to be consistent with our priors regarding the effects of an interest rate shock.

How can we rationalise the above restrictions regarding the ordering of the variables needed to generate plausible responses? The placing of the price variable prior to the policy instrument is consistent with the view that with quarterly data the central bank observes the current price level when setting the interest rate. Moreover, due to the sluggishness in the response of prices to interest rate changes, the latter does not influence prices immediately.

The ordering of the exchange rate variables after the interest rate would seem to be more difficult to justify. With capital mobility, one would anticipate that interest rate changes might have an immediate effect on the exchange rate. In addition, exchange rate shocks are likely to affect the setting of interest rates. Thus, the appropriateness of a recursive structure between interest rates and exchange rates seems to be questionable particularly in the case of a small open economy.

4.2.3 Model 3

To further investigate this point, we break the recursive structure imposed above and allow contemporaneous effects between variables. In particular, we allow simultaneity between shocks to interest rates and exchange rates. Our results suggest that permitting two way interactions between innovations in the domestic policy rate and the two exchange rates doesn’t alter our results. This appears to hold once the price variable is ordered prior to the policy rate and shocks to the price level have a contemporaneous effect on the policy rate and exchange rate variables.

For example, suppose we impose the following structure on B_0

$$B_0 X_t = \begin{bmatrix} 1 & & & & \\ b_{21} & 1 & b_{23} & b_{24} & \\ b_{31} & b_{32} & 1 & & \\ b_{41} & b_{42} & & 1 & \\ b_{51} & & & & 1 \end{bmatrix} \begin{bmatrix} p \\ i \\ dm \\ st \\ y \end{bmatrix}$$

Thus, prices are not affected immediately by shocks to other variables. The critical restriction here, in contrast to model 2, is that we now allow contemporaneous shocks to the interest rate and exchange rates to impact on each other simultaneously. In figure 4, we plot the response of the endogenous variables to a one standard deviation shock to the interest rate. Output falls with the onset of the higher interest rate reaching a trough after 4 quarters and then gradually recovering. A more gradual decline in prices is observed. The higher interest rate prompts an immediate appreciation of the punt and then a subsequent decline in its value.

When comparing the results between *model 2* and *model 3*, the qualitative response of the variables seems robust to whether the interest rate is ordered prior to the two exchange rates. In other words there appears to be no qualitative difference between the recursiveness scheme or whether simultaneity between innovations in the exchange rate and interest rate are allowed. This result holds provided condition (i) previously outlined for *model 2* is imposed.

So far we have only discussed the qualitative response of the endogenous variables to a rise in the interest rate. What about the quantitative effect of an interest rate change? Overall the effect on the macroeconomic variables to an interest rate shock is small in magnitude. This finding is not surprising given the main goal of Irish monetary policy during this period was to maintain the exchange rate. In the presence of capital mobility this left little scope for monetary policy to pursue separate domestic objectives.

5. Conclusion

In this study we examine the effect of an exogenous temporary change in the interest rate on output, prices and the exchange rate. Our results generate plausible response to a monetary contraction and we don't observe either a price or an exchange rate puzzle as is found in many of the previous studies.[20] While the qualitative results are favourable, the quantitative impact of unanticipated monetary policy is very small. This is not surprising given the main rule of monetary policy was to target the exchange rate during the period under investigation.

Finally, VAR models examining monetary policy have been criticised regarding the appropriateness of the identified monetary shock (see Rudebsuch 1998). In figure 5 we plot the relationship between the change in the interest rate and the identified monetary policy shock for *models 1 – 3*. The close relationship between the identified shock for each of the models and the change in the interest rate would appear to justify the appropriateness of the identified shocks. Further work might investigate the robustness of these identified monetary policy shocks, compared to alternative identification approach's, e.g. the narrative approach, Romer and Romer (1989) or the methodology applied by Bagliano and Favero (1998).

[20] In results not reported we find similar qualitative responses if we replace our measure of output with industrial production.

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Appendix 1: Definitions of Variables and Data Sources

Dollor/Punt exchange rate (*line ac*)

DM/Punt exchange rate (*line ac*)

Sterling/Punt exchange rate (*line ac*)

Money market interest rate: Ireland (*line 60b*)

Money market interest rate: Germany (*line 60b*)

Money market interest rate: UK (*line 60b*)

Consumer Price Index: UK (*line 64*)

Consumer Price Index: Ireland (line 64)

Source: International Financial Series (IFS)

Industrial Production : Ireland

Consumer Price Index: Ireland

Source: Central Statistics Office (CSO) Database

Fig 1. Variables

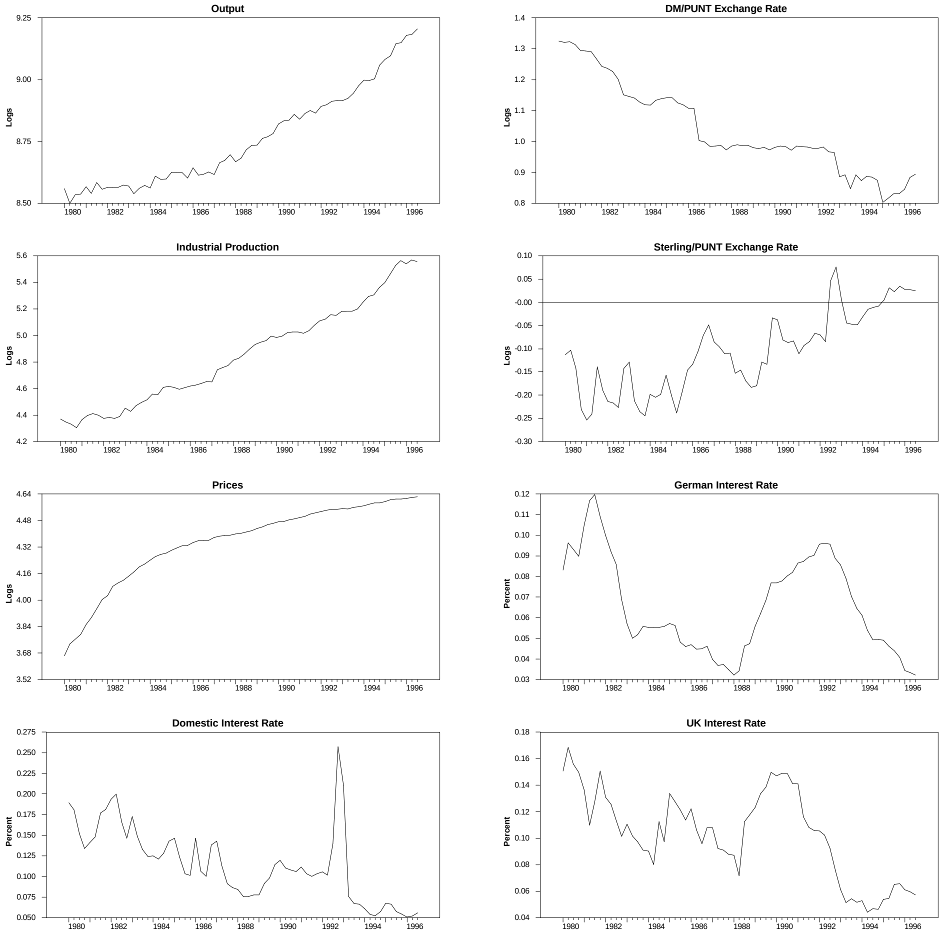

Fig 2. Impulse Responses to Interest Rate Shock

Model 1

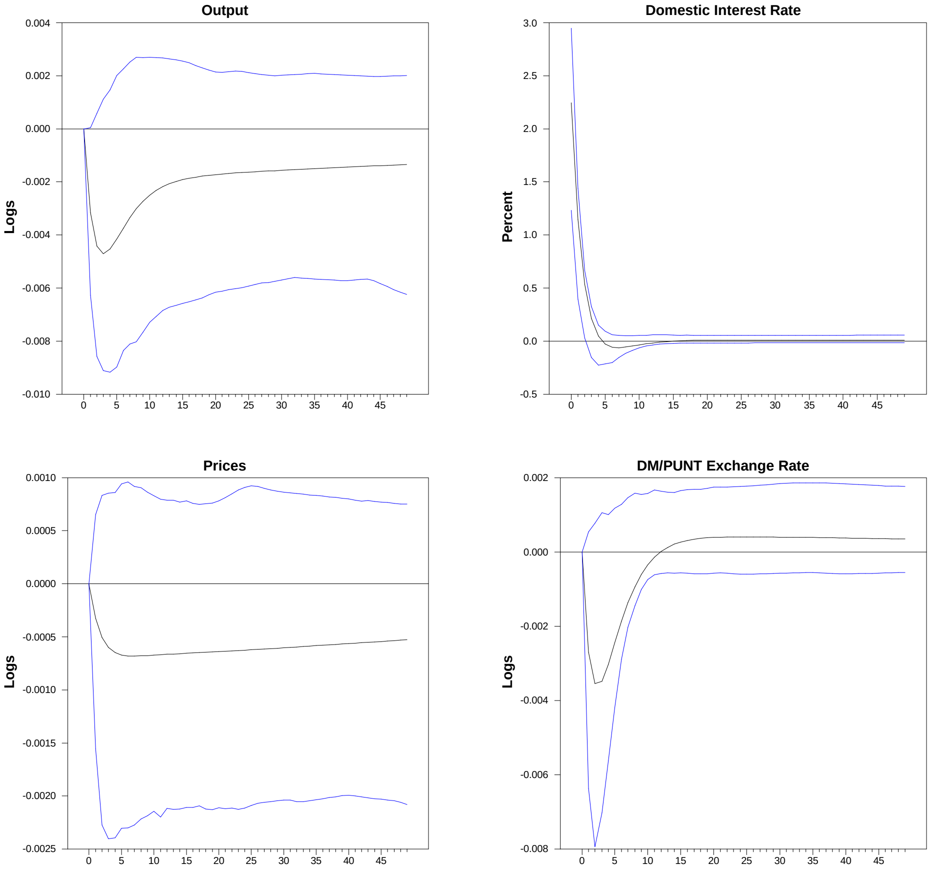

Fig 3. Impulse Responses to Interest Rate Shock

Model 2

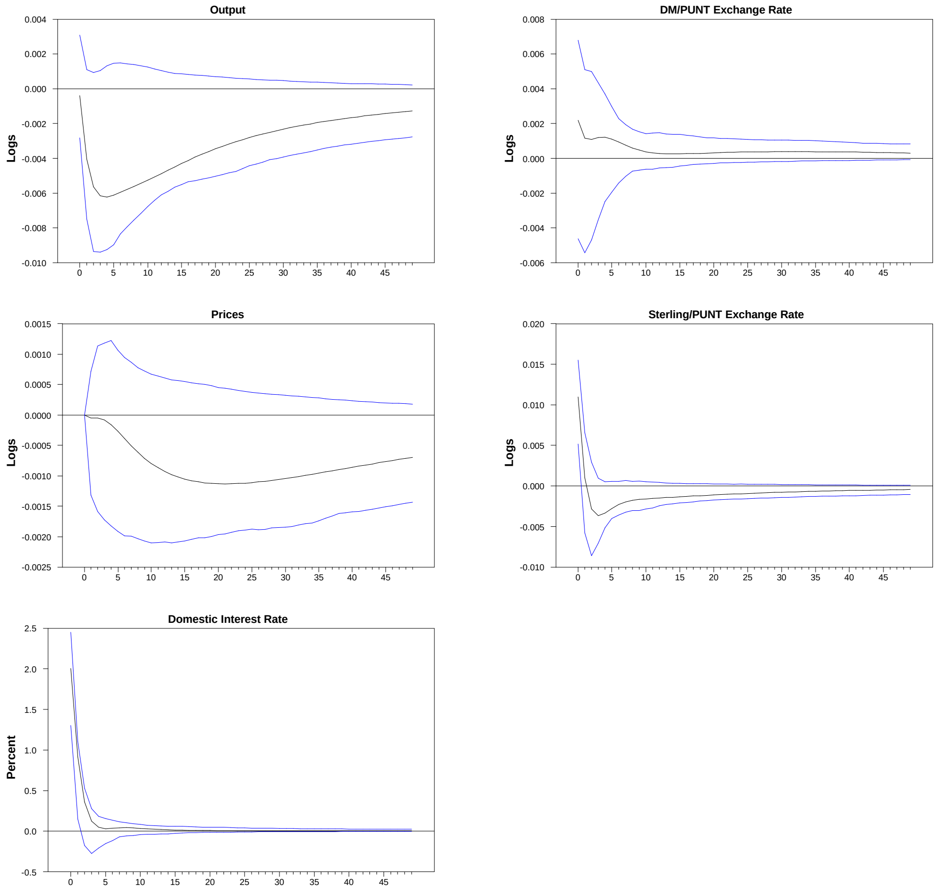

Fig 4. Impulse Responses to Interest Rate Shock
Model 3

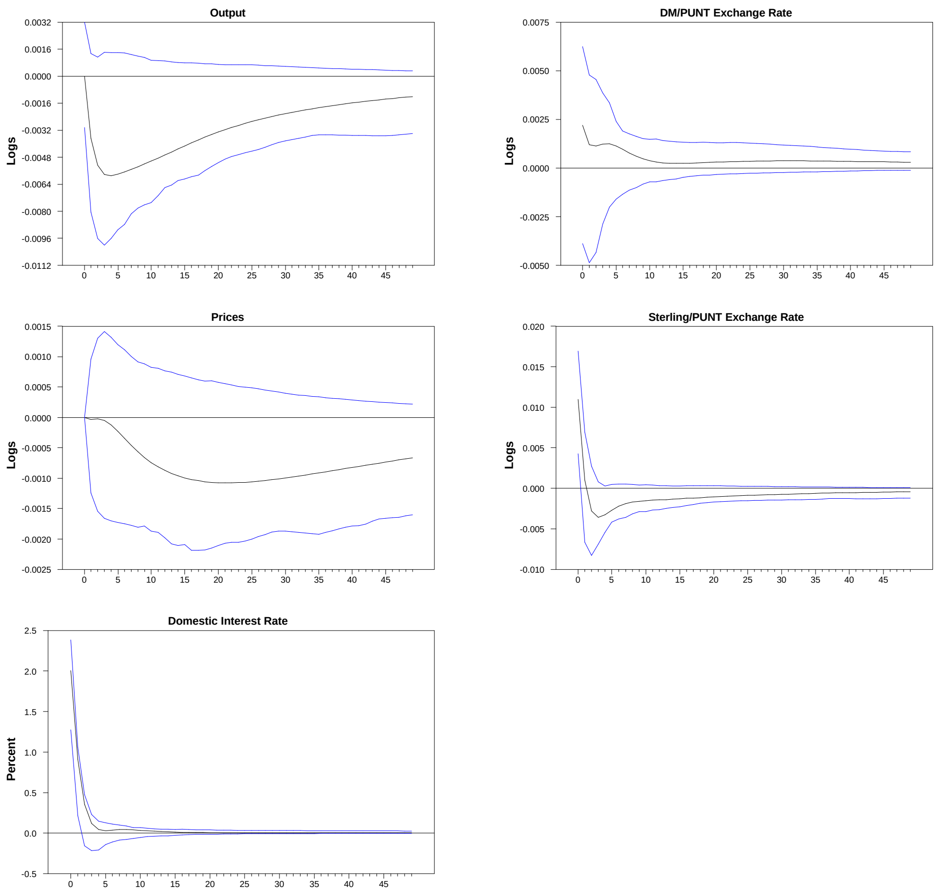

Figure 5a: Monetary Policy Shocks and Interest Rate Changes (Model 1)

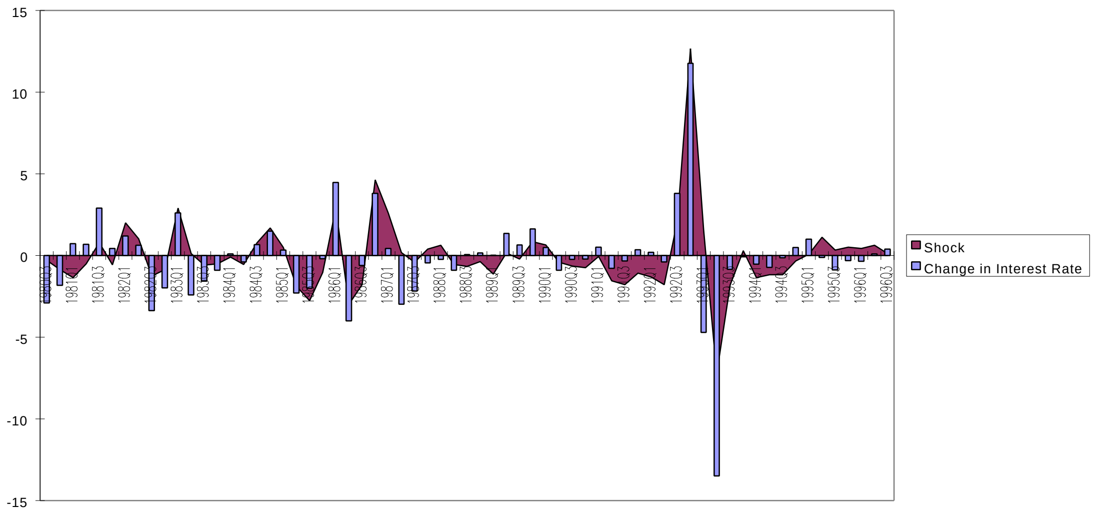

Figure 5b: Monetary Policy Shocks and Interest Rate Changes (Model 2)

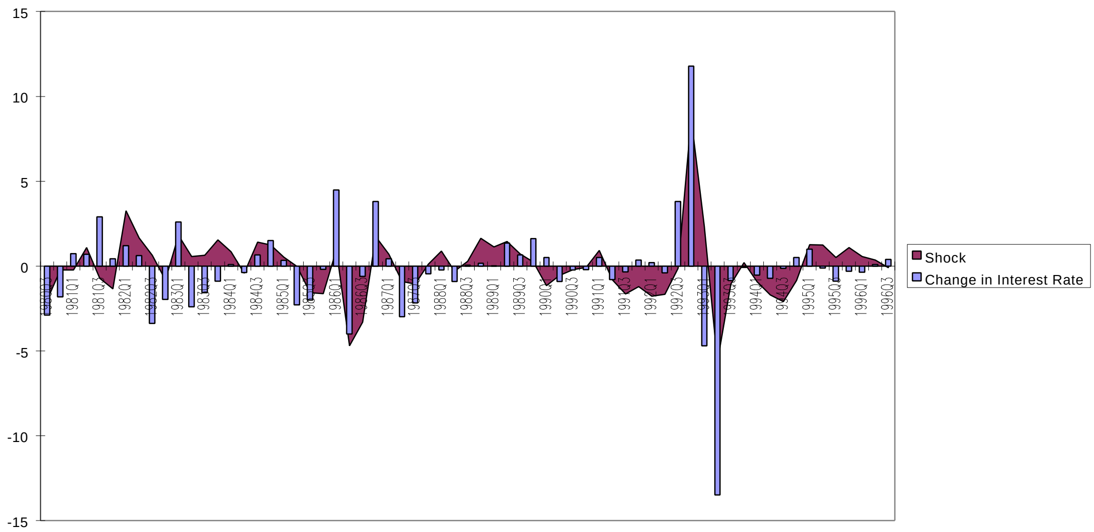

Figure 5c: Monetary Policy Shocks and Interest Rate Changes (Model 3)