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DIFFERENCES IN THE TRANSMISSION OF MONETARY POLICY IN THE EURO-AREA: AN EMPIRICAL APPROACH

By

Daniel McCoy*
Economic and Social Research Institute

and

Michael McMahon
Trinity College, Dublin

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*Daniel McCoy is a Research Officer at the Economic and Social Research Institute, Dublin and Michael McMahon is an undergraduate at the Department of Economics, Trinity College Dublin. This research was initiated when both authors were at the Central Bank of Ireland. Paper presented at the 14th Annual Conference of the Irish Economic Association, 1-3 April 2000, Waterford. Comments can be directed to danny.mccoy@esri.ie or Danny McCoy, ESRI, 4 Burlington Road, Dublin 4.

Abstract

The paper examines the impact of interest rate changes on real economic activity for a range of EU countries including Ireland. The objective is to compare how monetary policy shocks are transmitted to output in the economies of the euro area prior to a common monetary policy. A number of studies have analysed how the effects of monetary policy can vary between countries, for example Gerlach and Smets (1995) and Ramaswamy and Sloek (1997). These studies have analysed a range of EU countries but Ireland has tended to be omitted due to the lack of the necessary quarterly national accounts' data for output. In this paper we address this omission by using a constructed quarterly GDP data series from 1972 to 1998 for Ireland and apply a Vector Auto-regression (VAR) methodology that incorporates prices, output and interest rates. The paper uses both an unrestricted VAR model and a Structural VAR model based on Bernanke-Sims type decompositions to compare the impulse responses of output to a monetary policy shock in thirteen EU countries. In order to compare the responses we have used similar data series, sample periods and an identical econometric framework for all countries. The results would suggest that Ireland experiences greater output responses for a given monetary shock than all other euro area economies.

1. Introduction

The motivation for this paper is to examine the impact of interest rate changes on real economic activity in EU countries that share a common monetary policy under European Monetary Union (EMU). Over the last five years, a number of studies have analysed how the effects of monetary policy can vary from one country to another, for example Gerlach and Smets (1995), Barran *et al.* (1996), and Ramaswamy and Sloek (1997). While these papers analyse a range of countries, Ireland has tended to be excluded due to the lack of the necessary quarterly national accounts' data. We wanted to address this omission in order to compare the monetary transmission process in Ireland with other euro area countries in run up to monetary union. In this paper we address this omission by using a constructed quarterly GDP data series from 1972 to 1998 for Ireland and applying a Vector Auto-regression (VAR) methodology that incorporates prices, output and interest rates.

The monetary transmission mechanism is the process through which monetary policy decisions are transmitted into changes in real GDP and inflation. Modern macroeconomics tends to draw a distinction between the short and medium term when distinguishing the effects of monetary policy on the real economy. Over the medium term inflation is primarily a monetary phenomenon and in terms of the real effects on output money is considered to be neutral. In the short term, however, monetary policy is considered to have real effects.

There are two important dimensions to the conduct of monetary policy that need to be clearly distinguished. The first is the adjustment of monetary policy instruments in reaction to changes in objective variables such as output and inflation. Estimated reaction functions indicate that monetary authorities internationally respond to inflation and output gaps by changing interest rates in a manner consistent with the so-called Taylor rule. Taylor (1993) showed that movements in the US federal funds rate is captured by a rule that raises the rate by 1.5 percentage points in response to a percentage point increase in inflation and by 0.5 percentage point in response to a one percentage rise in GDP above its potential. A recent study by Gerlach and Smets (1999) using optimal control exercises suggests that monetary policy in the euro-area is best served by following a such a Taylor rule. The second dimension to monetary policy is the impact of monetary authorities' actions on the real economy. The monetary transmission mechanism consists of several interlinked channels, such as the interest rate or money channel, the credit channel, the exchange rate channel and the asset price channel, which can differ substantially across countries[1].

The focus of this paper is on the aggregate effect of these different transmission channels rather than on the relative importance of each in the different EU countries. The motivation for this focus arises from the need for the real effects of monetary policy to be relatively uniform across the different EU countries in order to facilitate the smooth conduct of monetary policy in the euro-area. It is also motivated by the lack of consensus among economists on the effects of monetary policy changes through different channels in different countries or even within a given country. The lack of consensus stems from the difficulty in

[1] For an excellent discussion of the monetary transmission mechanism, see the Symposium on the Monetary Transmission Mechanism in the Journal of Economic Perspectives (Fall 1995).

disentangling time series on interest rates into parts that are due to deliberate monetary policy measures and those that are due to endogenous responses of financial markets to unobserved economic disturbances. As a result, different empirical methodologies give rise to different estimates of the role and effect of monetary policy.

Our paper uses a parsimonious model comprising of prices, output and short-term interest rates across EU countries. In order to enhance the comparability of the results between the different countries we attempt to use a consistent data series where possible over a similar sample period. We use both a standard, or just identified, VAR model and a Structural VAR (SVAR) making the same identifying assumptions in each country to further facilitate comparison. While reliance on one particular model specification may seem limiting, there are no obvious reasons to believe that observed differences in monetary policy responses are artefacts of the econometric methodology chosen (Gerlach and Smets, 1995). Indeed, even within the VAR approach empirical studies have found the estimates of output responses to monetary shocks to be quite robust to alternative specifications, see Ramaswamy and Sloek (1997). It is certainly the case that different specifications and estimation strategies would be needed in different countries to capture the impact of factors like the exchange rate on monetary transmission mechanisms. The purpose of our analysis to compare the impulse responses of output to interest rate shocks across the range of countries so we the same specification for all.

The remainder of the paper is structured as follows. The next section deals with the methodology and identification of the model. Section 3 deals with the data used and the tests for stationarity, lags lengths and so on. Section 4 outlines the results from our estimation by providing graphical representation of the impulse response functions in order to evaluate the effect on output of demand, supply and monetary shocks. Section 5 concludes.

2. Methodology and Identification

VAR models are very good tools for assessing the dynamics of the economy in the aftermath of a monetary policy shock. The VAR methodology is particularly suitable for studying the monetary transmission mechanism in multi-country models. They require only a minimum number of restrictions to identify movements in endogenous variables due to different underlying shocks. There have been many studies using VAR monetary models in the US, as surveyed by Friedman (1995), while in Europe studies by Dale and Haldane (1994) and Tsatsaronis (1995) have followed similar approaches. The usefulness of the SVAR methodology in particular is set out in McCoy (1997). The SVAR approach has been developed over the last ten years as an extension of the traditional atheoretic VARs by combining economic theory with time-series analysis to determine the dynamic response of economic variables to various disturbances. This methodology is sometimes referred to as disturbance analysis.

The main problem with empirically estimating the effects of monetary policy is in clearly identifying monetary policy shocks. In addition, there is also a problem with measuring the stance of monetary policy, whether it is better to use a price (interest rate) or quantity (monetary aggregate) measure. In this paper we have opted to use a short-term interest rate to indicate monetary stance for two main reasons. The first reason is that monetary authorities generally pursue policy by changing very short-term interest rates to guide the financial system (Bernake and Blinder, 1992). A second reason is that monetary aggregates are subject to a wide variety of other disturbances, such as shifts in money demand, which can dominate the information contained about monetary stance (King and Plosser, 1984). Very short-term interest rates can contain considerable noise making it difficult to identify a representative interest rate, since central banks internationally use many different rates to provide finance. We have opted to use a short-term money market interest rate as a measure monetary stance.

The model we choose to work with in the paper uses only three endogenous variables, real GDP, prices and short-term interest rates (see Section 3 for a description of the data). This size of model limits the number of structural shocks that can be identified as there can be only one for each endogenous variable. This parsimonious representation can nonetheless comprise a standard macroeconomic model allowing for an IS-curve, a Phillips curve and a monetary policy reaction function. Within such a framework, identification of monetary shocks is a key issue that necessitates the imposition of some structure on the system. It is on the imposition of this structure that SVARs differ from the traditional VAR analysis.

If we let the structural model be represented in vector moving average (VMA) form as

$$X_t = A(L).\varepsilon_t \qquad (1)$$

where X is the vector of endogenous variables, A(L) is a matrix of lag polynomial of responses of endogenous variables to underlying structural shocks ε_t. To estimate (1), in order to recover the dynamic responses of economic variables to various disturbances, we need to find a reduced form VAR model as in (2).

$$B(L).X_t = e_t \qquad (2)$$

This VAR model can be estimated to obtain values for the matrix polynomial B(L) that can then be inverted to get a moving average representation as in (3) below.

$$X_t = C(L).e_t \qquad (3)$$

where $C(L) = B(L)^{-1}$ and e_t are estimated shocks which have no economic interpretation but have a variance/covariance matrix Σ. The σ^2 are the variance and σ_{ij} are the covariance terms where each $\sigma_{ij} = \left(1/T\right)\sum_{t=1}^{T} e_{it}\, e_{jt}$ and where

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \ldots & \sigma_{1n} \\ \sigma_{21} & \sigma_2^2 & \ldots & \sigma_{2n} \\ . & . & . & . \\ . & . & . & . \\ \sigma_{n1} & \sigma_{n2} & \ldots & \sigma_n^2 \end{bmatrix}$$

In order to identify the VAR, we map the parameters of the reduced form VMA model (3) into the structural VMA model (1). From (1) and (2) we get:

$$e_t = C(L)^{-1}.A(L).\varepsilon_t \qquad (4)$$

Let $A(0) = C(L)^{-1}.A(L)$, which is the contemporaneous impact matrix, and substituting into (4) we get:

$$e_t = A(0).\varepsilon_t \qquad (5)$$

To ensure a unique mapping between the estimated shocks and the structural shocks we need to find an estimate for A(0). This is done through imposing sufficient restrictions to allow us to solve for A(0) using estimates of C(L), or equivalently B(L), and Ω, where the matrix Ω is the variance/covariance matrix of the structural disturbances, ε_t. Finding A(0) involves estimating the Σ conditional on a set of restrictions. The estimation is set out in (6) below:

$$\Sigma = E[e_t e_t^{/}] = A(0)E[\varepsilon_t \varepsilon_t^{/}]A(0)^{/} = A(0)\Omega A(0)^{/} \qquad \mathbf{(6)}$$

The number of structural parameters to be estimated depends on the variance/covariance matrix Ω, which contains $(n^2 + n)/_2$ unique elements, and on the matrix A(L) containing n^2 elements. The total number of parameters to be estimated is $n^2 + (n^2 + n)/_2$. The matrix Σ is symmetric, since $\sigma_{12} = \sigma_{21}$, and so it contains only $(n^2 + n)/_2$ distinct estimated parameters to use in recovering the structural parameters in (1). Therefore there are n^2 further restrictions required for identification.

Since the structural disturbances are assumed to be white noise with zero covariance terms, implying that each disturbance arises from independent sources, the Ω is a diagonal matrix. This provides $(n^2 - n)/_2$ restrictions. In addition, the matrix A(0) is normally assumed to have main diagonal elements equal to unity. This results from the assumption that each equation is normalised on a particular variable and a separate shock. This provides a further n restrictions. This leaves $(n^2 - n)/_2$ restrictions needed for identification.

Traditional VARs propose an identification restriction based upon on a recursive structure known as a Choleski decomposition. This statistical decomposition separates the estimated residuals (e_t) from a reduced form representation of the structural model into orthogonal (uncorrelated) shocks by restrictions imposed on the basis of an arbitrary ordering of the variables. The decomposition implies that the first variable responds only to its own exogenous shocks, the second variable responds to the first variable and to the second variable's exogenous shocks and so on. The structure that results is referred to as being lower triangular, where all elements above the principal diagonal are zero. This is shown in the system below where the z_t are the Choleski restrictions and the ω_t is the vector of orthogonal shocks.

$$
\begin{aligned}
e_1 &= \omega_1 \\
e_2 &= z_1 e_1 + \omega_2 \\
e_3 &= z_2 e_1 + z_3 e_2 + \omega_3
\end{aligned}
$$

In the example of a three variable model given above, the Choleski decomposition provides the (9 - 3)/2 = 3 restrictions needed to exactly identify the system. However, this is just one possible ordering of the variables. There can be factorial n possible orderings, which in the three variable example would be 6 combinations. The choice of ordering is unlikely to be important if the correlation between the residuals is low but this is unlikely to be the case, given that variables included in a VAR will normally be chosen precisely because they have strong co-movements. The results from VARs can be quite sensitive to the ordering imposed which makes their interpretation quite difficult.

Given our three variable VAR, with the interest rate as a policy variable, there are two appealing ways of ordering the variables (Barran *et al.*, 1996). Ordering policy variables, such as the interest rate, first implies that monetary policy shocks affect all the variables contemporaneously, but monetary policy does not react to simultaneous shocks to output and prices. This is the type of ordering that was adopted by Bernanke and Blinder (1992). The idea that monetary policy decisions are made without consideration of the simultaneous evolution of the other variables is justified if the data on these other variables are not immediately available.

The second type of ordering would put the policy variables last. This implies that monetary policy decisions take into account the simultaneous movements in the price and output variables. Therefore monetary policy does not have any contemporaneous effect which may be rationalised by assuming the existence of time dependent rules, convex adjustment costs, menu costs or building and delivery lags.

In estimating our standard VAR we have ordered our interest rate policy variable first. The rationale for this is that the aim of the paper is to analyse the effect of interest rate shocks on the other variables rather than the reaction of monetary policy to changes in output and prices.

However, the atheoretical approach of standard VARs has been criticised on the grounds that the ordering imposed by a Choleski decomposition is not in fact atheoretical at all. It implies a particular type of recursive contemporaneous structure for the economy that may not be consistent with economic theory. Other criticisms include that the estimated shocks are not pure shocks but rather linear combinations of the structural disturbances and have no obvious economic interpretation (Cooley and LeRoy, 1985).

These criticisms of standard VARs led to the development of the SVAR approach. This work stemmed from the seminal contributions of Sims (1986), Bernanke (1986) and Blanchard and Watson (1986) who made use of economic theory to impose restrictions in order to recover the structure of the disturbances. These can be considered as short-run restrictions in that the shocks are considered to have temporary effects. An alternative SVAR approach advanced by Shapiro and Watson (1988) and Blanchard and Quah (1989), is to consider the shocks as having permanent effects. Depending on the approach taken the SVAR restrictions can be either contemporaneous or long-run or a combination of both depending on whether economic theory suggests the shocks are either temporary or permanent in nature.

In the case where the shocks are assumed to have temporary effects on the variables the restrictions are imposed on the contemporaneous elements contained in A(0). In contrast where the shocks are assumed to have permanent effects, the restrictions are imposed on the long-run multipliers in the impulse response functions, which in effect involves restrictions on C(L).

As it is the effects, rather than the response, of monetary policy that we are particularly interested in, restricting the contemporaneous response of the interest rate variable is appealing. The SVAR identification procedure we adopted is based on Bernanke-Sims methodology to impose contemporaneous restrictions. The identification is based on a vector X_t = (i,y,p). In this three variable case we need three restrictions on the A(0) matrix other than those used in the Choleski decomposition. The contemporaneous restrictions used are that if price level is predetermined, except for producers responding to aggregate supply shocks, then the residual on the price variable is independent contemporaneously to shocks in the other variables. This provides two zero restrictions in the first and second elements of the third row of A(0). The third restriction comes from assuming that output shocks do not contemporaneously impact on interest rates, thereby restricting the second element of the first row of A(0) to be zero. Other possible assumptions such as no instantaneous pass-through to prices seem less plausible[2], and the use of one more restriction than necessary would over-identify the model and therefore add unnecessary difficulty to its estimation. These assumptions provide the three remaining restrictions necessary to identify and estimate the structural model.

[2] This is because with the use of quarterly data, it is quite possible that monetary policy changes are reflected in the exchange rate, import prices or directly in prices through the mortgage interest rates.

3. Data Description

The data used in the paper was obtained from the International Financial Statistics (IFS) of the International Monetary Fund, from the Statistical Compendium of the OECD, from the National Bank of Belgium (NBB) database and from the Central Bank of Ireland database. The data set comprises of real GDP (in 1990 prices), interest rates (money market rate) and consumer prices (CPI) for countries Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom. It consists of as many quarterly observations as are available for each individual country over the time period 1972 Q1 to 1998 Q4. Output and prices are used logs and interest rates in levels.

GDP:

The series on nominal GDP has been obtained mainly from the IFS database (line 90), with the two exceptions being the Belgian data (NBB) and the Irish data (Central Bank of Ireland). The data was then converted into real terms using the GDP deflator (for 1990 prices) calculated from the European Commission AMECO database. It was assumed that the deflator for each year could be applied to each quarter of that year in the same way. Therefore all GDP data is for real GDP at 1990 prices.

For those years that did not have a sufficiently long quarterly data series, it was necessary to estimate a quarterly extension to the existing data set. The indicator used was the index of total industrial production. The process involved running a Chow-Lin procedure using the econometric programme RATS in order to extrapolate quarterly data. This quarterly data was then joined to the existing quarterly figures in order to provide a full data set.

For the case of Ireland absence of sufficiently long-run quarterly GDP data on Ireland made it necessary to carry out a conversion in order to generate the Irish GDP series. Available quarterly data for Irish GDP was provided by Central Bank of Ireland sources. The quarterly shares of GNP between 1972 and end 1979 were taken from figures computed by O'Reilly and Lynch (1983), and O'Reilly(1981). These shares, it was assumed, could be used as an accurate indicator of quarterly GDP because, for the time period under consideration (1972:1-1979:4), net factor income from abroad was not of a large magnitude. For the time period 1980:1-1998:4, the quarterly shares were taken from the quarterly GDP data that has been compiled at the Central Bank of Ireland. These shares were then applied to annual, nominal GDP figures from the CSO so as to ensure consistency of ESA 1979 basis. The conversion to real GDP at 1990 prices took place using quarterly deflators calculated from O'Reilly' data output and the model data set.

Interest Rates and Prices

The data for interest rates was taken from the IFS database using short-term money market rates (line 60b). Quarterly data on prices was also taken from the IFS database and the index used was the Consumer Price Index (line 64).

Sample Period Used and Seasonality

The sample covered is in the main for the period 1972 Q1 to 1998 Q4. There are some exception as a result of the absence or non-availability of necessary data series; these include Denmark (1975 Q1 to 1998 Q4), Finland (1978 Q1 to 1998 Q4), Portugal (1978 Q1 to 1998 Q4) and Sweden (1980 Q1 to 1998 Q4). A drawback in the data used is that the output series contained in the IFS databank are seasonalised in only about half of countries. This is apparent in the impulse response functions reported in the Appendix.

On the basis of our Akaike and Schwartz criteria the lag length of 4 quarters was chosen for estimating the VAR. Diagnostic tests of the data using Dickey-Fuller and Phillips-Perron tests indicated that for all countries in the sample there was non-stationarity in output and prices in levels. This result is consistent with the empirical literature on the transmission of monetary policy by VAR estimation. A common approach in this literature when comparing on the basis of impulse responses is to proceed to estimate in levels even in the presence of non-stationarity rather than in first differences or imposing cointegration restrictions.

This preference for an unrestricted version of the VAR is based on an assessment of the trade-off between loss of efficiency and loss of information. The Fuller (1976) result that differencing produces no gain in asymptotic efficiency in an autoregression, even where it is appropriate, is invoked in defence of not differencing.

However, consider equations (2) and (3) above - in order to estimate the VAR it is necessary to invert B(L) to get C(L). It is only possible to invert an MA process, if the roots of the characteristic equation of all lie outside the unit circle (Greene, 1993). While statistically a unit root is found in the data, the inversion procedure is completed by the program because it is not a precise unit root. The non-stationarity of the data may lead to imprecise estimation.[3]

As a result of these estimation considerations, we have chosen to run the analysis using both the data in levels and also the first differenced, stationary data. The results of both are presented in section 4.

The explanations advanced for not using cointegration, even where it exists, is that the true cointegrating relationships are unknown and these relationships are not the focus of the analysis. Imposing inappropriate cointegrating relationships can lead to biased estimates and biased impulse response functions.

4. Results

The impulse response functions from both the VAR and SVAR models outlined in section 2, and for both the levels and first differenced models are set out in the Appendix. The impulse responses are split into four groups of three countries in addition to the relevant impulse response for Ireland included in each plot.

For the levels data the differences between the VAR and SVAR specifications appear insignificant. This may be as a result of both

[3] This point was kindly highlighted to the authors by Prof. S. Nickell at the IEA Annual Conference 2000.

specifications imposing restrictions only on the contemporaneous impact matrix A(0). An extension of the analysis would be to impose long-run restrictions on C(L), or a combination of both of these types of restriction.[4]

Using a common econometric specification in levels, the impulse response results for Ireland would seem to be an outlier with the impact of a monetary shock on output appearing to have a much deeper and longer effect in comparison to the other EU countries.

Using similar methodologies, but specifying in first differences, the impulse response functions seem to be more plausible. In the case of all the impulse responses the effect of the temporary shock tends to zero over time. Again, in the first differenced case there is not a very significant difference between the Choleski and the Structural VAR analysis.

From this analysis it is also possible to see that the effects on the smaller, peripheral countries in the Euro-zone such as Ireland, Portugal, Finland and Denmark are deeper than those on the larger countries. While the Irish case continues to have a much deeper response, it is more plausible in that it returns to zero over a reasonable time horizon. This may suggest that the Irish undifferenced result arises from a misspecified model that excludes the exchange rate as a variable. Earlier attempts by us to include an exchange rate variable and to use a Vector Error Correction Mechanism (VECM) model proved unsatisfactory nor was it amenable to a cross-country comparison, though it may be a significant

[4] See Blanchard and Quah (1989) for long-run restrictions and Gali (1992) for a combination of both.

conditioning variable for the impulse responses observed in smaller economies.

5. Conclusions

The paper sets out to include Ireland in a comparison of the monetary transmission mechanism with EU countries. In line with other studies we attempted to use a common specification for all countries. The results using data in levels would suggest that a monetary shock resulting in higher interest rates would seem to have an implausibly large and persistent impact on output in the Irish case in comparison to other EU countries. When estimated in first differences, Ireland is more in line with other small EMU countries though it still has the deepest response to a monetary shock. This may point to the need for a unique econometric specification for each economy in order to capture the differences in the monetary transmission mechanism more accurately. The consequence of this recommendation would diminish the comparability of the results, but to proceed otherwise might be ill-advised.

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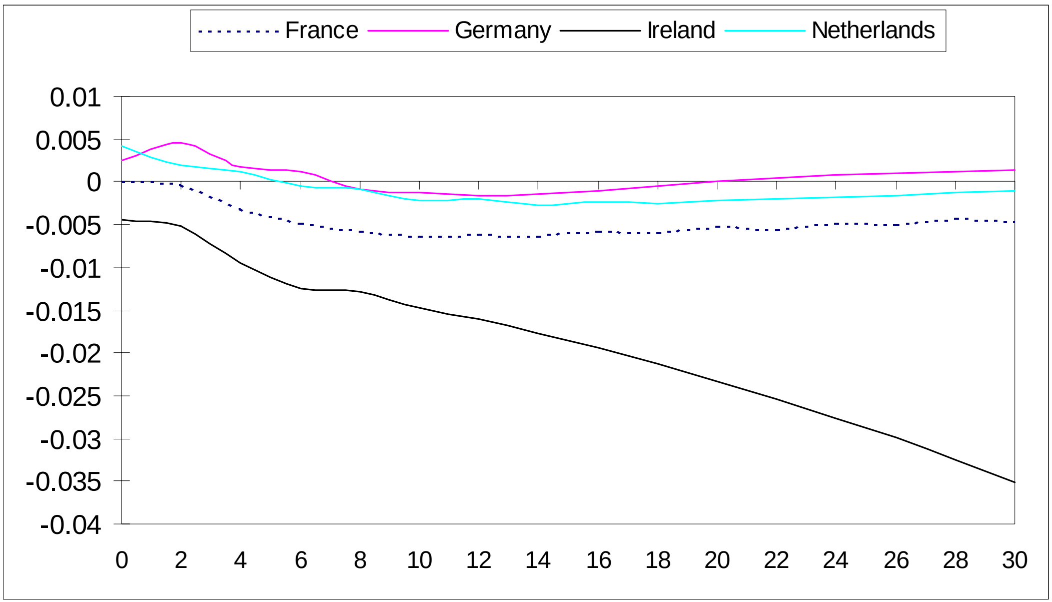
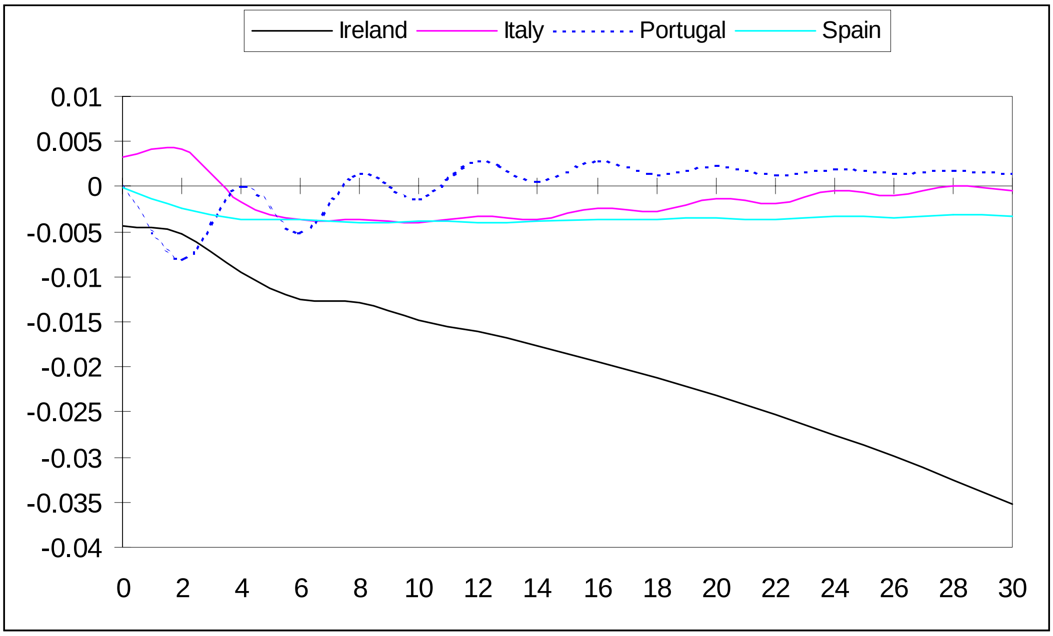
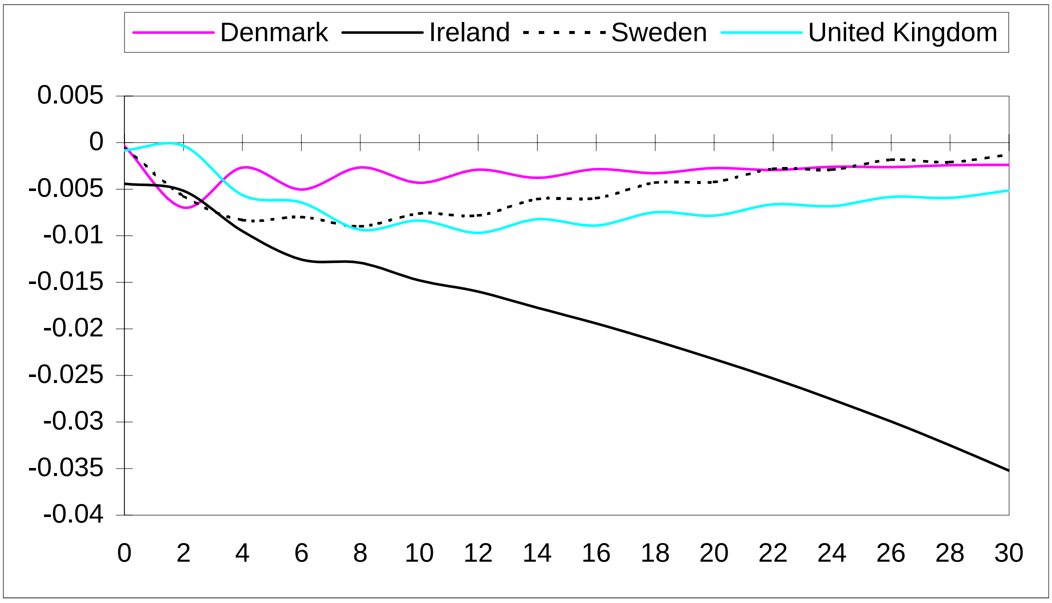
Appendix

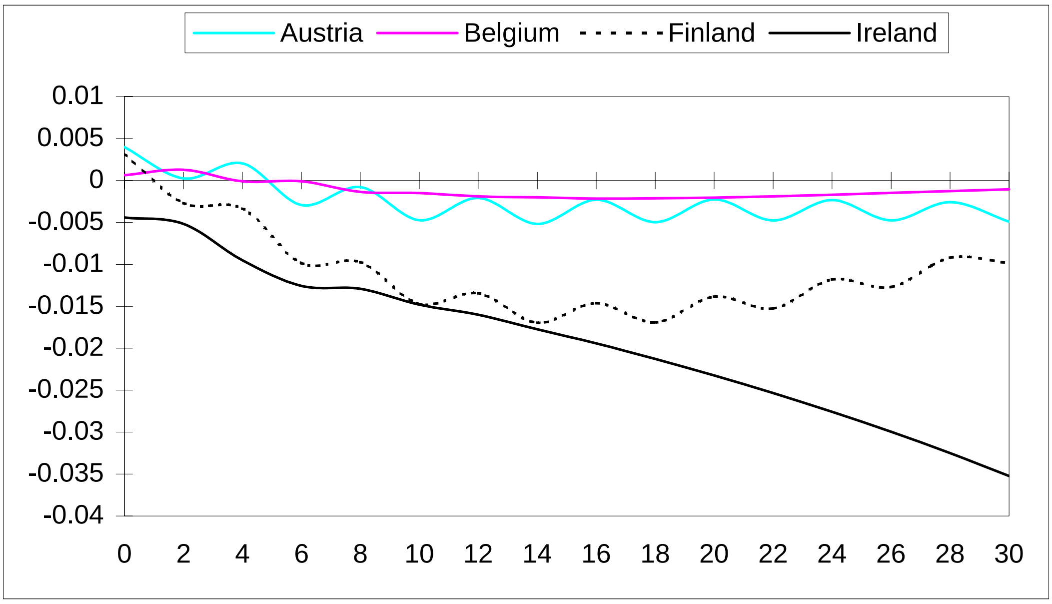
Impulse Response Functions:
Choleski VAR in Levels



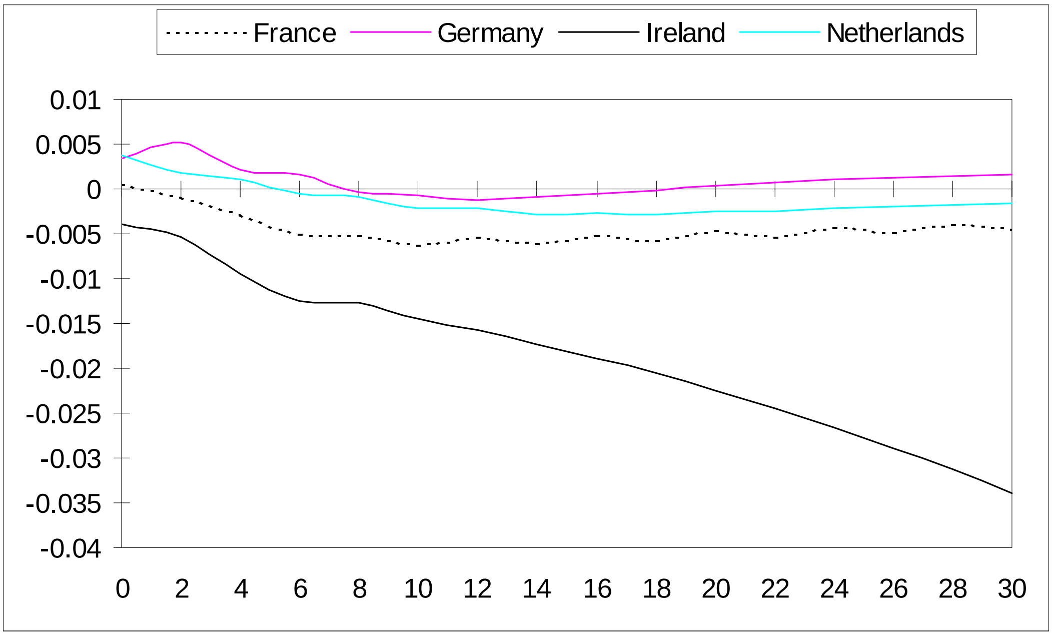


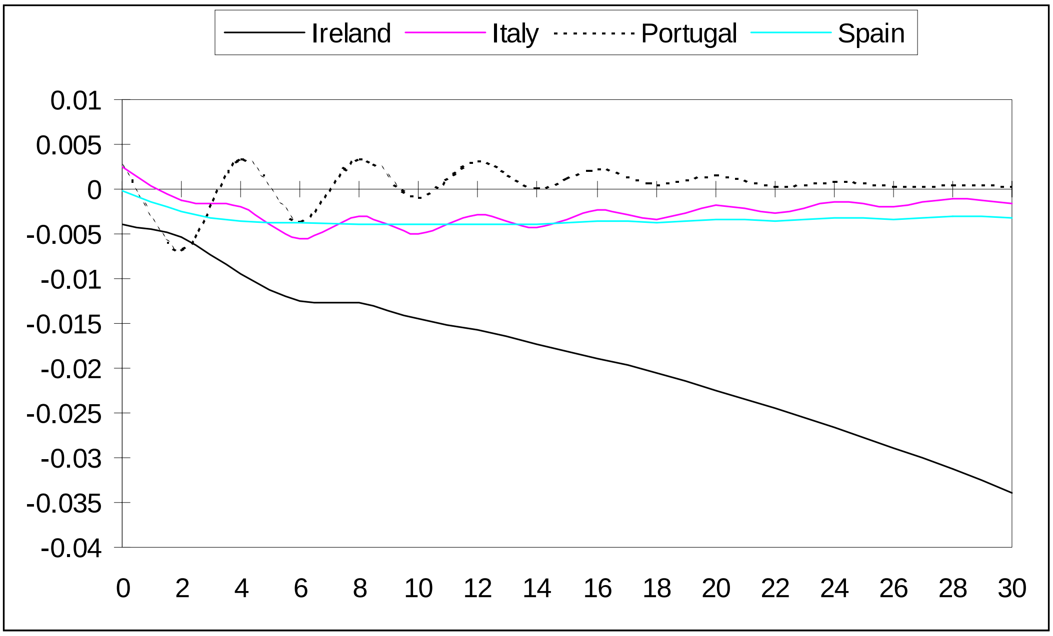
Impulse Response Functions:
Choleski VAR in Levels (contd.)



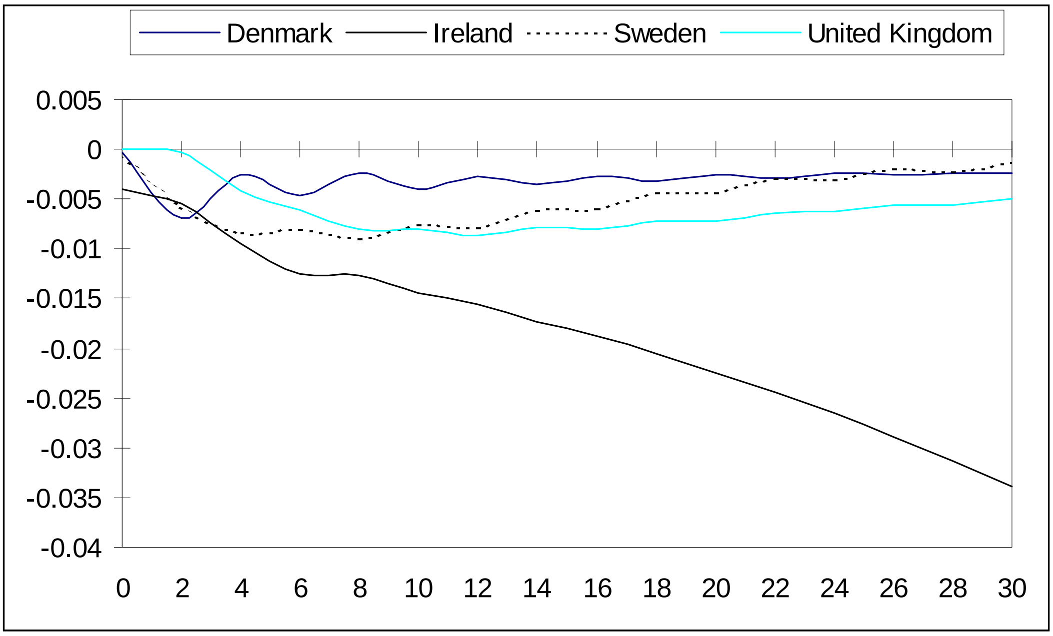


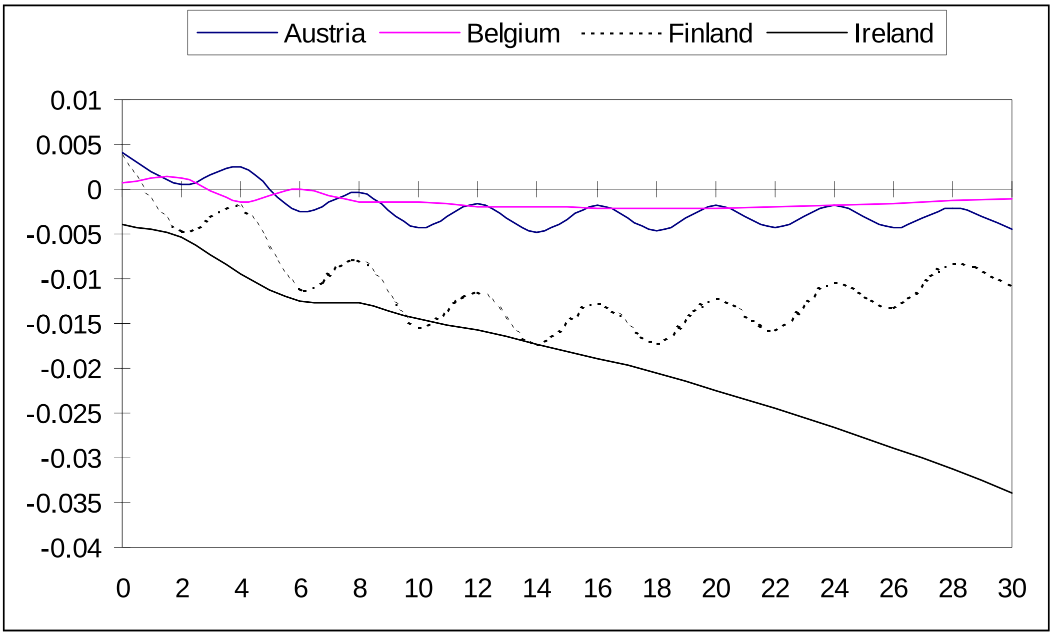
Impulse Response Functions:
SVAR in Levels



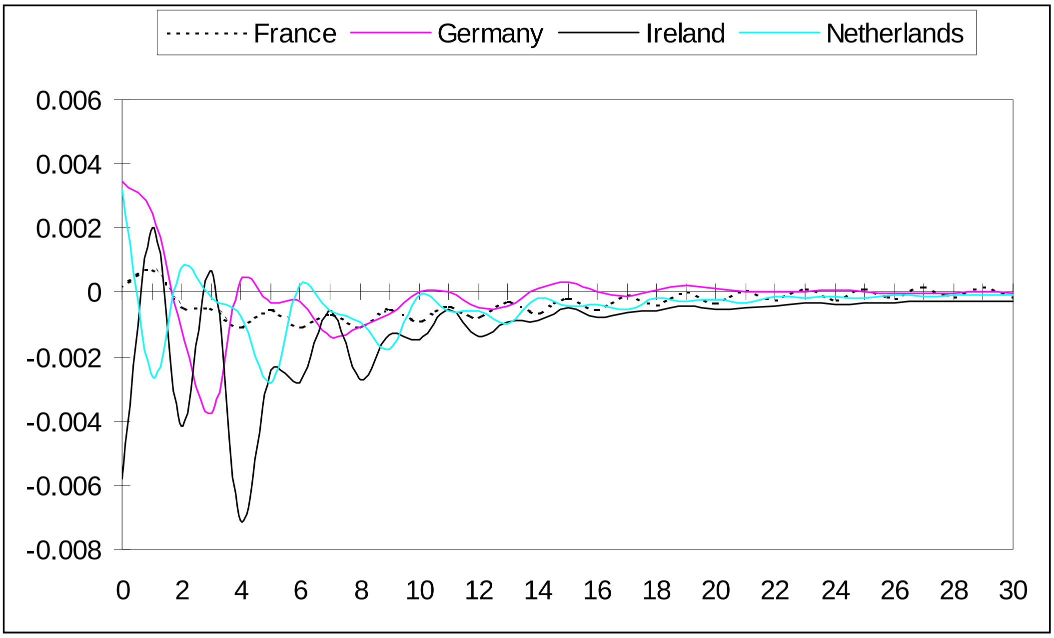


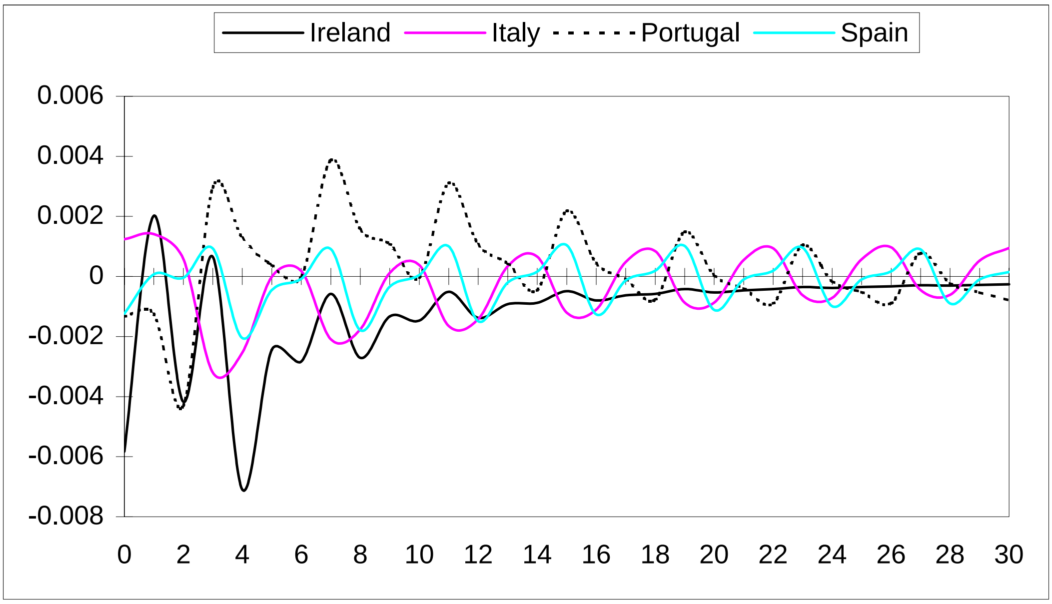
Impulse Response Functions:
SVAR in Levels (Contd.)



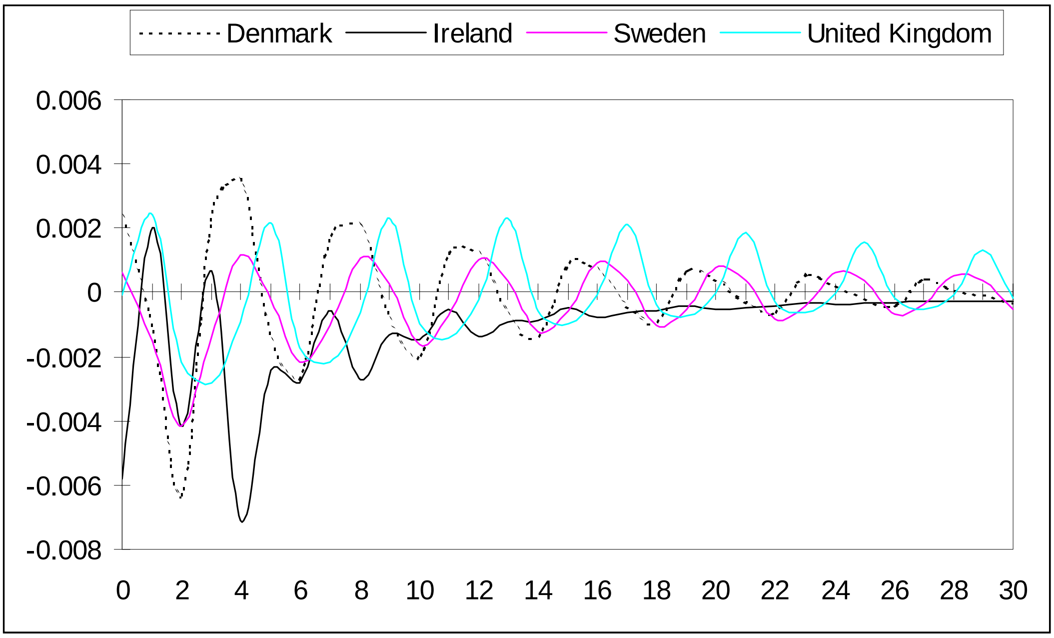


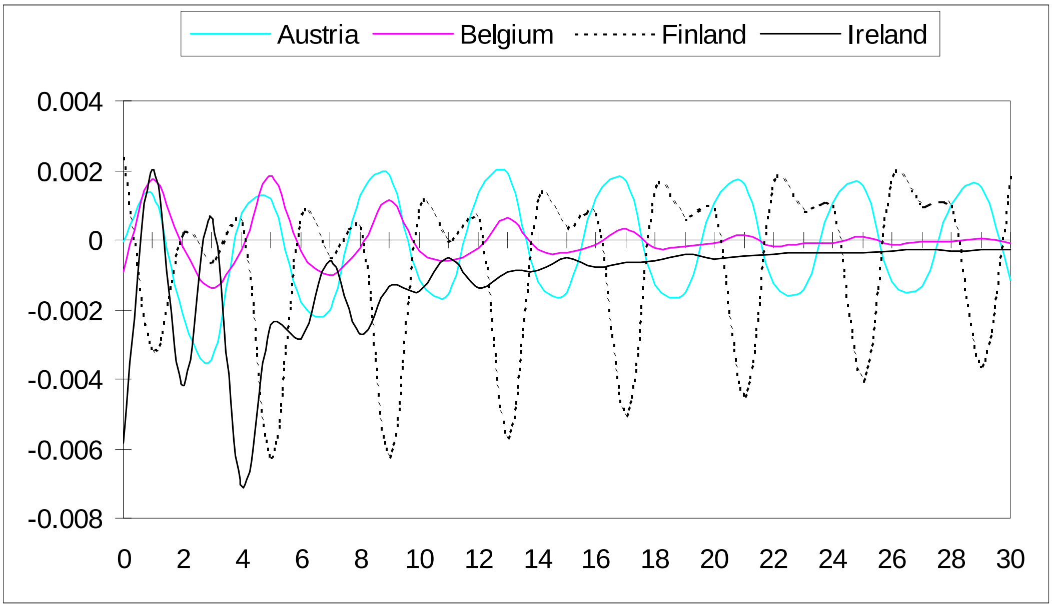
Impulse Response Functions:
Choleski VAR in First Differences



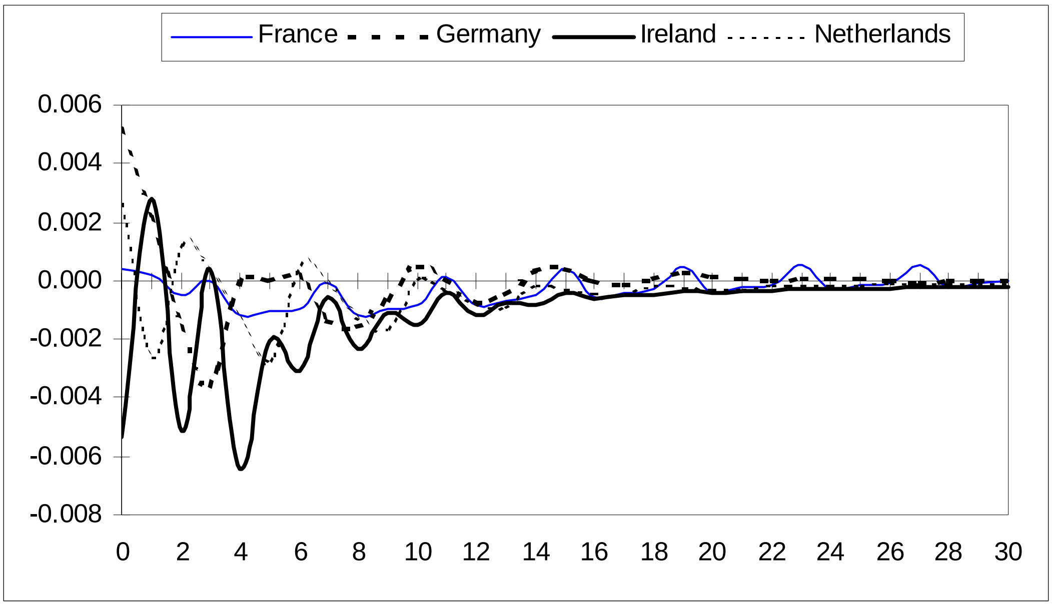


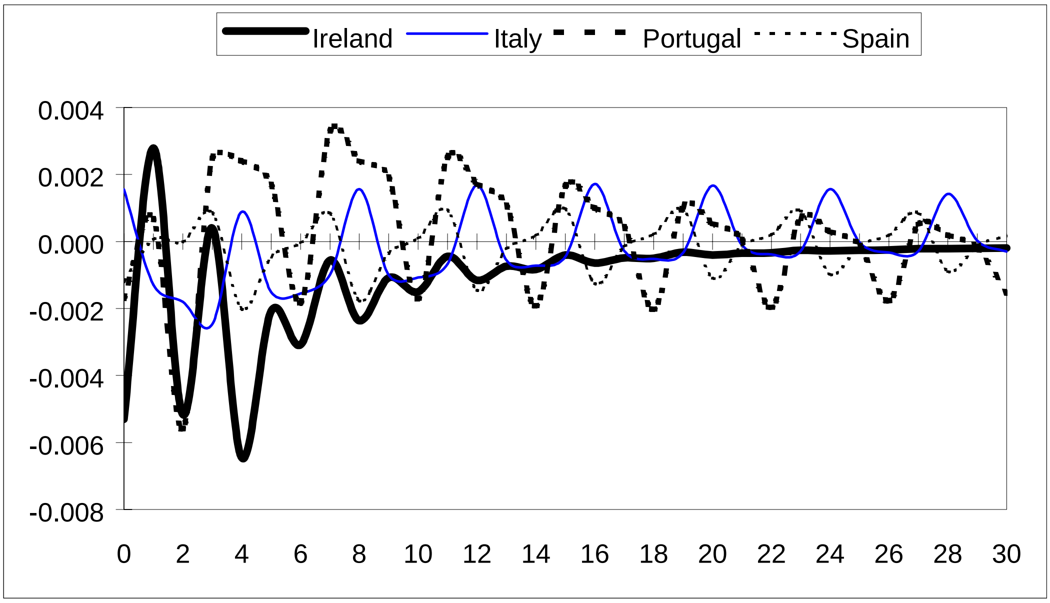
Impulse Response Functions:
Choleski VAR in First Differences (contd.)





<u>**Impulse Response Functions:**</u>
<u>**SVAR in First Differences**</u>





Impulse Response Functions:
SVAR in First Differences (contd.)