The Effects of EU Shocks on the Macrovariables of the Newly Acceded Countries -A Sign Restriction Approach-

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Draft, March 2005

Abstract

This paper analyses the response of seven of the newly acceded countries (NACs) to EU supply and monetary shocks. A typical NAC perceives an EU technology disturbance as a positive supply shock and an EU monetary expansion as a negative demand shock. When we split the seven countries into two groups, results for group one which includes the Czech Republic, Hungary, Poland and Slovakia suggest that an EU supply shock feeds through as a demand shock, increasing both prices and output. This hints that trade acts as a strong channel of EU shock propagation. For both groups, monetary disturbances explain a large proportion of NAC's output fluctuation while technology disturbances account for a significant part of export variations. EU shocks are identified as in Canova and De Nicoló (2002) using sign restrictions of the cross-correlation function of the variables' responses to orthogonal disturbances. These restrictions are derived from an SDGE model.

JEL Classification: E3, F4, C2
Keywords: European Union, economic integration, structural VAR

*I am very grateful to my supervisors Dr. Mike Clements and Dr. Martin Ellison for their invaluable comments, suggestions and support. Discussions with Giacomo Carboni and Professor Neil Rankin are also gratefully acknowledged.

"But Europe is solid to herself, France, Germany, Italy, Austria and Holland, Russia and Roumania and Poland, throb together, and their structure and civilization is essentially one." J. M. Keynes, The Economic Consequences of Peace.

1 Introduction

On May 1, 2004 the European Union (EU) welcomed ten more countries as part of its largest enlargement ever[1]. As these countries will be expected to join the EMU in a more or less distant future there are several economic issues arising from the enlargement. One is how similar the economic cycles experienced by the newly acceded countries (NACs) are to those faced by incumbent EU[2] countries and how quickly the NACs adjust to domestic and international shocks relative to the economies of the EU. Another is to assess the importance of external shocks for the NACs' economic fluctuations.

A large literature has been written to examine the similarities of economic development among EU countries- Bayoumi (1992), Bayoumi and Eichengreen (1992), Gerlach and Smets (1995) and Kieler and Saarenheimo (1998), but only a small although growing number of papers have analysed the dynamic interaction between aggregate shocks in the EU and the economic cycles of the NACs- Fidrmuc and Korhonen (2001), Frenkel and Nickel (2002), Suppel (2003) and Weimann (2002). Canova (2003) answered similar questions for the Latin American economies while Faust (1998), Uhlig (1999) and Canova and de Nicoló (2002) set new methodological directions for finding structural interpretations to orthogonal innovations, thus opening new avenues for dealing with these issues.

In order to approach the first issue raised, this paper looks at the impact of EU shocks on the NACs not only as a single group, but also as two groups based on the individual NAC's geostrategic positioning and similarity of response to EU shocks. To approach the second issue, the paper looks at how significant the external shocks are in determining movements in the macrovariables of the NACs, the time lag with which the NACs react to these and whether there are common movements in the EU and NACs following an EU shock. Furthermore, it also inquires about the main channels of shock propagation and what is the importance of each channel.

Results from research on the former issue shed light on the sources of economic fluctuations in the NACs and potentially point policy makers towards better tools when dealing with external disturbances. As regards the latter issue, over the last ten years both trade and financial integration have taken new dimensions in Europe (See Table 1) which may

[1]It is the largest number of candidates accepted at the same time ever, it brings about an area increase of 34%, a population surge of 105 m and a substantial addition of history and cultures.

[2]In this paper we use the acronym EU to stand for the European Union as it was before the last accession wave.

mean that goods markets and interest rate channels play an important role in aggregate EU shock propagation.

The paper is structured as follows. The next section lays out results and methodological issues presented in empirical and theoretical papers which deal with the EU. Section 3 presents some stylised facts on the NACs while Den Haan (1990) and Gavin and Kydland (1999)'s models which are introduced in Canova and de Nicoló (2003) are briefly explained in section 4 together with the derivation of all the theoretical restrictions used in the empirical model to identify shocks. This section could be expanded to cover a more complex SDGE model which will be combined with Bayesian methods of inference in such a manner that more uncertainty can be introduced than is common in the calibration literature[3]. Section 5 introduces the empirical model, the methodology and presents the data used. Section 6 discusses the results and their implications while section 7 concludes.

2 Literature Review

This paper draws on the information provided in three areas: empirical research on the EU and the NACs in an optimal currency area framework, empirical work on identified structural VARs and theoretical and applied research on stochastic dynamic general equilibrium models. This work is most closely related in technique and partially in motivation to Canova (2003), discussed below.

The first strand of research, which is mainly empirical and spins off from the classical theory of optimal currency areas, focuses on shock identification within the EU, analyses growth differences and inflation correlation between the EU and the NACs and proves the incidence of asymmetries. Bayoumi and Eichengreen (1992) looked at how economically similar the countries are within the EU and found that demand and supply shocks here were more idiosyncratic than across US regions. When splitting the EU into core and non-core members they found that core members, with Germany in the middle, experienced shocks which seemed to be synchronised and to which these countries responded in a similar way. However the response speed was slower than the US regional response to aggregate shocks. They estimated a structural VAR following Blanchard and Quah's (1989) methodology and identified supply and demand shocks for each country of the EU as well as for regions across the US. More recent studies included the Central and Eastern European Countries (CEECs). Fidrmuc and Korhonen (2001) estimated a structural VAR for each country in the EU and CEECs following the same procedure and found that demand and supply shock correlation is higher among the EU countries than between the EU as a whole and the CEECs. Frenkel and Nickel (2002) reached the same conclusion that there is weaker correlation between the

[3]Smets and Wouters (2003) represent an important step in increasing the amount of uncertainty in a SDGE model and in using Bayesian methods in estimating and comparing a SDGE model with a BVAR and a VAR.

NACs and the EU than intra-EU. The scope of these studies is limited by the methodology used which assumes that there is a reasonable degree of structural stability between the indicators used. As the data on NACs covers the first half of the '90s the assumption is a poor approximation of reality. Another shortcoming of these studies is that they do not distinguish between real demand and monetary shocks, which raises questions about what is actually captured as a demand shock.

Suppel's (2002) paper tried to correct the first set of shortcomings by only considering data later than 1995 or 1996 and by considering the NACs as a group when calculating different correlation relations. He looked at the symmetry of growth fluctuations using both direct correlation and a structural VAR. His conclusions are in line with the literature that, overall, CEECs experience higher but more volatile GDP growth than countries within the EU. The paper mentioned though that the most developed CEECs economies, such as Hungary, demonstrated a similar or even higher cycle correlation with the Euro area than the Euro area peripheral countries, particularly Portugal and Greece.

The papers above discussed the EU-NACs business cycle co-movements by interpreting the size of the GDP growth correlation coefficients, by calculating Theil's inequality or by estimating a structural VAR and calculating the correlation of supply and demand shocks - or a combination of any of these three. However the literature did not cover the sources of cycle fluctuations, whether these are domestic or external, which are predominant, nor how external shocks impact domestic economies. Canova (2003), who belongs to the second body of research this paper draws on, raised these issues but in the case of Latin American economies and their dynamic interaction with the US. He concludes that US monetary shocks generate large and significant fluctuations in the Latin American economies which are transmitted through the interest rate channel. Methodologically, he built on Canova and de Nicoló (2002) who introduced a novel technique identifying structural innovations from estimated disturbances. The seeds of this approach date back to Faust (1998) and Uhlig (1998,1999).

Both Faust (1998) and Uhlig (1999) disagree with the use of informal restrictions on impact or long term coefficients which are traditionally used in VAR identification and which sometimes lead to circular references. They suggest a way of systematically inspecting different identification schemes and making all restrictions formal. While Faust (1998) imposes sign restrictions only on impact, Uhlig(1999) imposes them for a few periods after the shock's impact and includes all identified impulse responses under a penalty function which penalises bigger impulse responses of the same sign.

Canova and de Nicoló (2002,2003) share their desire to make all restrictions formal and explicit to achieve a robust VAR identification. They do not impose zero restrictions on impact coefficients like Sims (1980) or zero impulse responses at infinity as Blanchard and Quah (1989) or sign restrictions on impact coefficients like Uhlig(1999). Instead they impose sign restrictions on the cross-correlation function of certain variables in response to a structural shock, restrictions which are formally derived from a SDGE model. Due to their choice of variables included in the VAR, namely industrial production, inflation, real balances and the slope of the term structure they are able to distinguish between real demand and money shocks and to conclude that nominal demand shocks are the dominant source of output and inflation fluctuation in the G-7 countries. A detailed description of the methodology introduced by them will be given in section 4.

The third area of interest for this paper builds on SDGE models because it provides a framework in which structural VAR identifying restrictions are derived. As this paper will use these type of restrictions in the spirit of Canova and de Nicoló (2002), a brief summary of the literature concerned with the link between SDGE and VAR identification is given below.

Although SDGE models have been regarded as a poor approximation of the DGP, in the last 15-20 years they have been the focus of many macroeconomists who tried to add features which would bring these models closer to the data. These took different forms from mixing estimated parameters with some considered a-priori ones to applying computational experiments instead of traditional econometrics. Seeking to avoid all the criticism which comes with these methodologies Canova (2002) mingles structural VAR estimation with calibration techniques and compares the performance of a limited participation model and of a sticky price monopolistic competition model against actual data. Although this validation method does not find that these two classes of models fully account for the dynamics of a small set of macro-variables it is still an important step forward towards robustness of SDGE model results. Dedola and Neri (2003) use a similar methodology to identify technology shocks in a VAR model of the US, Japan and West Germany.

Choosing a SDGE model does not directly ensure robustness of the restrictions imposed to identify innovations within the data as different models may suggest different restrictions. Canova and de Nicoló (2002) point out that this can be achieved by finding restrictions which are robust across a general class of models. At this stage, we detail the model as it is presented and calibrated in Canova and de Nicoló (2003) and will aim to look further into more complex open economy SDGE models and apply Bayesian parameter estimation and model comparison with a view to the EU characteristics.

3 Stylised facts

On May 1, 2004, 31 years since the first enlargement, ten countries joined the European Union, sharing a common goal of integration and economic advancement. Whilst such an enlargement brings clear economic, social and political advantages, it may also bring disadvantages through a lack of economic cycle synchronicity and different responses to particular international or domestic shocks. Since this research is driven by a desire for answers to a set of key policy related questions such as what are the effects of the EU shocks on the newly acceded countries and what are the main transmission channels through which these propagate it would be interesting to look at some trade stylised facts.

Table 1: Imports/Exports with EU(%)

Trade	**2002**		**2003**	
Country	**Imports**	**Exports**	**Imports**	**Exports**
Cyprus	55.90	56	59.37	59.14
Czech Republic	60.20	68.40	59.22	69.82
Estonia	57.90	67.97	53.57	68.39
Hungary	75.13	56.24	73.59	55.11
Latvia	52.94*	60.39*	50.95*	61.84*
Lithuania	50.22	69.18	55.78	62.50
Malta	68.06	47.41	67.99	48.76
Poland	61.69	68.76	61.13	68.78
Slovak Republic	45.56*	60.56	51.40*	60.63
Slovenia	67.99*	59.37*	67.26*	58.43*

1) Source: IFS
2) Note: All numbers with *are sourced with: Central Statistical Bureau Of Latvia, National Office of Statistics of the Slovak Republic and National, Office of Statistics of Slovenia respectively.
3) Data for Cyprus, Lithuania and Malta are taken from the External and intra-European Union trade bulletin, March 2005

From the table above, the consistently high degree of economic cooperation between the EU and the NACs suggests that the trade channel could potentially be a key conveyor of economic shocks. If a trade channel were to be active the mechanism of transmission would function as follows (see Canova (2003) or an undergraduate text book on AD/AS). An innovation that increases the EU price level should affect the trade balance of the NACs. Imports become more expensive relative to exports so the NACs would have an incentive to export more which will increase domestic production in order to cope with the increase in demand. The increase in domestic prices depends on how much spare capacity exists, which will determine whether the increase in aggregate demand will be reflected in prices or output (demand pull inflation). It will also depend on the exchange rate's adjustment and the flexibility of import contracts which may or may not give rise to domestic cost push inflation. Given the strong trade links listed in the table above,we would expect trade to have an important role as a transmission channel.

Although, a-priori, trade seems to be an important channel in the EU-NACs dynamic, the financial integration of the last ten years points towards other potentially important channels such as the interest rate channel. In a standard AS/AD analysis for an open economy, a positive innovation in the EU interest rate will generate a hot money flow from the NACs to the EU depreciating the domestic currency against the EURO. Thus domestic output and prices could increase. The size of the domestic output and price movement is given by the type of the exchange rate regime and the size of the financial integration of the countries in question. An interesting question is whether the FDI movement across these countries conveys any information.

The identification of the two channels above requires information about exports of the NACs and a measure of the international competitiveness, namely the real effective exchange rate. Because the theories above do not make any reference to the timing of the movement of the variables all identifying sign restrictions will be placed only at the impact of the innovation The next section presents the methodology used to identify US supply and money shocks which will also be applied on EU and the NACs.

4 Theoretical Model and Formal Derivation of Restrictions

Using restrictions derived from a SDGE model to estimate a structural VAR represents a significant development in macroeconomics because it brings structure and theoretical rigor into empirical work. Issues arising from imposing arbitrary restrictions are thus eliminated. The theoretical restrictions which are derived below, are based on Canova and De Nicoló (2003), who use an open economy version of the model used by Den Haan (1990) and Gavin and Kydland (1999).

The model comprises two identical countries which interact only through the financial market. Each economy has a goods market, a financial market and a government. The representative agent observes which shocks appear (technology, government purchases and money growth) and receives money transfers with which he buys internationally traded bonds in financial markets. Once financial markets shut, agents provide their labour on the goods market for which they are paid a wage that they use to buy goods and services from the domestic firm. The firm's output is taxed by the government and the remainder is distributed in the form of wages and profit to the agents. The firm shuts down at the end of the period and reopens at the beginning of the next one. More formally and following closely Canova and de Nicoló (2003), agents maximise the expected utility of their actions as described below:

$$\max_{\{c_{it}, l_{it}, M_{it}, B_{it}\}} E_0 \sum_{t=0}^{\infty} U(c_{it}, l_{it})$$

subject to:

$$l_{it} = 1 - h_{it} - v_{it}$$

and

$$c_{it} + \left(\frac{B_{it+1}}{P_{it}}\right) + \left(\frac{M_{it+1}}{P_{it}}\right) = y_{it} + \left(\frac{M_{it}}{P_{it}}\right) + \left(\frac{B_{it}}{P_{it}}\right)(1 + I_t) - T_{it}$$

where h_{it} is hours worked, v_{it} denotes shopping time while l_{it} is leisure time, T_{it} is the lump sum transfer of money from the government to the household at the beginning of each period, B_{it} is the stock of outstanding internationally held bonds in country i at time t, I_t the one period interest rate and P_{it} is the price level at t in country i. The production function is given by $y_{it} = f(h_{it}, A_{it})$ where A_{it} is a technology disturbance.

The government budget constraint is:

$$\left(\frac{M_{it+1} - M_{it}}{P_{it}}\right) = g_{it} - T_{it}$$

where g_{it} are government purchases and the supply of money is:

$$M^s_{it+1} = (1 + \mu_{it+1})M^s_{it}$$

where μ_{it} is the money supply growth rate.

The world bond market clearing condition is that the bonds which are being sold in one country are entirely bought by the agents in the other country:

$$\zeta B_{1t} + (1 - \zeta)B_{2t} = 0$$

Canova and de Nicoló give specific forms to the utility, production and shopping time functions for the two economies, derive the first order conditions implied by the maximisation problem above and log-linearised around the steady state. It is important to note that each country's system is driven by three exogenous shocks, namely to money, government spending and technology. It is assumed that these shocks are independent across countries and types and have a persistence matrix ρ_i.

In this model a supply shock takes the form of a technology shock which is associated with a surprise increase in A_{it} and which generates a negative cross-correlation between output and prices but a positive one between output and real balances. The increase in output leads to an increase in consumption which means that more money or shopping time is needed. As the money supply is fixed this increase in consumption can only be achieved with extra shopping time. The reduction in prices comes as a result of the wealth effect which decreases hours worked and increases leisure. As prices decrease real balance increases immediately after the shock.

A demand shock can arise from innovations in preferences of the economic agents, fluctuations in the flexible-price equilibrium output level or sudden increases in government spending (Walsh pg. 517). In this model a real demand shock could only come from a surprise increase in government purchases which reduces both domestic and foreign consumption and due to the wealth effect increases both domestic labour supply and output. Thus, real balances will decrease as prices rise.

The third type of shock in the model is a monetary innovation. An unexpected increase in the money supply (rise in μ_{it}) will generate inflation which will act as a tax on leisure. As less leisure time is used agents spend more time working or shopping which pushes up output and consumption on impact. Real balances will increase as the surge in money supply is larger than the one in inflation.

All these restrictions (summarised in Appendix 2) refer in principal to the contemporaneous impact of the three shocks on the three main variables of interest and generate responses which are shared by a large class of dynamic models. Although this is an open economy model, the results are consistent with a closed economy model (see Christiano et al. (1996, 1997). The next section will incorporate the sign of the response of output, inflation and real balances to these three types of shocks into the empirical model. As a note for future work, it would be interesting to look at an open economy model where exchange rate and/or interest rate differentials were allowed and to contrast its results with those obtained when analysing the NACs.

5 Empirical model and methodology

The complexity of the links among the incumbent countries in the EU and the NACs, the multiple economic and political crises and the relatively short existence of some countries as independent entities, make it difficult to have a model that would encompass all these aspects. Ideally one would use a multi-country model in which sectors in different countries would be allowed to compete but also to integrate, where simultaneous lags and feedback would be allowed among the NACs and the older EU member countries. Since this is not possible for the reasons mentioned above we resort to applying an unrestricted VAR in two set-ups: a single country VAR and a pooled VAR with country-specific fixed effects. Following Canova (2003) and thus distinguishing this paper from most of the empirical literature[4] on EU business cycles we use sign restrictions on the cross-correlations of the aggregate variables' responses to particular shocks.

Before we start writing down the empirical model, in a desire to simplify matters we assume that the shocks are unidirectional in the EU-NACs interaction, hitting the EU area and then feeding through the NACs and not rippling back. We break the estimation process in two. Firstly, we identify shocks originating in the EU economies and distinguish between supply, monetary and real demand shocks. When identifying shocks originating in the EU we introduce in the EU VAR model two exogenous variables, namely US inflation and MXEF, an equity index. This will ensure that if there are shocks originated in the American economy which affect both the EU and the NACs these will be accounted for as such and not be mistaken as domestic disturbances. Secondly, we estimate a reduced form structural model for some NACs as well as for them as a block.

The reduced form VAR for the EU economies includes a measure of real activity (industrial production), inflation, real balances and the slope of the term structure of the interest rate. The sample period covers monthly data from 1990:01 to 2004:07 and refers to the middle of the month. All series are seasonally adjusted and were taken from IFS and Eurostat. At this stage we did not consider the possible non-stationarity of the series since we were interested only in the short term behaviour of the variables[5], but will look into the possibility of introducing a VECM in future work.

The use of the slope of the term structure is motivated by two reasons. One is that it seems to incorporate information about other nominal impulses that variables such as unemployment may not convey (Canova and de Nicoló (2002)). Another is that it has been argued in the literature[6] that the slope has better predictive power for inflation and real activity than a measure of short term interest rates. Real balances are used instead of nominal ones because its response to different shocks allows a clear distinction between real and nominal demand shocks.

The reduced form VAR for the NACs includes industrial production, inflation, exports, the real effective exchange rate as a measure of international competitiveness and interest rates. These series have different starting points, the longest being Hungary starting in 1991 and the shortest being Czech Republic starting in 1994.

As in Canova (2003), we can formally write the model in a structural form as:

[4] Although there is a growing number of papers using sign restrictions. Peersman 2005 identifies technology shocks in the Euro Area.

[5] Sims, Stock and Watson (1990) discuss the problems that may arise from having non-stationary variables in a VAR but conclude that the OLS estimators are consistent regardless of whether the VAR contains integrated components.

[6] Canova and de Nicolo (2002, 2003) have a detailed explanation of the advantages of using the slope of the term structure.

$$\underbrace{\begin{bmatrix} \delta_{11} & \delta_{12} \\ 0 & \delta_{22} \end{bmatrix}}_{\delta} \begin{bmatrix} a_t \\ e_t \end{bmatrix} = \underbrace{\begin{bmatrix} \varphi_1 \\ \varphi_2 \end{bmatrix}}_{\varphi} + \underbrace{\begin{bmatrix} \alpha_{11}(L) & \alpha_{12}(L) \\ 0 & \alpha_{22}(L) \end{bmatrix}}_{\alpha} \begin{bmatrix} a_{t-1} \\ e_{t-1} \end{bmatrix} + \underbrace{\begin{bmatrix} \beta_{11}(L) \\ \beta_{22}(L) \end{bmatrix}}_{\beta} ext_t + \underbrace{\begin{bmatrix} 0 \\ \gamma_{22}(L) \end{bmatrix}}_{\gamma} \pi_t^{us} + \underbrace{\begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix}}_{\epsilon_t}$$

where ϵ_t is a structural innovation with zero mean and unit standard deviation. a_t is the block of newly acceded countries while e_t represents the EU variables. Further, let the reduced form VAR be:

$$\begin{bmatrix} a_t \\ e_t \end{bmatrix} = \underbrace{\begin{bmatrix} \Phi_1 \\ \Phi_2 \end{bmatrix}}_{\Phi} + \underbrace{\begin{bmatrix} A_{11}(L) & A_{12}(L) \\ 0 & A_{22}(L) \end{bmatrix}}_{A} \begin{bmatrix} a_{t-1} \\ e_{t-1} \end{bmatrix} + \underbrace{\begin{bmatrix} B_{11}(L) \\ B_{22}(L) \end{bmatrix}}_{B} ext_t + \underbrace{\begin{bmatrix} 0 \\ G_{22}(L) \end{bmatrix}}_{G} \pi_t^{us} + \underbrace{\begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix}}_{\nu_t}$$

where $\Phi = \delta^{-1}\varphi$, $A = \delta^{-1}\alpha$, $B = \delta^{-1}\beta$, $G = \delta^{-1}\gamma$, $\nu_t = \delta^{-1}\epsilon_t$ and δ is a 2x2 matrix of coefficients of how much each variable, namely a_t and e_t influence each other contemporaneously. As a result of this ordering we are able to independently run a 4-variable VAR for the EU economy and identify supply, real and nominal demand shocks affecting the EU economy and use these shocks in the NAC's 5- variable VAR.

The key step in applying the VAR methodology to the questions posed, lies in identifying supply, real demand and money shocks. To obtain estimates of ϵ_{2t} given values of the estimated residuals v_{2t} we follow Canova and de Nicoló (2002) who rather than impose zero restrictions on VAR coefficients (Sims (1980)) or on long-term impulse responses (Blanchard and Quah (1989)) use sign restrictions on the cross-correlation function of variables' responses to particular shocks.

Formally, after running the EU 4-variable VAR we get an estimate of the variance-covariance matrix $\sum_{v_2} = E(v_2, v_2')$ which can be rewritten in terms of the underlying shocks as $\sum_{v_2} = E(\delta_{22}^{-1}\epsilon_2(\delta_{22}^{-1}\epsilon_2)') = \delta_{22}^{-1}E(\epsilon_2\epsilon_2')(\delta_{22}^{-1})' = AA'$ since $E(\epsilon_2\epsilon_2') = I$ by assumption. One way to decompose the var-cov matrix in the form applied here, is to break it down in eigenvalues (V) and eigenvectors (P) such that $\sum_v = PVP' = AA'$. This decomposition has the advantage of generating orthonormal shocks which makes the value of P unique for each variance-covariance matrix decomposition without imposing any zero restrictions. The only restrictions made so far are that the shocks should be independent from one another and that their variance is the identity matrix. Although P is unique the multiplicity of orthonormal decompositions comes from the fact that for any orthonormal matrix J, $JJ' = I$ so a valid decomposition of $\sum_{v_2}$ is also $\sum_{v_2} = AJJ'A'$. A Cholesky decomposition would impose that A be lower triangular.

Although the eigenvectors-eigenvalues decomposition does not have any economic meaning, we incorporate theoretical restrictions, thus attaching economic interpretations to the identified shocks. Going further we test if the sign restrictions derived in section 3 (and listed in Appendix 2) hold. To do this, first we write the structural model for the EU in Wold MA form so that:

$$e_t = C(L)\varphi_{22} + C(L)\beta_{22}(L)ext_t + C(L)\gamma_{22}(L)\pi_t^{us} + C(L)\epsilon_{2t}$$

where $C(L)$ is a matrix polynomial in the lag operator that is equal to $(1-\delta_{22}^{-1}\alpha_{22}(L))^{-1}\delta_{22}^{-1}$ and e_{2t} is a 4x1 vector. Next we calculate the cross-correlation function conditional on a particular shock which takes the following form:

$$Corr(Y_{it}, Y_{j,t+r}|\epsilon) = \frac{(C^i(l)\epsilon)(C^j(l+r)\epsilon)}{\sqrt{[C^i(l)\epsilon]^2[(C^j(l+r)\epsilon)]^2}}$$

where $Y_t = \{a_t, e_t\}$, i and j are two variables that are considered and $(C^j(l+r)\epsilon)$ is the impulse response of variable j at lag r to a shock ϵ. If the sign of the pairwise correlation conforms with the one indicated by the dynamic model then we save the impulse response function. If it does not we consider the non-uniqueness of the MA representation to provide alternative candidate structural shocks. We do this by using an orthonormal rotational matrix J of the following form:

$$J(\theta)_{ij} = \begin{bmatrix} 1 & 0 & ... & 0 & 0 \\ 0 & \cos(\theta) & ... & -\sin(\theta) & 0 \\ ... & ... & 1 & ... & ... \\ 0 & \sin(\theta) & ... & \cos(\theta) & 0 \\ 0 & 0 & ... & 0 & 1 \end{bmatrix}$$

where i and j represent the rows which are being rotated, while θ is the rotation angle. In a 4 variable model we need a 4x4 rotational matrix which implies that for each angle θ we have 6 bivariate rotations, 3 combinations of bivariate rotations and an infinite number of combinations of bivariate rotations where two variables are rotated by a different angle, θ_1 for each θ that the other two variables are rotated by.

Our algorithm works in three steps. First we make 4000 random draws for each rotation angle θ and θ_1 from the interval $[0, \pi]$. For each combination of angles we use the sign of the correlation coefficient for $r = 0$ from above to identify orthonormal shocks. Among all these shocks we pick the ones that maximise the number of shocks exhibiting conditional correlations consistent with the theoretical restrictions. If the identification is not unique Canova and de Nicoló (2002) suggest increasing the lag at which the restrictions are imposed, considering the magnitude of the response to a shock and adding pairwise correlation between the variables of the system and an additional one demanding that the signs at different lags are consistent with the theory. Our algorithm follows Canova and de Nicoló (2002) with two exceptions. First we consider two rotational angles and second rather than using an angle grid we perform a random draw for each angle.

In estimating impulse responses we take into account both data and identification uncertainty. We do this by bootstrapping the estimated residuals of the reduced form VAR, recalculating the variance covariance matrix and re-running the VAR for each draw, drawing randomly from the set of structural matrices consistent with the chosen sign restrictions.

6 Results

6.1 Identification of Structural EU Shocks

We start by looking into the informational content of the EU' structural disturbances. Using the restrictions derived for the SDGE we identify a valid supply and monetary shock. Figure 1 depicts their effects on output, inflation, real balances and the slope of the term structure at cc. 7 year horizon.

As a response to an expansionary supply shock industrial production increases, inflation drops sharply while real balances go up on impact and long term interest rates increase relative to short term rate. The response of industrial production is sluggish and seems to have the tendency of reverting to a slightly higher steady state level which is consistent with the implication of a permanent technology shock. While industrial production and the slope of the term structure have their maximum response after 24 and 6 months respectively, real balances and inflation 's responses are largest at impact. It takes the slope and inflation about three years to revert to the steady state level while real balances' response dies out within 8 months.

A nominal shock increases industrial production and real balances on impact, achieving a maximum effect on industrial production after 10 months and on real balances on impact. Inflation responds fully with a delay of 6 months after which it quickly converges to the steady state. The slope does not react on impact although it increases and reaches its maximum value after 4 months suggesting that initially the long term and short term interest rate moved together or did not change. Within a 4 month period long term interest rates increased relative to the short term indicating the existence of inflationary expectations which are incorporated in the long term interest rate.

In both cases the industrial production response is sluggish compared to the response of the other variables while prices seem to adjust relatively quickly as a result of the nominal shock but to be slow in converging in the case of the productivity shock. Since our procedure does not impose zero restrictions, but only sign restrictions, we let the data decide on the timing and magnitude of the impact and find that price stickiness does not seem to be evident. This is in line with Canova (2003) and Canova and de Nicoló (2002, 2003) but at odds with some versions of the sticky price literature (Christiano et al. (2001)).

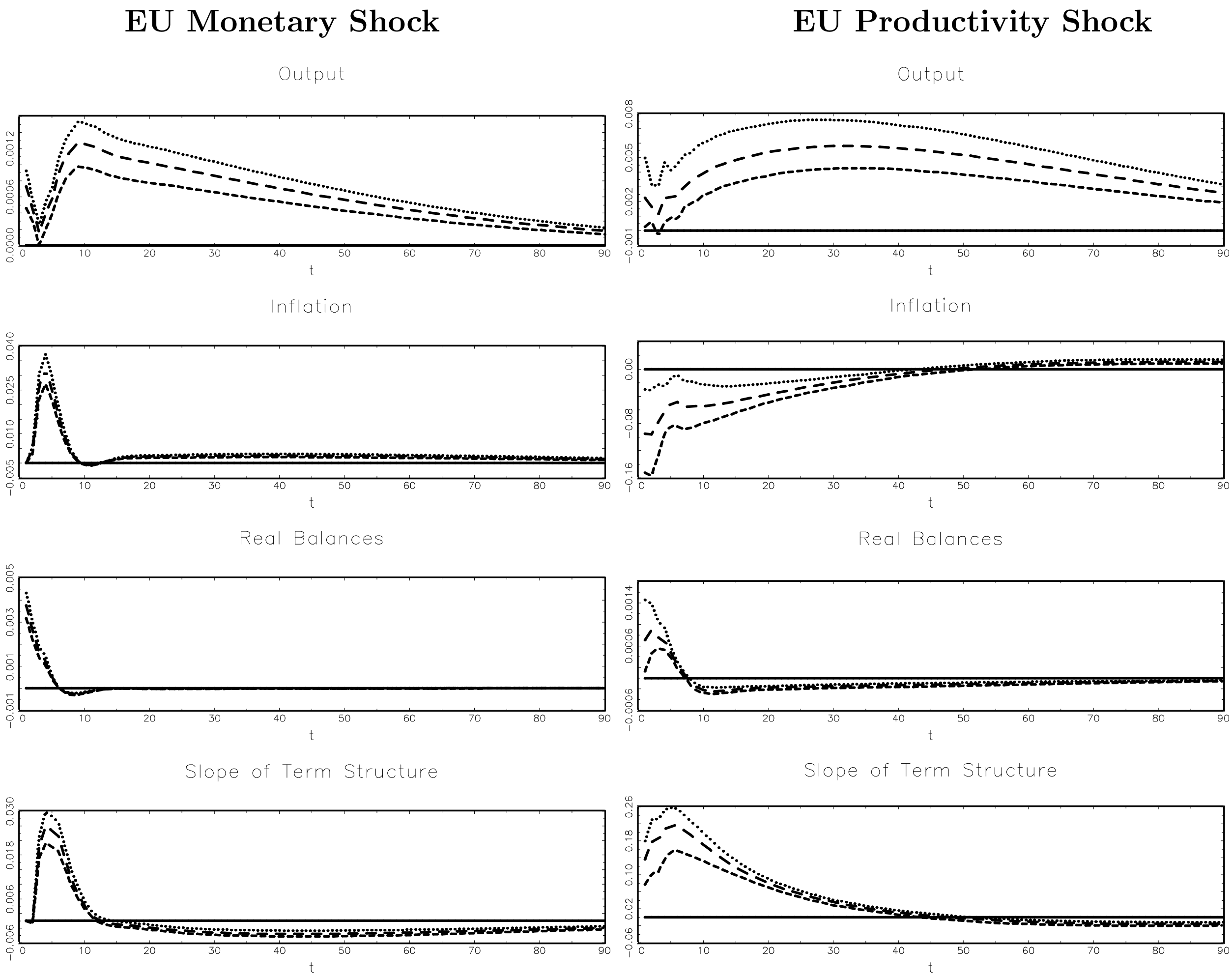

Figure 1 Impulse Responses of Older EU Members (Sign Restriction)

These results were obtained by programming the identification algorithm in Gauss. We considered 100 replications of the variance-covariance matrix in the bootstrapping procedure, 4000 random draws for each of the two angles and 90% percentile bootstrapping intervals.

Before we proceed to use these shocks in the NACs system, it would now be interesting to compare the supply and monetary shocks obtained using the sign restriction identification scheme with those ones would find using a standard Cholesky decomposition. Figure 2, the left hand panel, shows that an output shock decreases prices indicating potentially the existence of a supply shock although real balances decrease on impact which, based on the economics theory detailed in section 4 we would expect to increase. The right hand panel of the of Figure 2 depicts a negative inflation shock which can be interpreted as a positive supply shock since output and real balances move in the same direction while exhibiting a negative correlation with the change in the price level.

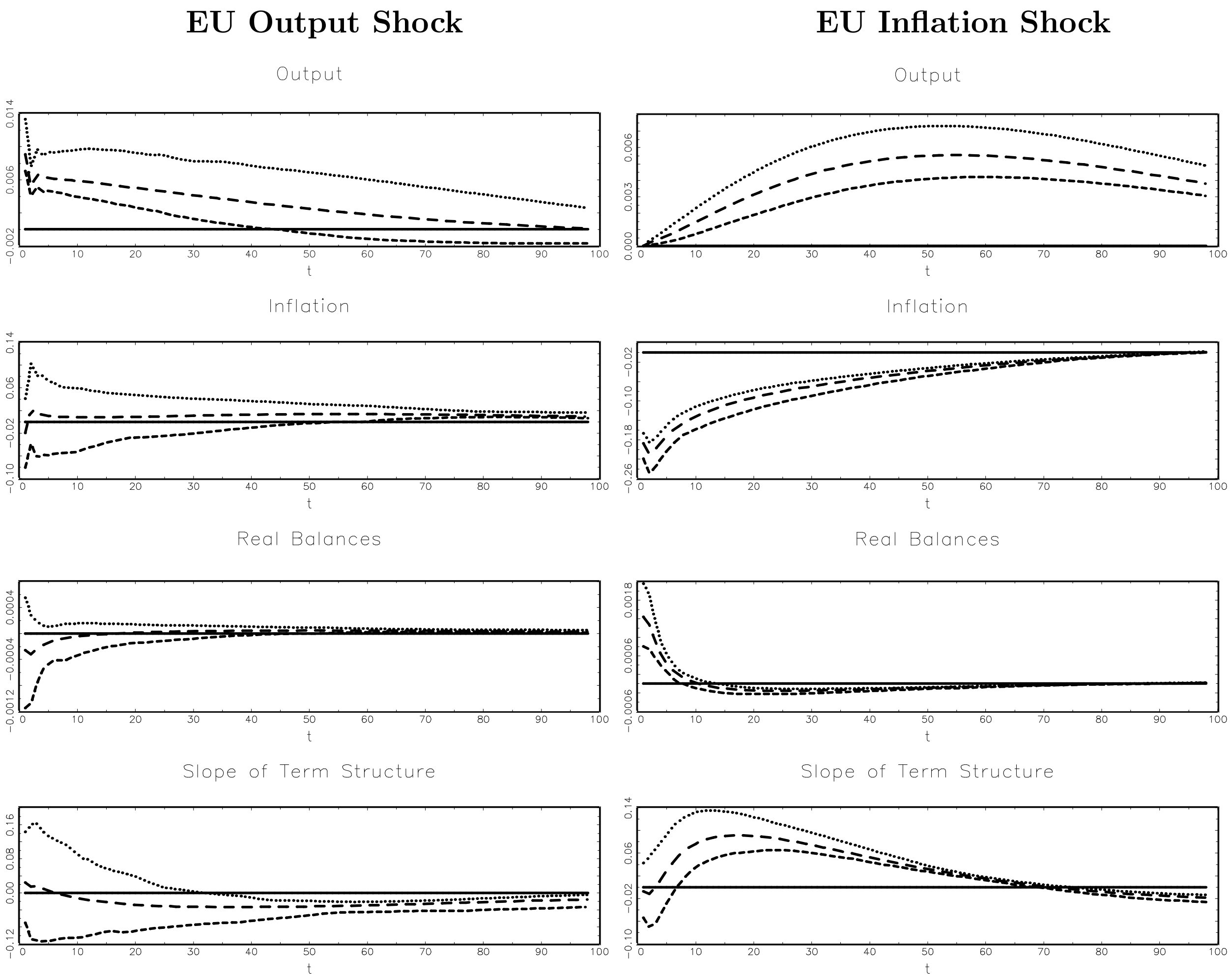

Figure 2 Impulse Responses of Older EU Members (Cholesky decomposition)

The left hand panel of Figure 3 displays a positive real balances shock which has a puzzling negative effect on output. One would expect output to increase when individuals have more real income. None of the identified shocks in Figure 2 or 3 points towards a monetary shock which would be recognised by its positive effect on output, inflation and real balances. Using the sign restriction approach we were able to identify both a supply and a monetary shock but only a supply shock using the traditional Cholesky decomposition.

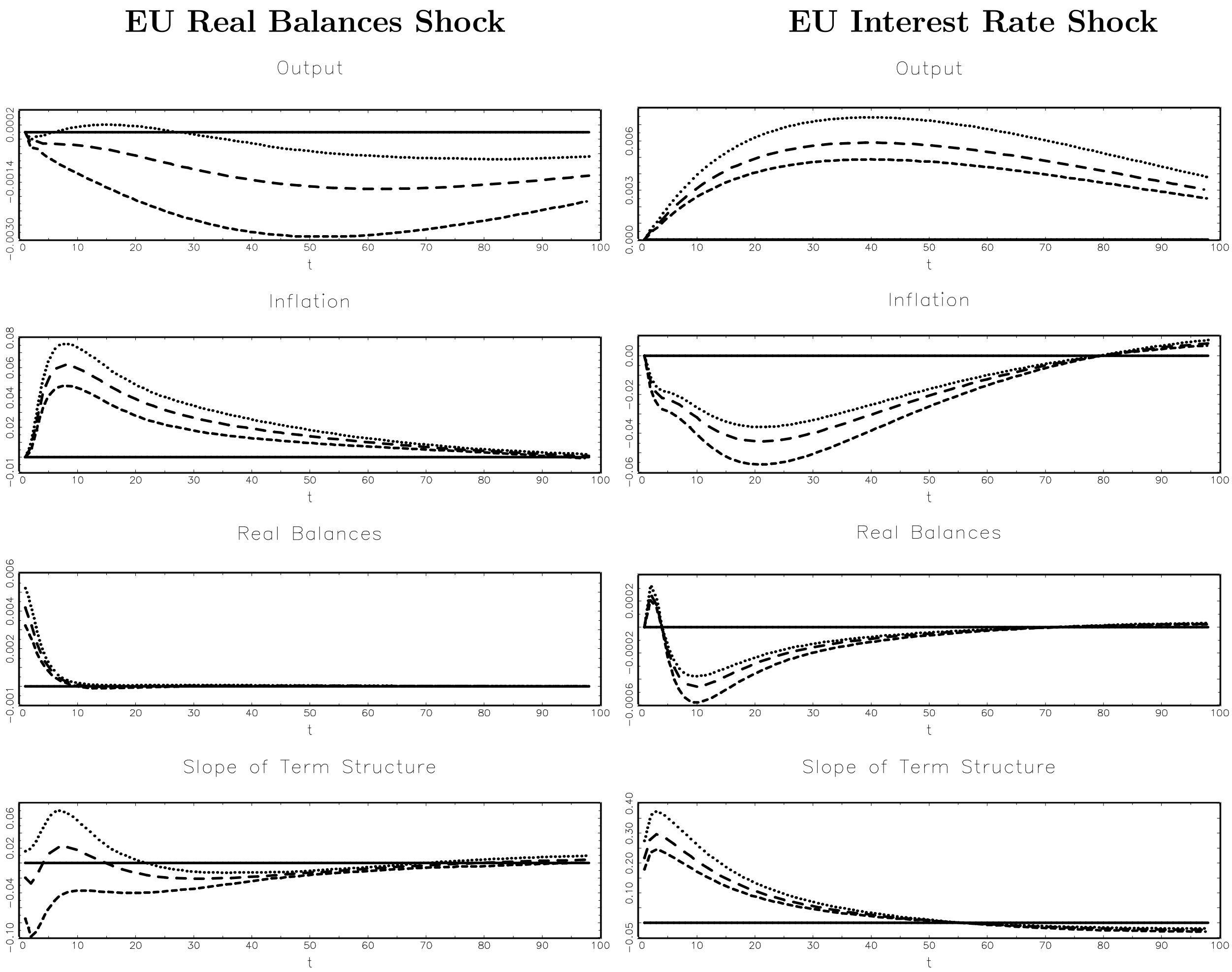

Figure 3 Impulse Responses of Older EU Members (Cholesky decomposition)

To conclude, there are two major differences between the results obtained using a sign restriction approach and those resulted from using a Cholesky decomposition. The first is that the sign restriction identification scheme helps us to identify a monetary shock and thus to be more precise about the nature of a shocks allowing us to label a monetary shock and not just consider it a demand. A second major difference is that the sign restriction approach is more robust and draws theoretical knowledge on DSGE models whereas the Cholesky decomposition is sensitive to the ordering of the variables that is more or less done ad hoc. We ordered our variables as in Sims (1986) In the sections that follow we will be using the disturbances identified using sign restrictions of the of the cross-correlation function of our variables' impulse responses and not the Cholesky results.

6.2 Impulse Response of the Newly Aceeded Countries- Pooled VAR

Is is now interesting to look at how these shocks propagate into the NACs' economies. Due to data restrictions we consider only seven out of the ten acceded countries, namely Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Poland and Slovakia.

Methodologically we regard the demand and supply shocks identified in the section above to be exogenous variables in the NAC's VAR. We pool all countries together and split them into groups hoping to exploit the cross sectional information and extract a common trait which exists in these countries. We report in Appendix 4 the sign of the individual country's parameter estimates and consider these only in forming the two groups. Two specifications are considered, one in which all 7 countries are pooled together and one in which we split them in two groups according to their geostrategic position and their similarity of response to EU shocks. Group 1 includes the Czech Republic, Hungary, Poland and Slovakia[7] while group 2 comprises Cyprus, Estonia and Lithuania. The 5 variables that are pooled together for this analysis are industrial production, inflation, the real effective exchange rate, exports and the deposit interest rate.

In order to understand the two specifications better we now take the chance to make a_t, the block of newly acceded countries, explicit for each specification. From now onwards we denote $a_t = a_{it} = \{a_{it}^{all}, a_{it}^{G}\}$ where a_{it}^{all} stands for the block variables of all countries pooled together and a_{it}^{G} for the block variables of group1 and group 2. i is a country counter and takes values between $\{1, ...7\}$ for the first specification and between$\{1, ...4\}$ and $\{1, ...3\}$ for group 1 and 2 respectively of the second specification. More formally rewriting the structural VAR in a more manageable form we get:

$$\delta_{11} a_{it} = \varphi_{i1} + \alpha_{11}(L) a_{it-1} + \alpha_{12}(L) e_{it-1} - \delta_{12} e_{it} + \beta_{12} ext_{it} + \epsilon_{1\ it}$$

[7]Economic intuition suggests that Slovakia should belong to group 1 considering its geografic position, trade and historical links with the rest of group 1 countries. However Slovakia's response to an EU productivity shock would seem at odds with this. When we performed the LR test for the inclusion of the Slovakian economy in Group 1, the marginal significance coefficient was 0, rejecting $H0$ and thus suggesting that we should keep Slovakia in group 1.

$$a_t = \delta_{11}^{-1}\varphi_{i1} + \delta_{11}^{-1}\alpha_{11}(L)a_{it-1} + \delta_{11}^{-1}(\alpha_{12}(L)L - \delta_{12})e_{it} + \delta_{11}^{-1}\beta_{12}ext_{it} + \delta_{11}^{-1}\epsilon_{1\ \mathrm{it}}$$

but by substituting the values of the incumbent EU group which we got in the previous section:

$$e_t = (1 - \delta_{22}^{-1}\eta_{12}(L))^{-1}\delta_{22}\varphi_{22} + (1 - \delta_{22}^{-1}\eta_{12}(L))^{-1}\delta_{22}\beta_{22}ext_t + (1 - \delta_{22}^{-1}\eta_{12}(L))^{-1}\delta_{22}^{-1}\epsilon_{2t}$$

we get an expression for the pooled NAC's variable as a function of its own lags, the equity index ext_t, the EU and domestic shocks:

$$a_{it} = \Psi_{1i} + \delta_{11}^{-1}\alpha_{11}(L)a_{it-1} + \Psi_2\epsilon_{2\ it} + \Psi_3 ext_{it} + \delta_{11}^{-1}\epsilon_{1\ it} \quad \text{where}$$

$$\begin{aligned}
\Psi_{1i} &= \delta_{11}^{-1}\varphi_{i1} + \delta_{11}^{-1}(\alpha_{12}(L)L - \delta_{12})(1 - \delta_{22}^{-1}\eta_{12}(L))^{-1}\delta_{22}\varphi_{22}, \\
\Psi_2 &= \delta_{11}^{-1}(\alpha_{12}(L)L - \delta_{12})(1 - \delta_{22}^{-1}\eta_{12}(L))^{-1}\delta_{22}^{-1}, \\
\Psi_3 &= (\delta_{11}^{-1}(\alpha_{12}(L)L - \delta_{12})(1 - \delta_{22}^{-1}\eta_{12}(L))^{-1}\delta_{22}\beta_{22} + \delta_{11}^{-1}\beta_{12})
\end{aligned}$$

Whenever we report results we will be referring to the model above estimated either for a_{it}^{all} or a_{it}^{G}. Both specifications were estimated using OLS.

There are advantages and disadvantages in using a pooled model. On the plus side, assuming that the DGP for all the seven countries is the same and considering that the time dimension of pooled countries is relatively short, the pooled model recovers correctly the average informational content from the pooled residuals and provides efficient estimates of the coefficient of the system. On the other hand some form of heterogeneity is likely to be present in the system which could lead to inconsistent parameter estimates and biased structural inferences. However Benczur and Ratfai (2005) find that the countries in our sample exhibit a homogenous pattern in cyclical dynamics, therefore we carry on with a pooled system and in order to partially address some of the heterogeneity problem we consider a fixed effects pooled VAR by allowing country specific intercepts and also split this into the two groups.

Figure 4 depicts the average response of a NAC to an EU monetary and supply shock using 68% percentile bootstrapping intervals. An EU supply shock seems to behave like a supply shock for an average NAC in the sense that output goes up on impact and converges to the steady state within 3 months while prices decrease and reach the largest drop after two months and bounce back to the equilibrium very slowly. An EU monetary shock seems to affect the transition countries negatively with both output and prices going down on impact.

EU Monetary Shock **EU Productivity Shock**

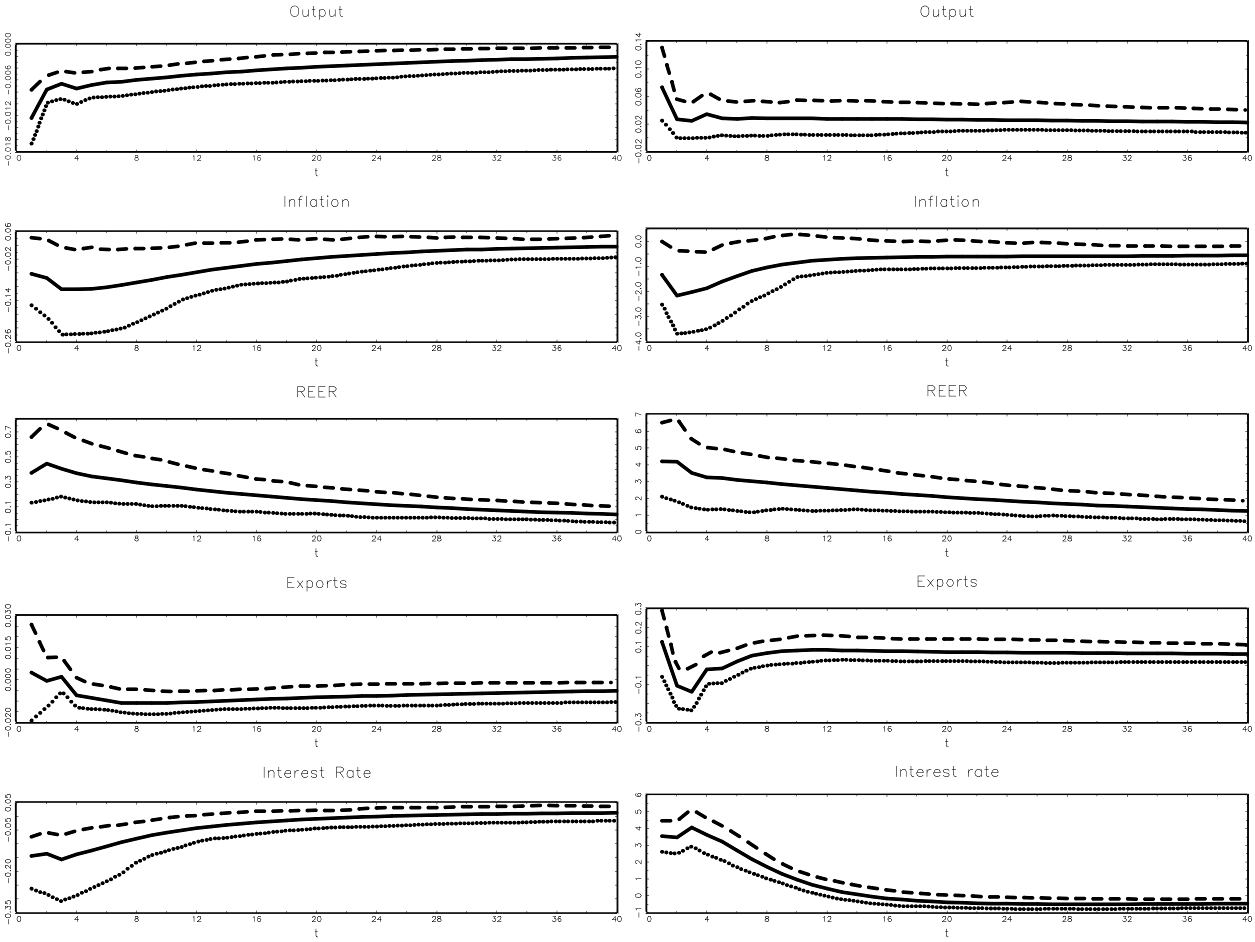

Figure 4 Impulse Responses for Entire Group

We now split the two countries into two groups in order to see if possible region effects change the results. In Figure 5, an average country from group 1 responds to an EU supply shock with an increase in both output and prices which resembles a demand shock. This could be explained by strong trade links between EU member countries, in the sense that a large part of the manufacturing industry of core EU countries is outsourced to group 1 countries. One of the main reasons for this is that these countries offer strategic advantages, both as a market and as an industrial base, including lower labor costs[8], skilled workforce and a high

[8]According to a Deutsche Bank Trade Report in January 2005 the average hourly wage in the car manu-

potential for market growth. So an increase in productivity lets say of a German worker could lead to an increased demand for parts in Slovakia which would push up output as well as prices and lead to more exports. The increase in the REER is consistent with empirical results using a Balassa Samuelson framework- Maeso-Fernandez et al. (2001) find that a one percent change in productivity differential leads to a 4 to 5 percent real appreciation of the Euro which would mean a real depreciation of the average group 1 real exchange rate.

EU Monetary Shock **EU Productivity Shock**

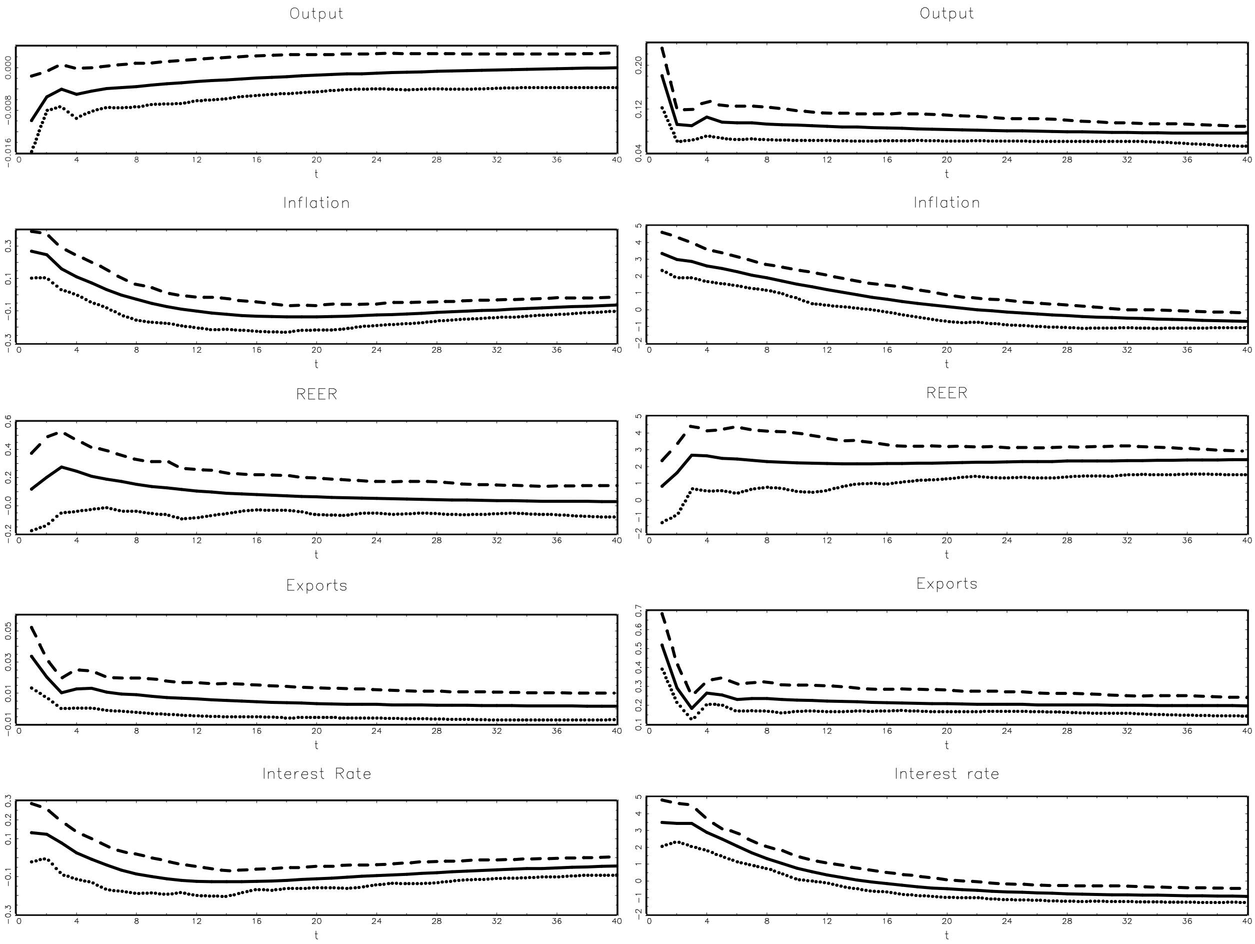

Figure 5 Impulse Responses for Group 1

facturing car parts industry is EUR 28.5 in the western part of Germany and EUR 16.5 in the eastern part, this average comes to EUR 4.2 in Hungary, EUR 5.4 in Poland, EUR 4.2 in the Czech Republic and EUR 3.3 in Slovakia'. The wage costs is cc. a quarter of all production costs, which gives the region a strong competitive advantage.

A monetary shock produces a negative correlation between output and interest rate responses, a result that is in line with the default risk literature in developing economies (Arellano (2005)) which says that in a period of economic downturn, the default risk of emerging economies increases due to both their non-contingent foreign debt and their desire to borrow more, which pushes domestic interest rate up.

Figure 6 illustrates the impulse responses of group 2. The EU supply shock feeds through as a positive supply shock with a negative correlation in movement between output and price while the EU monetary shock passes through as a negative demand shock which drags down both prices and output.

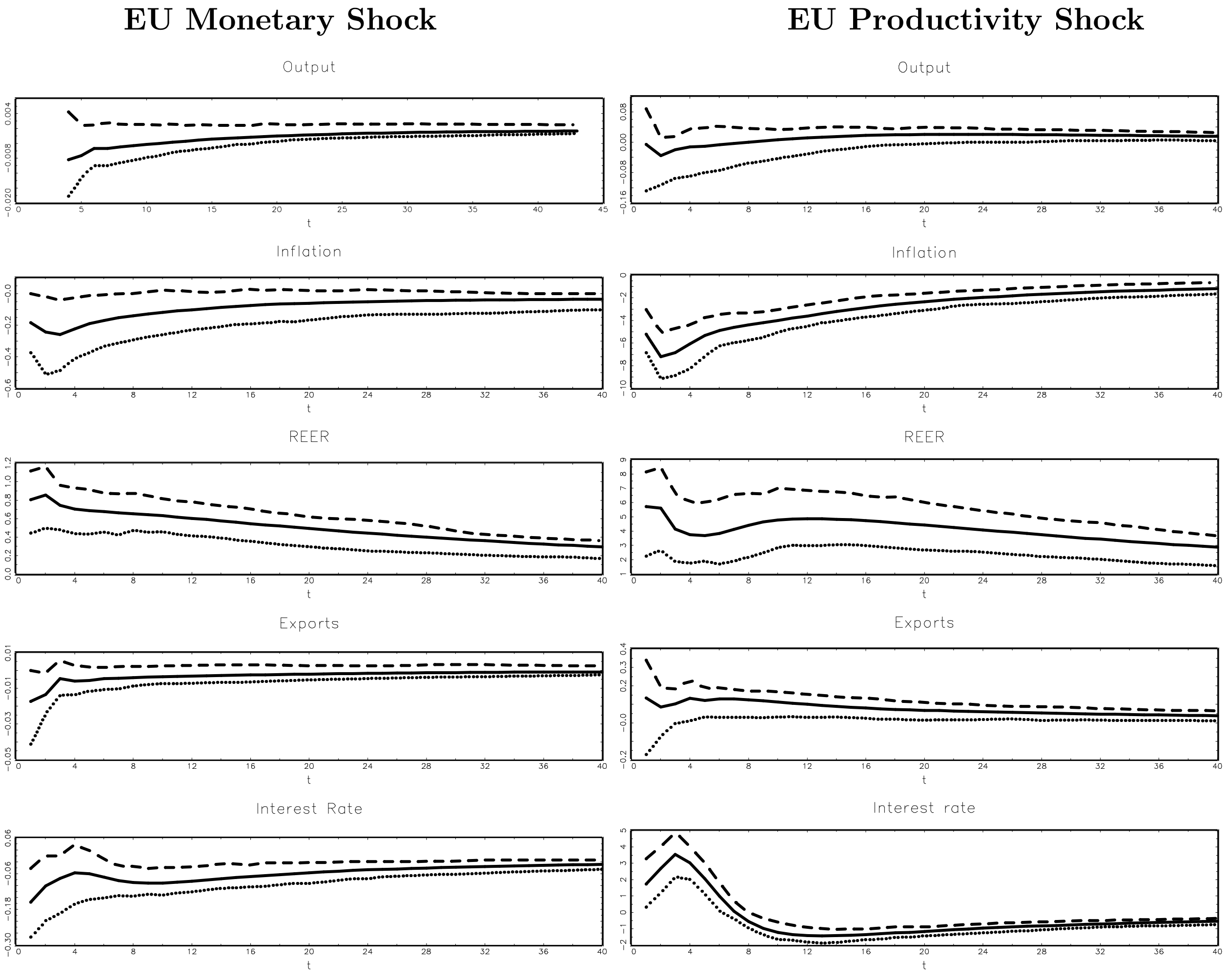

Figure 6 Impulse Responses for Group 2

For both shocks output's response is not statistically significant. The interest rate shows co-movement with the EU one as it decreases in response to a EU monetary shock and increases in response to an EU productivity shock. A monetary shock in the EU increases European prices which reduces EU competitiveness through the appreciation of their real exchange rate. In a typical group 2 country this manifests in an increase in the REER. The puzzling competitiveness effect on exports may be due to the quick reduction of interest rates in tandem with the EU interest rate drop.

Overall, output's response to either a monetary or supply shock has the same sign for the three specifications while price's reaction to these shocks differs and suggests that a supply shock happening in the EU would hit group 1 as a positive demand shock while it sinks through group 2 economies as a supply shock. There are potentially very important lessons to learn before allowing all these countries to join the Monetary Union and asking them to give up their monetary policy.

6.3 The Importance of EU disturbances for the Newly Acceded Countries

Now that we saw that some of impulse responses are statistically significant it would be interesting to look at how much of the variability of the output, inflation, real effective exchange rate, exports and interest rates is explained by the disturbances of the older member countries. Table 2 below shows the forecast error variance decomposition (FEVD) which provides information about the relative importance of each random innovation in affecting the variables in the VAR. The FEVD was obtained by calculating the percentage of the variance of a 6 month forecast of the five endogenous variables that is caused by each of the three external shocks.

It comes across that output and exports' variability can be explained in a large proportion by the three external shocks, a result that holds for the three specifications. REER's 6 month ahead forecast error can be explained in proportion of 5% only by the external shocks although when breaking up the countries into groups is seems that these shocks can explain 11% of its variability in a typical country in group 1 but go as high as 20% for group 2. This makes sense since group 1 countries have experienced large market intervention to stabilize their nominal exchange rates during the 1990s which must have affected the REER. All results in this section indicate that most of the variability of the macroeconomics variables of the NACs are driven mainly by two shocks, a result which is at odds with the literature that argues for a large number of stochastic disturbances (Smets and Wouters (2002)) but in line with results in structural factor literature (Forni at al 2004) which favours a very small number of shocks.

Table 2: FEVD at 6 steps ahead for pooled VAR (%)

All countries	**Monetary**	**Productivity**	**MXEF**	**Total**
Output	34	8	50	**95**
Inflation	2	5	34	**40**
REER	2	1	1	**5**
Exports	2	4	71	**88**
Interest Rate	5	34	1	**38**
Group 1				
Output	10	38	50	**98**
Inflation	5	14	50	**69**
REER	0.5	0.5	0.1	**11**
Exports	21	58	12	**91**
Interest Rate	0.1	16	45	**61**
Group 2				
Output	52	4.5	21	**77**
Inflation	4	32	13	**48**
REER	9	2	9	**20**
Exports	6	9	77	**78**
Interest Rate	5	34	7	**52**

7 Conclusion

The central aim of this paper was to analyse the impact of different types of shocks originated in the EU on the Newly Acceded Countries and to assess its relative importance. We used a sign restriction approach à la Canova and De Nicoló (2003) to estimate the EU VAR. All theoretical sign restrictions were derived from an open economy SDGE model used by Den Haan (1990) and Gavin and Kydland (1999) and were used to identify a EU monetary and a supply shock. We compared these results with those obtained using a traditional Cholesky decomposition and concluded that the ones derived using a sign restriction identification scheme were superior due to two main reasons. First, the restrictions used were derived from a SDGE model as opposed to being ad hoc and second it allowed the identification of a monetary shock that was not possible to distinguish using a Cholesky decomposition. We introduced the shocks derived from the sign restriction specification as exogenous variables in the pooled VAR of the NACs considering two specifications, one in which all countries were pooled together and another in which the NACs were split into two groups according to their geostrategic position and to their similarity of response to EU shocks.

We find that supply shocks occurring in the EU have different effects on these countries than they have on its group countries; some perceive it as a demand shock through strong trade channels, others feel it as a supply shock through the interest rate channel. Timing wise, most NAC's variables react within a maximum of 3 to 4 months from when the shocks hits the EU economy. We also find that supply shocks explain a large proportion of output taking values between 4.5% and 38%, results which seem to be in line with findings which use a similar procedure for shock identification (Peersman at al (2005) find figures of between 35% and 40%). Monetary shocks's contribution to output variation ranges between 10% and 52%, results which, although at odds with the findings of the empirical literature, mainly concentrated on the US (Uhlig (1999)) are in line with the most recent held views on output fluctuation in the G7 (Canova and De Nicoló (2002)).

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Appendix 1: Example of Rotational Matrices

Bivariate Rotation: rotate two variables while keeping the other two fixed. For a 4 variable VAR there are 6 bivariate rotation. Below there is an example when only the first and the second row are being rotated.

$$\begin{pmatrix} \cos(\theta) & -\sin(\theta) & 0 & 0 \\ \sin(\theta) & \cos(\theta) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Combination of Bivariate Rotations using one angle, θ: rotate two variables by θ while rotating the other two by the same angle while keeping the orthogonality condition still satisfied. For a 4 variable VAR there are 3 combination of bivariate rotations. The matrix below depicts an example when the first and the third row are rotated together while the second and the fourth are rotated together and by the same angle.

$$\begin{pmatrix} \cos(\theta) & 0 & -\sin(\theta) & 0 \\ 0 & \cos(\theta) & 0 & -\sin(\theta) \\ \sin(\theta) & 0 & \cos(\theta) & 0 \\ 0 & \sin(\theta) & 0 & \cos(\theta) \end{pmatrix}$$

Combination of Bivariate Rotations using two angles, θ and θ_1: rotate two variables by θ while rotating the other two by θ_1 preserving the orthogonality condition. For any size VAR there will be an infinite number of rotations given by the fact that for each θ we can rotate the other two variables by any angle θ_1. To reduce the infinite problem to an accountable one, we choose θ and θ_1 from the interval $(0, \frac{\pi}{2})$ by fractioning it into 100 points for each angle. Below we reproduce the previous example but rotate the second and the fourth rows by a different angle than the angle by which the first and the third row are rotated.

$$\begin{pmatrix} \cos(\theta) & 0 & -\sin(\theta) & 0 \\ 0 & \cos(\theta_1) & 0 & -\sin(\theta_1) \\ \sin(\theta) & 0 & \cos(\theta) & 0 \\ 0 & \sin(\theta_1) & 0 & \cos(\theta_1) \end{pmatrix}$$

Appendix 2: Table with Contemporaneous Sign Restrictions

Structural Disturbance	Y	Corr(Y, Π)	Corr(Y, M/P)	Corr(Π,M/P)	Type of Shock Conditional on Sign Restriction
ϵ_1	+	+	+	+	Monetary
ϵ_2	+	+	-	-	Read Demand
ϵ_3	+	-	+	-	Supply

Appendix 3: Description of data

NACs	Industrial Production	CPI	REER
Cyprus	42366...ZF...	42364...ZF...	423..RECZF...
Czech Republic	93566..CZF...	93564...ZF...	935..RECZF...
Estonia	EOIPTOT.H*	93964...ZF...	EOXRREEK*
Hungary	94466...ZF...	94464...ZF...	944..RECZF...
Lithuania	LNI66...F*	94664...ZF...	LNXTW..RF**
Poland	96466..BZF...	96464...ZF...	964..RECZF...
Slovakia	93666..BZF...	93664...ZF...	936..RECZF...

NACs	Exports	Imports	Interest rate	Range
Cyprus	42370...ZF...	42371...ZF...	42360L..ZF...	1991:01- 2004:04
Czech Republic	93570...ZF...	93571.V.ZF...	93560L..ZF...	1994:01- 2004:04
Estonia	EOEXPGDSA*	EOIMPGDSA*	93960L..ZF...	1994:01- 2004:06
Hungary	94470...ZF...	94471.V.ZF...	94460L..ZF...	1991:01- 2004:06
Lithuania	LNI7D0WDA*	LNI7D1WDA*	94660L..ZF...	1994:01- 2004:06
Poland	96470...ZF...	96471.V.ZF...	96460L..ZF...	1991:01- 2004:02
Slovakia	93670...ZF...	93671.V.ZF...	93660L..ZF...	1994:01- 2004:06

Source:
1) IFS
2) *Data Stream- IMF data base
3) **Central Bank of Lithuania

We worked with logarithmic values of the index of industrial production and REER while we used difference in logarithm for CPI. Terms of trade were calculated as a ration between exports and imports while the interest rate was used in its original percentage form. All industrial production series are seasonally adjusted.

EU 12	Series Code	Unit
Industrial Production	EMESINPRG	index
HCPI	EMCONPRCF	index
M3	EMECBM3.B	bn euro
Interest rate- 3 months	EMESTBIL	%
Interest rate- 10y gov. bond yield	EMESSFUB	%
Range	1990:01- 2004:06	monthly data

Source:
1) *Data Stream- Eurostat data base

As above we worked with logarithmic values of the index of industrial production while we used difference in logarithm for CPI. Real balances were computed by dividing the level of nominal balances, namely the logarithm of the index of M3, by the level of prices, namely logarithm of CPI index. The slope of the term structure was obtained by subtracting the short term interest rate from the long run, 10 year government bond yield. With the exception of the interest rates all variables are seasonally adjusted and real balances are detrended using a hp filter. Future work will consider linearly detrended real balances although we do not expect results to change.

Appendix 4: Signs of Individual Country's parameter estimates

Monetary Shock

Country	Industrial Production	Inflation	REER	Trade	Interest Rate
Cyprus	-	-	-	-	+
Czech Republic	-	+	-	-	-
Estonia	+	-	+	+	-
Hungary	+	+	-	-	+
Lithuania	-	+	+	-	-
Poland	-	+	+	-	+
Slovakia	-	-	+	+	+

Productivity Shock

Country	Industrial Production	Inflation	REER	Trade	Interest Rate
Cyprus	-	-	-	-	+
Czech Republic	+	+	+	-	+
Estonia	+	-	-	-	+
Hungary	+	+	-	-	+
Lithuania	+	-	+	-	+
Poland	+	+	+	-	+
Slovakia	+	-	-	-	+