Department of Economics
Working Paper No. 138

After Two Decades of Integration: How Interdependent are Eastern European Economies and the Euro Area?

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March 2012

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After Two Decades of Integration: How Interdependent are Eastern European Economies and the Euro Area?

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Abstract

This article investigates the interrelations between the initial members of the Euro area and five important Central and Eastern European economies. We set up a theoretical open economy model to derive the Purchasing Power Parity, the Interest Rate Parity, the Fisher Inflation Parity, and an output gap relation. After taking convergence into account, they are used as restrictions on the cointegration space of a structural vector error correction model. We then employ generalized impulse response analysis to assess the dynamic effects of shocks in output and interest rates on the respective other area as well as the implications of shocks in the exchange rate and in relative prices on both areas. The results show a high degree of interconnectedness between the two economies. There are strong positive spillovers in output to the respective other region with the magnitude of the impact being similarly strong in both areas. Furthermore, we find a multiplier effect being present in Eastern Europe and some evidence for the European Central Banks' desire towards price stability.

JEL classification: C11, C32, F41

Keywords: European Economic Integration, Structural Vector Error Correction Model, Generalized Impulse Response Analysis

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1 Introduction

In April 1989, the anti-communist Solidarność won the vast majority of available parliamentary seats in Poland which marked the beginning of a series of peaceful revolutions in Central and Eastern Europe (CEE). Subsequently, Albania, Bulgaria, Czechoslovakia, East Germany and Romania overthrew their communist governments, which was followed by the dissolution of the Soviet Union. Since the fall of the Iron Curtain, there has been a remarkable pace at which integration between Western Europe and some of the former Warsaw Pact countries took place. While there were doubtlessly also backlashes, the overly successful process culminated in the accession of the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia to the European Union (EU) on May 1, 2004. Bulgaria and Romania followed suit on January 1, 2007. Since then, five of these countries even managed to adopt the Euro as their single currency.

Various aspects of the relationship between the EU and CEE were deemed to be of utmost economic importance over the last twenty years. While CEE countries predominantly benefited from high Western European FDI inflows and the prospect of EU accession, EU countries gained by having access to new unsaturated markets (see for example Breuss, 2001; Matkowski and Próchniak, 2007). Furthermore, barriers on the labor markets between the EU and CEE were continuously removed (European Commission, 2008). Despite these facts, the interdependencies between the EU and CEE have not been thoroughly investigated which is mainly due to a lack of sufficiently accurate data and the unsatisfactory coverage of time series (Benkovskis et al., 2011). We attempt to contribute in closing this gap by investigating the interrelations between the 12 initial members of the Euro area (EU-12) and the five Eastern European countries Czech Republic, Hungary, Poland, Slovakia and Slovenia (CEE-5). In so doing we make use of aggregate EU-12 data for GDP, interest rates and prices and construct a corresponding data file for the CEE-5 which additionally contains a price differential variable and an artificial exchange rate between the two areas.[1] Then we analyze the effects

[1] See Appendix B for details on the construction of the dataset.

of shocks in output and in interest rates that hit one of the two areas as well as shocks in the exchange rate and in relative prices in order to assess their impact upon the other region. The methodology we rely on is based upon a series of papers (Pesaran and Shin, 1998; Garratt et al., 1999, 2003, 2006), where the authors argue in favor of using a structural vector error correction model (SVECM) combined with generalized impulse response analysis to assess the effects of exogenous shocks on macroeconomic variables. The advantage of this model class over other approaches like vector autoregressive models (VARs), structural vector autoregressive models (SVARs) and standard vector error correction models (VECs) is that theoretical long-run relationships — which are deemed to be more credible than short-run relationships — are used to identify cointegrating relations and that the ordering of endogenous variables neither matters for the cointegration space nor for the impulse response analysis. Altogether this minimizes the investigator's need for arbitrary modeling choices.

As already indicated, the literature closely related to our purpose is rather scarce. Most studies on the effects of macroeconomic shocks in the CEE region exclusively consider domestic shocks. For example, the monetary transmission mechanism in CEE countries has been studied extensively (see Égert et al., 2006; Égert and MacDonald, 2008, for an assessment of the interest pass-through and a survey on the monetary transmission mechanism in CEE, respectively). Only a few analyses exist that consider the dynamic effects of foreign shocks on CEE economies. Most recently, however, a couple of studies have begun to devote greater attention to this issue. Jiménez-Rodriguez et al. (2010) point out that the degree of homogeneity in the response of future Euro area members to foreign shocks is one important indicator to asses the preconditions for the well-functioning of an enlarged monetary union. In investigating this issue, the Euro area and the United States are considered as the foreign economy in a near VAR model that allows for structural breaks in the constant, the trend, and the variance. The analysis shows that while the response to commodity price shocks differs among the ten CEE countries, a shock in the foreign interest rate leads to a fall in industrial production in all and to a fall in prices in most of them.

Moreover, an increase in foreign industrial production triggers an increase in domestic industrial production as well as a real appreciation of domestic currencies. The CEE countries show a high degree of homogeneity in most of the responses to shocks in industrial production, indicating a good precondition for joining the monetary union.

Benkovskis et al. (2011) analyze the transmission of monetary policy shocks from the Euro area to Poland, Hungary and the Czech Republic. They employ a factor augmented VAR (FAVAR) model and show that there are substantial effects of Euro area monetary policy on economic activity in the considered CEE countries which mainly work through the interest rate channel and through changes in foreign demand. Furthermore, the exchange rate is shown to be important in explaining movements in CEE prices.

In a recent contribution, Crespo Cuaresma et al. (2011) explore the transmission of fiscal shocks from Germany to the CEE-5 countries. They use a structural VAR model and show that while a fiscal expansion in Germany triggers expansionary fiscal policy measures in all the five CEE countries included, the effects on GDP differ among them. While output increases in Poland and Hungary, it decreases in Slovenia, Slovakia, and the Czech Republic. Altogether, the results confirm that there are strong interdependencies between Germany and the CEE-5 with respect to fiscal policy.

This short overview indicates that the empirical work is almost entirely based on times series applications that lack a theoretical background or otherwise focus on identification of shocks via *short*-run restrictions drawn from the literature. However, two recent contributions are based upon the insights of Pesaran and Shin (1998), Garratt et al. (1999), Garratt et al. (2003) and Garratt et al. (2006) in order to analyze the effects of shocks between two economic areas: Gaggl et al. (2009) investigate the Euro area and the United States and use a dynamic open economy model to derive five relations that may be used for identification of the *long*-run relationships of the error correction part. The restricted VEC model is estimated for each economy separately and generalized impulse response analysis is carried out to reveal the effects of shocks in one economic area on the other one and also to investigate differences in adjustment processes to deviations from long-run equilibria between the Euro area and the United States. In an assessment of the transmission of shocks between Austria and Germany, Prettner and Kunst (2011) modify the model of Garratt et al. (2006) to account for the integration of these countries' labor markets. Their analysis shows that economic shocks in Germany have significant and sizable impacts on the Austrian economy, while corresponding shocks to Austrian variables impact upon the German economy to a lesser extend.

To the best of our knowledge, there exists no paper that applies a similar modeling strategy like Garratt et al. (2006), Gaggl et al. (2009) and Prettner and Kunst (2011) to the CEE region. However, there is one study worth mentioning because it also applies long-run economic theory to restrict the cointegration space of a VEC model. Passamani (2008) sets up a structural cointegrated VAR model for the Czech Republic, Hungary, Poland and Slovakia, with the Euro area as foreign region. The authors incorporate interest rate and purchasing power parity conditions as cointegrating relations and test their validity to assess the underlying countries' convergence processes. The effects of international shocks are, however, not considered.

Our paper proceeds as follows: section 2 is devoted to a description of the underlying theoretical framework on which we base our analysis, section 3 describes and assesses our econometric specification and in section 4 we present the results regarding the impact of exogenous shocks hitting one area on the other economy. Finally, section 5 concludes.

2 The Model

In this section we rely on households' dynamically optimal consumption-savings decisions and on a neoclassical description of the production sides of our model economies in deriving restrictions to be imposed on the cointegration space of the SVECM. In so doing we generalize the model used by Prettner and Kunst (2011) to allow for two different currencies in the two economic areas we are investigating.

2.1 Consumption Side

Following Prettner and Kunst (2011), we assume that in each of the economies there is an infinitely lived representative household who chooses sequences of consumption goods produced at home and abroad in order to maximize its discounted stream of lifetime utility

$$\max_{\{C_t\}_0^\infty, \{C_t^*\}_0^\infty} \sum_{t=0}^{\infty} \beta^t \left(C_t^\alpha C_t^{*1-\alpha} \right). \tag{1}$$

In this expression $\beta = 1/(1+\rho)$ is the subjective discount factor with $\rho > 0$ being the discount rate, t is the time index with $t = 0$ referring to the present year, C_t denotes consumption of the domestically produced aggregate which we take as the numéraire good and an asterisk refers to the foreign economy such that C_t^* describes consumption of the good produced abroad. We assume that the utility function has a Cobb-Douglas representation with $0 < \alpha < 1$ being the share of the consumption aggregate produced at home. The household has to fulfill a budget constraint such that its expenditures and savings in period t are equal to its income in that very period. Furthermore, households are subject to a cash-in-advance constraint in the spirit of Clower (1967) such that individuals are only allowed to consume from money holdings in a certain period and not from capital or bonds. Altogether these two constraints can be written as

$$\begin{aligned} C_t + \frac{P_t^*}{e_t} C_t^* + K_t + B_t + \frac{B_t^*}{e_t} + M_t &= (1+r_t)K_{t-1} + w_t L_t + \frac{1+i_t}{1+\pi_t} B_{t-1} \\ &\quad + \frac{1+i_t^*}{1+\pi_t^*} \frac{B_{t-1}^*}{e_t} + \frac{M_{t-1}}{1+\pi_t}, \end{aligned} \tag{2}$$

$$C_t + \frac{P_t^*}{e_t} C_t^* \leq \frac{M_{t-1}}{1+\pi_t}, \tag{3}$$

where P_t^* refers to the price level of the consumption aggregate produced in the foreign country, K_t denotes the real capital stock, B_t are real bonds issued by the corresponding government, e_t represents the nominal exchange rate which states how much of the foreign currency one unit of the home currency is able to buy, M_t refers to individual's real money holdings, r_t denotes the real rate of return on capital (which is equal to the real interest rate because we abstract from depreciation), i_t represents the nominal interest rate on governmental bonds, π_t is the inflation rate, w_t the real wage rate, and L_t refers to labor supply, which we assume to be inelastically given by the time constraint of the household. Since households are rational, they do not want to hold more money than necessary to finance optimal consumption in period t, which means that the cash-in-advance constraint holds with equality. Altogether this leads us to the following results of the dynamic optimization problem

$$CPI_t = \frac{CPI_t^*}{e_t}, \tag{4}$$

$$\frac{1+i_t}{1+\pi_t} = \frac{1+i_t^*}{1+\pi_t^*}\frac{e_{t-1}}{e_t}, \tag{5}$$

$$1+r_t = \frac{1+i_t}{1+\pi_t}, \tag{6}$$

where CPI_t and CPI_t^* denote the consumer price indices in the domestic and foreign economy, respectively (see appendix A for the derivations and the connection between consumer price indices and price levels of home and foreign consumption aggregates). The first equation represents the Purchasing Power Parity (PPP) relationship, stating that — adjusted for the nominal exchange rate — the price levels in the two countries move in line. The second equation refers to the Interest Rate Parity (IRP), stating that there is no difference in the return on investments between home and foreign bonds. The third equation represents the Fisher Inflation Parity (FIP), stating that investments into government bonds and into physical capital should deliver the same return. Altogether these conditions are ruling out arbitrage rents (cf. Blanchard, 2003; Garratt et al., 2006; Gaggl et al., 2009) and are often simply assumed to hold in related models.

2.2 Production Side

The production side of the two economies closely follows that outlined in Prettner and Kunst (2011) who build their description upon Garratt et al. (2006) and Barro and Sala-i-Martin (2004). Output at home is produced according to a production function that can be written as

$$Y_t = A_t L_t f(k_t), \tag{7}$$

with Y_t denoting real output, f being an intensive form production function fulfilling the Inada conditions, A_t referring to the technology level of the economy and k_t being the capital stock per unit of effective labor. Following Garratt et al. (2006), the number of employed workers is assumed to represent a fraction δ of the total population N_t such that

$$L_t = \delta N_t. \tag{8}$$

Consequently, the unemployment rate is equal to $1-\delta$. Furthermore, it is assumed that there are technology adoption barriers (cf. Parente and Prescott, 1994) such that

$$\eta A_t = \theta A_t^* = \bar{A}_t, \tag{9}$$

where $\bar{A}_t$ is the technological level in the rest of the world and $\eta > 0$ and $\theta > 0$ measure incompletenesses in technology adoption and diffusion. Putting things together and dividing domestic by foreign output gives

$$\frac{y_t}{y_t^*} = \frac{\theta\delta}{\eta\delta^*}\frac{f(k_t)}{f(k_t^*)}, \tag{10}$$

where y_t denotes per capita output. Equation (10) describes an output gap (OG) relation in the sense that differences in output per capita between the two economic areas can be explained by the relative size of technology adoption/diffusion parameters, the relative size of employment rates and different capital intensities.

2.3 Stochastic Representations of the Restrictions

Taking logarithms of equations (4), (5), (6) and (10) and rearranging yields

$$\begin{aligned}
\log(CPI_t) &= \log(CPI_t^*) - \log(e_t), &(11)\\
\log(1+i_t) - \log(1+i_t^*) &= \log(1+\pi_t) - \log(1+\pi_t^*), &\\
&\quad + \log(e_{t-1}) - \log(e_t) &(12)\\
\log(1+i_t) - \log(1+\pi_t) &= \log(1+r_t), &(13)\\
\log(y_t) - \log(y_t^*) &= \log\left[f(k_t)\right] + \log(\theta) + \log(\delta) &\\
&\quad - \log\left[f(k_t^*)\right] - \log(\eta) - \log(\delta^*), &(14)
\end{aligned}$$

which are deterministic relationships holding in a long-run equilibrium. In the short run — during the adjustment process — these equations need not be fulfilled with equality. Instead there are long-run errors denoted by ϵ measuring short-run deviations from these long-run relationships (cf. Garratt et al., 2006). The stochastic counterparts to equations (11), (12), (13) and (14) in terms of the endogenous variables of the SVECM therefore read

$$p_t - p_t^* + e_t = b_{1,0} + \epsilon_{1,t+1}, \tag{15}$$

$$i_t - \Delta p_t = b_{2,0} + \epsilon_{2,t+1}, \tag{16}$$

$$i_t - i_t^* = b_{3,0} + \epsilon_{3,t+1}, \tag{17}$$

$$y_t - y_t^* = b_{4,0} + \epsilon_{4,t+1}, \tag{18}$$

where the estimates of $b_{1,0}$ and $b_{2,0}$ are expected to be close to zero, the estimate of $b_{3,0}$ should reflect the logarithm of the real interest rate and the estimate of $b_{4,0}$ should reflect the differences in the logarithm of the structural determinants of the output gap.

3 Econometric Model

If all endogenous variables are integrated of order one ($I(1)$), a general SVECM including a constant term and a deterministic trend can be written as

$$A\ \Delta z_t = \tilde{a} + \tilde{b}t - \tilde{\Pi} z_{t-1} + \sum_{i=1}^{p-1} \tilde{\Gamma}_i \Delta z_{t-i} + \tilde{u}_t, \tag{19}$$

where A is a $k \times k$ matrix containing the contemporaneous effects between endogenous variables included in the $k \times 1$ vector z_t, Δ refers to the differencing operator, $\tilde{a}$ and $\tilde{b}$ are the $k \times 1$ vectors of intercept and trend coefficients, the matrices $\tilde{\Pi}$ and $\tilde{\Gamma}_i$ contain the coefficients of the error correction and the autoregressive part, respectively, p is the lag length of endogenous variables before differencing, and $\tilde{u_t}$ is a vector of serially uncorrelated disturbances with mean zero and variance covariance matrix Ω (cf. Garratt et al., 2006). In order to get to the reduced form, equation (19) has to be premultiplied by A^{-1} such that we have

$$\Delta z_t = a + bt - \Pi z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + u_t, \tag{20}$$

with $a = A^{-1}\tilde{a}, b = A^{-1}\tilde{b}$, $\Gamma_i = A^{-1}\tilde{\Gamma}_i$, $\Pi = A^{-1}\tilde{\Pi}$, $u_t = A^{-1}\tilde{u}_t$ and the variance covariance matrix of u_t being $A^{-1}\Omega(A^{-1})'$. If all the variables in z_t are $I(1)$ but there exist one or more stationary linear combinations $\beta' z_t$, the variables are said to be cointegrated and deviations from these stationary relationships can be regarded as deviations from long-run equilibria. If there exist r such cointegrating relations, the matrix $\Pi = \alpha\beta'$ has rank r with α representing a $k \times r$ matrix containing the coefficients measuring the speed of adjustment towards long-run equilibria and β being a $k \times r$ matrix containing the cointegrating relations. For exact identification of the long-run relationships we would need to impose r^2 restrictions on β. Usually these restrictions are obtained by following Johansen (1988) and Johansen (1991) in orthogonalyzing the cointegrating vectors by setting the jth entry in the jth column vector of β to one and the other first $r-1$ entries to zero. This approach does not provide a clear economic interpretation such that we will instead follow Garratt et al. (2006) and use the theoretical restrictions derived in section 2 for identification.

The vector of endogenous variables described in appendix B includes the logarithm of the domestic output index y_t, the logarithm of the domestic interest rate index i_t, foreign[2] inflation (as the first differences of the logarithmic foreign price index p_t^*), the logarithm of the foreign interest rate index i_t^*, the price differential $p_t - p_t^*$ with p_t being the logarithm of the domestic price index, the logarithm of the exchange rate index e_t and the logarithm of the foreign output index y_t^* such that we have $z_t' = (y_t,\ i_t,\ \Delta p_t^*,\ i_t^*,\ (p_t - p_t^*),\ e_t,\ y_t^*)$. Therefore we consider the reduced form model

$$\Delta z_t = a - \alpha\beta' z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \Psi\Delta\ P_t^o + \epsilon_t, \tag{21}$$

with the logarithm of the oil price index P_t^o being an exogenous variable that is allowed to affect the endogenous variables contemporaneously, Ψ_i representing the vector of the associated coefficients and the overidentifying matrix $\beta'_{\mathbf{oi}}$ defined by equations (15), (16), (17) and (18) reading

$$\beta'_{\mathbf{oi}} = \begin{pmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & -1 \end{pmatrix}. \tag{22}$$

The first row of this matrix refers to the PPP, the second row to the foreign FIP, the third row to the IRP and the last row to the OG relation. Note that in our estimation we do not allow for a time trend in the data but we include a constant and a time trend in each cointegrating relation such that the dimensions of α and β change accordingly. The reason for doing so is to account for the convergence process of the CEE economies to the EU-12 (see for example Matkowski and Próchniak, 2007).

[2] Note that we use foreign inflation because the results of unit root tests presented in appendix B prevent us from relying on EU-12 inflation. Hence we implement the CEE-5 FIP relationship.

3.1 Implementing the Long-term Relations

The first step in the empirical analysis is to decide on the number of lags to be included in the model and to find out the corresponding number of cointegrating relations. We base the choice regarding the lag order on the Bayesian Information Criterion (BIC), as well as on residual analysis. As compared to the Akaike Information Criterion (AIC), the BIC favors more parsimonious models. This is a particular advantage in our case because of the limited sample size for CEE-5 data. Table 1 in appendix C shows the two information criteria up to lag order five. As expected, the AIC suggests the largest model with $p = 5$, while the BIC favors the smallest model with $p = 2$. The associated rank and eigenvalue tests on the the number of cointegrating relations are therefore based on a VAR(2) model. They suggest the presence of four such relations which matches the theoretical results. The residual analysis carried out after estimation shows that we do not face serious problems regarding autocorrelation, heteroscedasticity and structural breaks with this model specification. Nevertheless, we carry out robustness checks with regards to alternative model specifications in subsection 4.4.

Imposing all four relations derived in section 2 on the cointegration space results in 28 restrictions on the matrix β. For exact identification only 16 such restrictions are required. Moreover, the theoretically implied structure of the long term relationships might be overly strict and lifting them could lead to more accurate estimation. We therefore also consider an exactly identified version of matrix β, where we allow for partial adjustment and lift part of the zero restrictions according to Garratt et al. (2006).[3] In order to assess the support of the data for either of the two structures, we employ a likelihood ratio test on over-identifying restrictions. In so doing we follow Garratt et al. (2006) and use non-parametric bootstrapping with re-sampling to gain the appropriate critical values which would otherwise be biased in small samples. In 2000 replications we obtain the upper 5% critial value 53.97. The test statistic resulting by comparing the overidentified model with the exactly identified one exhibits a value of 93.69. The test hence rejects

[3]In particular, we lift the zero restrictions on $\beta_{12}, \beta_{13}, \beta_{14}, \beta_{27}, \beta_{36}, \beta_{42}, \beta_{45}, \beta_{46}, \beta_{47}$.

the tight, overidentified matrix in favour of the modified version. This result suggests that allowing for partial adjustment and for a more flexible structure of cointegrating relations could improve the estimation from a statistical point of view. Furthermore, it represents our first empirical result, namely that the integration of CEE-5 is not yet fully completed. This is consistent with the results of Cuestas (2009) and Arghyroua et al. (2009).

However, the use of an exactly identified matrix introduces several disadvantages. Besides the looser implementation of theoretical considerations regarding the two economies, the application of any certain exactly identified matrix is an arbitrary choice.[4] Furthermore, there would be disadvantages with respect to the efficiency of our estimates because we face rather short time series and the use of the exactly identified version implies the estimation of 12 additional parameters. Finally, residual analysis indicates the presence of autocorrelation in case of the exactly identified model which could lead to biased and inconsistent parameter estimates. We therefore incorporate the matrix that imposes the theoretical relations directly but compute impulse responses of the exactly identified model as a robustness check. The comparison of the impulse responses of the two models shows that, overall, the results do not change substantially (see section 4.4).

The results of the error correction specifications are presented in Table 4 in appendix C. Altogether, the error correction terms appear mostly to be significant, indicating that automatic adjustment back to stationary relationships takes place.

The adequacy of the model is further assessed and compared to alternative specifications on the basis of a series of residual tests. Table 3 in appendix C summarizes the results of the Jarque-Bera test on normality and the White test on heteroscedasticity. Considering a significance level of 5%, the Jarque Bera test cannot reject the null hypothesis of normal distribution for all equations except for the price differential, while the White test does not reject the null hypothesis of homosecdasticity for all equations

[4] To work with exactly identified matrices would request to either derive the structure of that matrix according to a certain rule or to test many possible structures against each other and then choose the best in terms of the likelihood.

except the one referring to the EU-12 interest rate. Furthermore, we compute the Portmanteau test on autocorrelation of the residuals. As shown in table 2 in appendix C, autocorrelation does not seem to be a serious problem either. Altogether, these results confirm the choice of the model size with respect to the lag order. Finally, we perform the CUSUM test on parameter stability being particularly relevant for the time series of Eastern European countries. The results of this test, which are available from the authors upon request, show that there is no significant indication of structural breaks in the relationships among the time series at the 5% level.

4 The Dynamic Effects of International Shocks

In order to reveal the effects of shocks in output and in interest rates as well as the effects of shocks in the exchange rate and in relative prices on the EU-12 and the CEE-5 countries, we compute generalized impulse response functions (GIRFs) by shocking the residuals of endogenous variables and tracing their effects with a particular emphasis on the respective other area. The procedure regarding the computation of generalized impulse response functions has been suggested by Koop et al. (1996) and Pesaran and Shin (1998). It circumvents the need for applying the Choleski decomposition and hence the dependence of the results on the arbitrary ordering of endogenous variables in the z_t vector. Furthermore, we again apply a non-parametric bootstrapping procedure with replacement relying on 2000 replications of model estimations in order to compute 95% confidence intervals around the impulse response functions.

4.1 Shocks to the Euro Area

We start with the responses to a 1% shock in EU-12 GDP, for which the results are shown in Figure 1. The response function of domestic GDP shows a significantly higher output level over a period of almost three years. The effect diminishes slowly indicating that GDP growth decreases below its potential rate for a certain time period such that the long-run impact of the shock is insignificant. In contrast to other studies (eg. Gaggl et al., 2009), we do not observe a multiplier effect.

The shock in EU-12 GDP not only has an impact on domestic output but also results in an immediate increase in CEE-5 output by 0.4%, yet the dynamics are reeinforced in the subsequent quarters. Altogether the positive spillovers to Eastern Europe stay significant for approximately two and a half years.

In response to the positive shock in output, EU-12 interest rates increase slightly, but the effect is not significant at the 5% level except between quarters eight and eleven after the shock occured. There is also no significant response of interest rates in CEE-5 for which the point estimate of the impulse response function shows a decrease at first, followed by a later increase. Neither the CEE-5 inflation rate nor the price differential show a significant change in response to the EU-12 output shock. While it is not surprising that there is no direct effect on inflation in Eastern Europe, the result is interesting when interpreted together with the response function of the price differential. Taken together, the two figures indicate that prices in the EU-12 increase in response to a positive output shock, which would be intuitive. Altogether there is no significant effect of the positive Euro area output shock on the exchange rate.

Figure 2 displays the effects of a shock in the EU-12 interest rate. First of all, there is a strong impact on the EU-12 interest rate itself in the first two quarters after the shock. The effect peaks at an increase in the interest rate of 1.6% in the third quarter, while in the fourth quarter interest rates start to decrease slowly with no significant long-run effect remaining. The interest rate in CEE-5 increases slightly in response to the shock in EU-12 interest rates but the effect is not significant at the 5% level until the fourth quarter after the shock took place. In the long-run, after around nine quarters, the response of CEE-5 interest rates turn insignificant again. Another interesting result is that the shock to the interest rate has a small dampening effect on EU-12 output setting in after three quarters and getting stronger and significant over time with the response of CEE-5 GDP following a similar pattern. In the long run and for both areas, the response of output turns

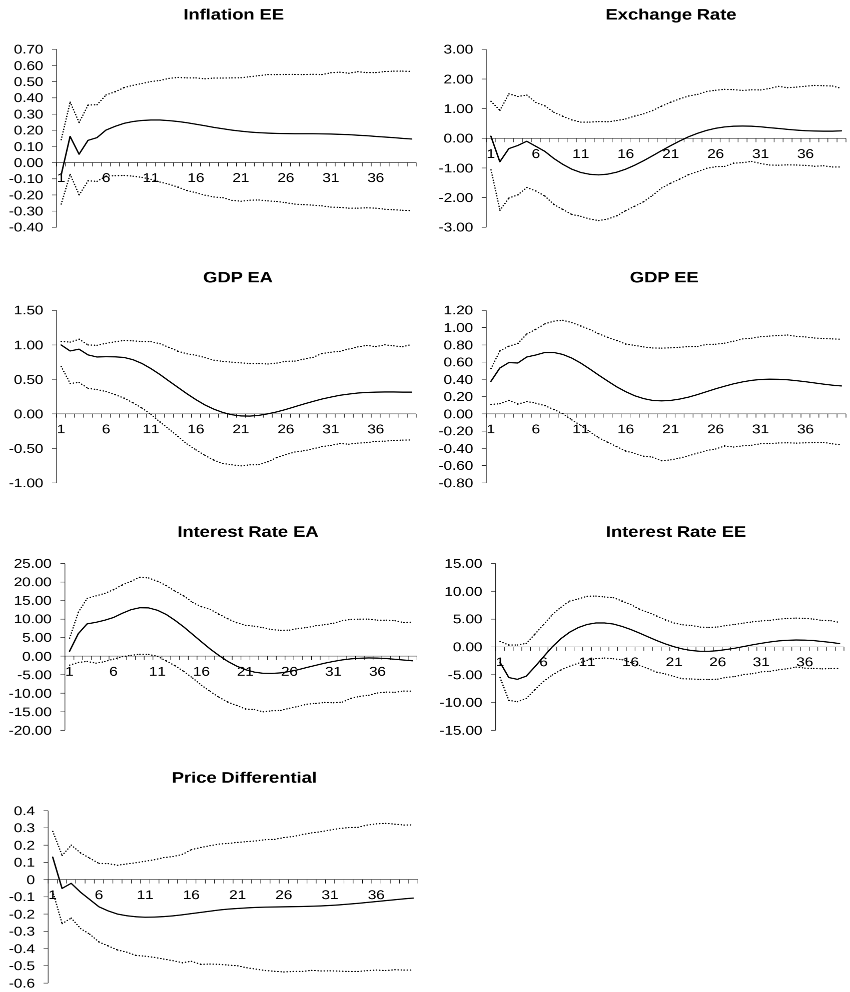

Figure 1: Generalized Impulse Responses to a 1% Shock to EU-12 GDP

insignificant confirming neutrality of monetary policy. There is no significant response of the price differential and CEE-5 inflation, although according to the point estimates there is a slight reduction in Eastern European price pressures, with Euro area inflation supposedly decreasing by less such that the point estimate of the price differential increases.

Altogether, the responses to a shock in the EU-12 interest rate are in line with the literature. With respect to the effect on output, most studies report a decline which sets in after two to six quarters and returns to the pre-shock level after approximately three years (see Barigozzi et al. (2011), Boivin et al. (2009), van Els et al. (2003), Peersman and Smets (2001), Cecioni and Neri (2011) and Gaggl et al. (2009), where the effect is permanent). Similar to Benkovskis et al. (2011), we do not only observe a decline in EU-12 GDP but a spillover effect to the CEE region resulting in a decline in CEE-5 output in the same order of magnitude as in the EU-12. As compared to other studies we neither observe an indication for a price puzzle, i.e., an increase in consumer prices in response to a monetary tightening (Weber et al., 2009; European Central Bank, 2010; Cecioni and Neri, 2011), nor for a decrease in prices (Christoffel et al., 2008). However, in contrast to these studies, we can only assess price movements in the EU-12 *relative* to the CEE-5. We do not find evidence for an appreciation of the nominal exchange rate in response to monetary tightening which contrasts Barigozzi et al. (2011). The reason might be that we have a two-country model that not only allows domestic variables to respond to the interest rate shock but also foreign GDP and interest rates.

4.2 Shocks to Eastern Europe

Figure 3 shows the generalized impulse responses to a 1% shock in CEE-5 output. The variable itself reacts to its own shock with the dynamics being reinforced in the successive quarters apparently due to a slight multiplier effect being present in Eastern Europe. The initial 1% shock translates into an increase of approximately 1.2% after one year. Subsequently, the response of output starts to decay slowly from the peak effect and turns insignificant after around two years. The shock of CEE-5 GDP does not only show a strong response in Eastern Europe itself but there are substantial positive spillover effects to the EU-12 which are approximately as strong as in the reverse case. Starting from a direct increase of EU-12 GDP amounting to 0.5% in the first quarter, the effect peaks at an overall 0.9% in the third

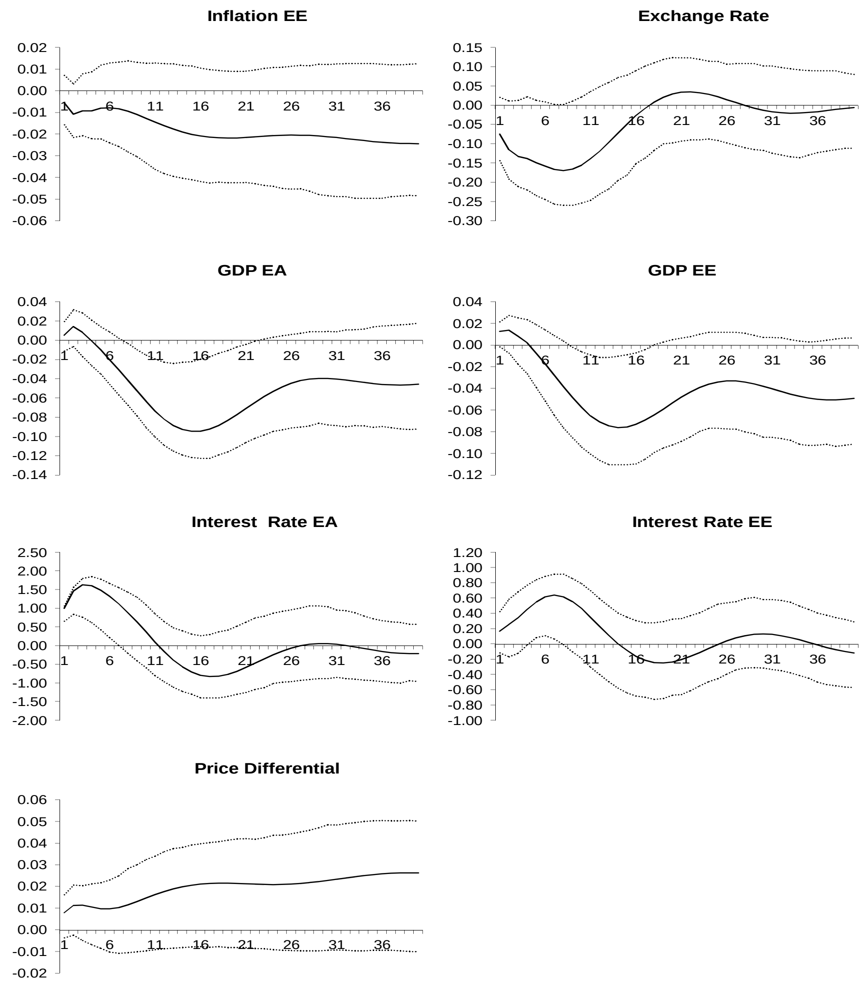

Figure 2: Generalized Impulse Responses to a 1% Shock to EU-12 Interest Rates

quarter after the shock. The positive response of EU-12 GDP due to an increase in demand from CEE-5 is significant on the 5% level but only for around two years. The latter could be explained by the significant positive reaction of EU-12 interest rates potentially indicating the strong desire of the European Central Bank for price stability.

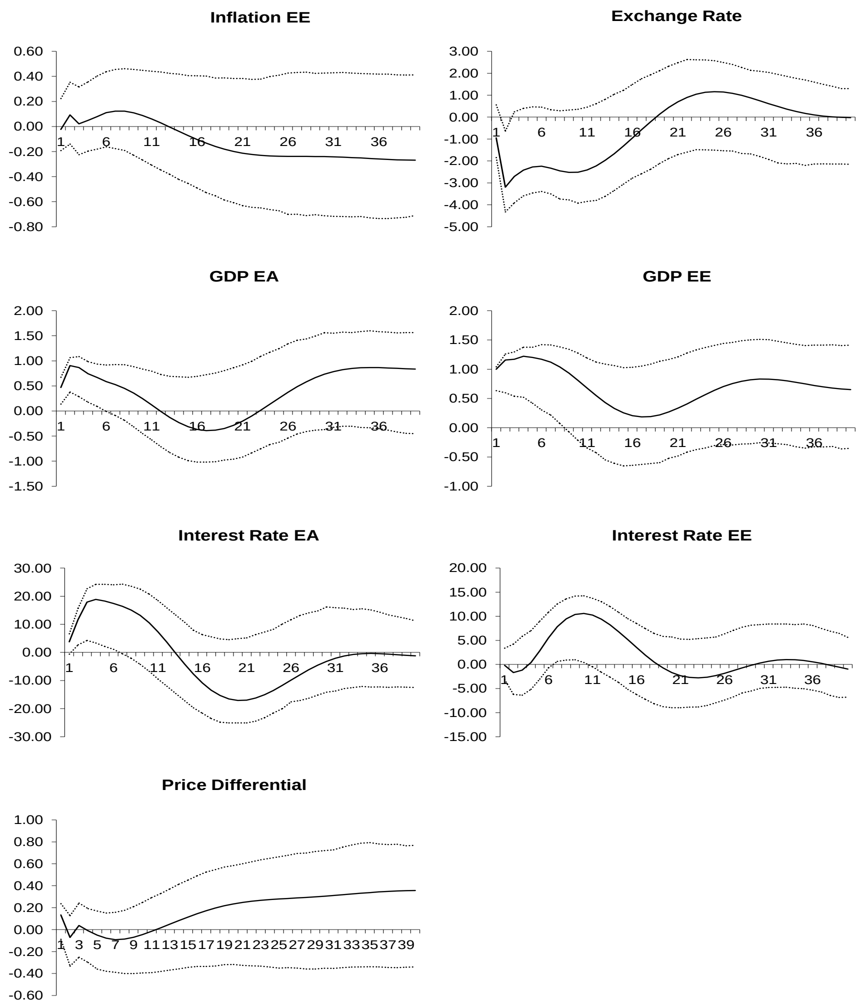

Figure 3: Generalized Impulse Responses to a 1% Shock to CEE-5 GDP

According to the point estimate, the shock in CEE-5 GDP furthermore results in an appreciation of the currencies of these countries by 3% in the first quarters following the shock. This seems to help offsetting the positive impact that higher output would have had on the price level without an adjustment in the exchange rate. According to the point estimate, the insignificant response of inflation in CEE-5 shows a slight upward pressure on prices. Due to the fact that inflation does not react significantly, there is no clear response in the price differential. While the interest rate in CEE-5 is in general not increasing significantly, it does so in the Euro area for almost two years.

The responses to an interest rate shock in CEE-5 are given in figure 4. Although in general not significant at the 5% level, the responses of the output levels of both economies point to a slight dampening effect in the first quarters following the shock. The pattern shows that the dampening effect of higher CEE-5 interest rates on output is more pronounced for Eastern European GDP which would have been expected. In contrast to a shock in EU-12 interest rates, the corresponding shock in CEE-5 only leads to significant responses of Eastern European interest rates themselves but does not seem to transmit to the other economy. Again it is interesting to look at the time pattern of CEE-5 inflation in relation to the price differential in order to gain insights where a movement in price levels comes from. In this case, we do not find a significant impact on CEE-5 inflation, although the point estimate indicates a decrease in the inflation rate after the third quarter. At the same time, we see that the price differential decreases significantly in the first quarter. This indicates that while prices in Eastern Europe need some time to adjust, there is a much faster adjustment in the Euro area.

As Égert and MacDonald (2008) point out, there is substantial disagreement in the literature concerning the effects of interest rate shocks on the CEE region. Our results seem to resemble very much the results of Creel and Levasseur (2005) who also observe a price puzzle accompanied with an exchange rate puzzle, but a weak and late dampening effect on GDP. As in Darvas (2006), the full impact of the interest rate shock on CEE-5 output needs some time to materialize.

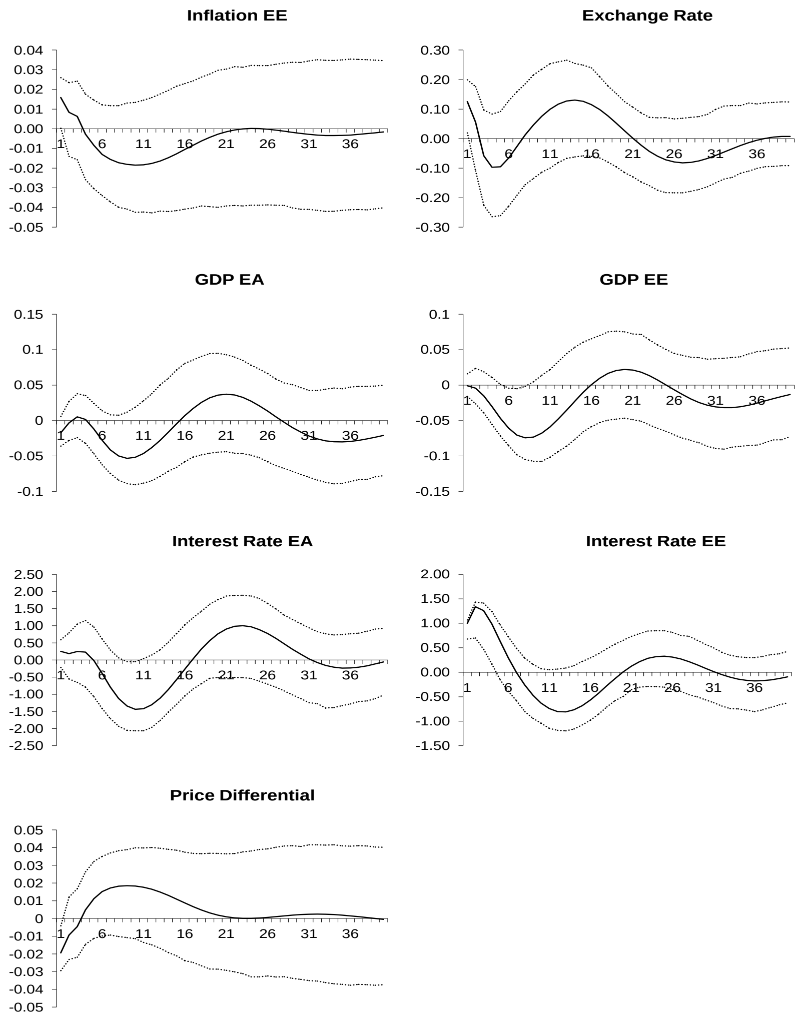

Figure 4: Generalized Impulse Responses to a 1% Shock to CEE-5 Interest Rates

4.3 Shocks to the Exchange Rate and to Relative Prices

Figure 5 shows the responses to a positive 1% shock in the exchange rate which is tantamount to an 1% appreciation of the Euro. After the immediate impact there is a further appreciation to 1.1% in the subsequent quarter.

Afterwards, the effects of the shock decay and become insignificant after six quarters. The shock to the exchange rate affects the interest rates in the Euro area as well as in Eastern Europe. While the EU-12 interest rate decreases significantly in the first four quarters by approximately 2.6%, interest rates in CEE-5 tend to increase significantly by over 1% for around three quarters. Looking at the price movements in the two economies, there is a decrease in relative prices, implying that Euro area products become less expensive relative to Eastern European products in response to an appreciation of the Euro. This is exactly what we would expect in case of constant real exchange rates as implied by the PPP. The positive effect on Eastern European inflation indicates that the more expensive imports from the EU-12 contribute to raising the price level of consumption there. Price movements partly offset the loss in competitiveness induced by a Euro appreciation, and hence real GDP in EU-12 and CEE-5 does not react significantly. Altogether this suggests that a loss in competitiveness induced by a nominal appreciation of the Euro is to a substantial extent offset by lower inflation. The dampening effect of an appreciation on inflation is, however, relatively low as compared to other studies on the exhange rate pass through in CEE (e.g. Beirne and Bijsterbosch, 2009).

Finally, we compute the responses to a positive shock in relative prices in order to gain insights about the effects of relative consumer price changes between the two economies which are shown in figure 6. A positive shock in the relative price level significantly impacts upon the relative price level itself and on Eastern European inflation. The response of the price differential shows that an initial 1% shock leads to higher Euro area prices relative to prices in Eastern Europe by 0.6-0.8% within the first year. The time pattern of the response suggests that this effect is a permanent one. The increase in the relative price level is reflected by a strong and significant negative response in Eastern European inflation. Although our model does not contain information on Euro area inflation, an increase in the relative price level could also be related to an increase in EU-12 inflationary pressure. The strong negative response of Eastern European inflation, however, suggests that a great part of the impact is associated with price movements

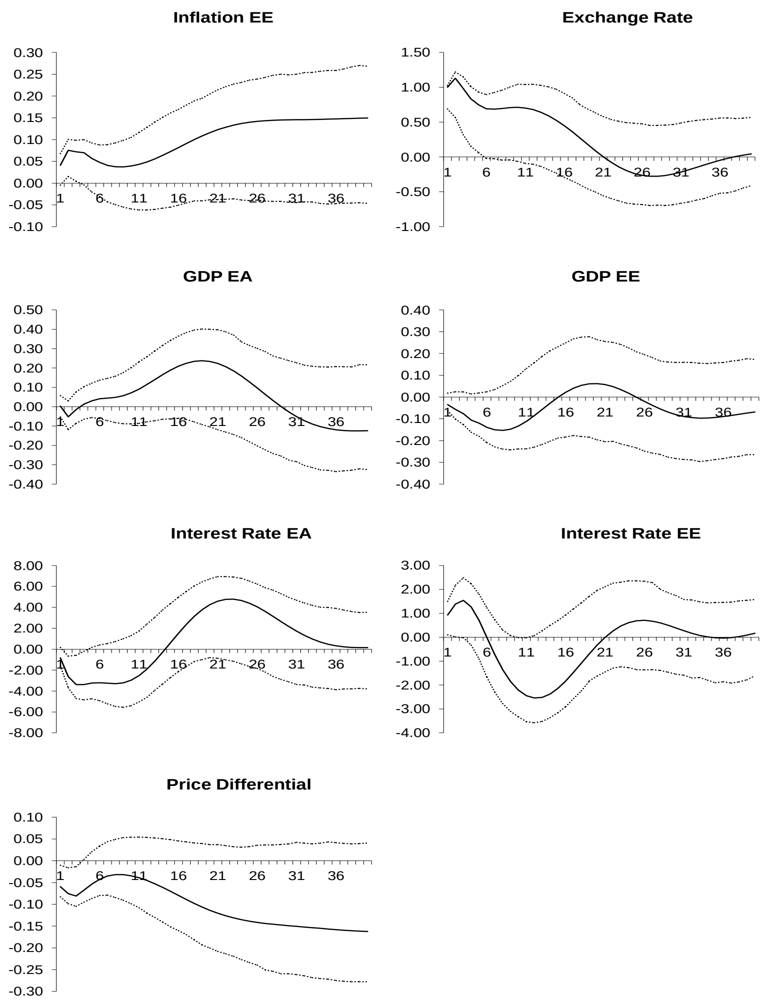

Figure 5: Generalized Impulse Responses to a 1% Shock to the Exchange Rate

there. As a consequence to lower inflation, Eastern European interest rates decline, while EU-12 interest rates increase. The former effect is significant for around four quarters, while the latter effect teeters on the edge of insignificance for around ten quarters. Besides that, we find that the exchange

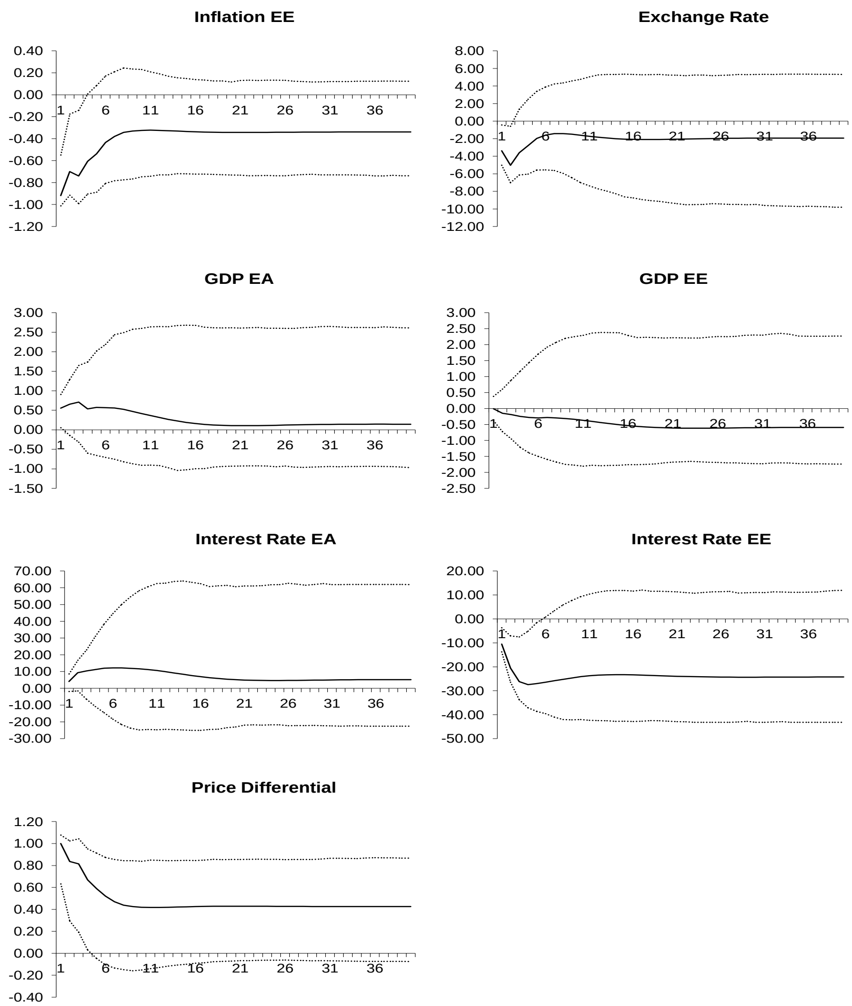

Figure 6: Generalized Impulse Responses to a 1% Shock to the Price Differential

rate again partly offsets the increase in the relative price levels because there is a significant depreciation of the Euro in response to such a shock.

4.4 Robustness Checks

When choosing the lag order in equation (20), we decided to rely on the BIC which suggests the smallest possible model, a VEC(1). As a first robustness check we therefore analyzed the results of a similar model with a lag order of two and compared the impulse responses to the ones described. They show the same directions for all kinds of shocks discussed in the previous section. Nevertheless, the results change in two respects. First, the phase-out of a one time shock shows a more oscillating pattern and second, the responses to shocks diminish very slowly. In our view, this additionally supports the choice of a smaller model, especially in light of the rather short data series available.

As discussed in subsection 3.1, directly imposing the theoretical relations might be overly tight and relaxing the structure on the cointegration space could therefore improve the estimation from a statistical point of view. Consequently, we also compute the impulse responses of the exactly identified model. There are no major changes with respect to GDP shocks originating from the EU-12. The shape and the time pattern do not change for most of the variables except for EU-12 and CEE-5 output, where the responses now show a multiplier effect that increases output above the original shock. Concerning the effects of the interest rate shock in the EU-12, the exactly identified model delivers a positive response of EU-12 output, while all the other responses stay the same as compared to the benchmark model. However, EU-12 interest rates show a stronger increase in the first quarters following the shock than in the benchmark model.

In contrast to the over-identified framework, the increase in inflation following a CEE-5 output shock is now significant. Responses do not change much for CEE-5 interest rates and the price differential and also the positive increase in the EU-12 interest rate is still there in the exactly identified case. We also find the same positive spillover effect to EU-12 output. As before, CEE-5 inflation increases and we observe a slight increase in the exchange rate in the first quarter following a shock in CEE-5 interest rates. We do not find an impact on neither EU-12 nor CEE-5 output. The EU-12 interest rate does not react significantly, even though the CEE-5 interest rate now increases stronger in response to its own shock in the second and third quarter.

With respect to shocks in the exchange rate and the price differential, the responses are very similar to the ones obtained by the over-identified model and do — if at all — only differ slightly in their shape and time pattern.

Overall, therefore, our results seem to be robust against the change in the lag order. Employing the suggested exactly identified cointegration structure instead of the over-identified model would also not change the results qualitatively.

5 Conclusions

We investigated the interrelations between initial members of the Euro area and five important Central and Eastern European economies. In so doing we made use of a structural vector error correction approach that minimizes the dependence of the final results on arbitrary modeling assumptions. The need to impose a causal recursive ordering on impulse response functions is circumvent by using generalized impulse response functions instead of the Choleski decomposition, while the need to rely on arbitrary orthogonalizations of cointegrating vectors is dealt with by using theoretically derived relationships as restrictions on the cointegration space instead of relying on the standard approach advocated by Johansen (1988) and Johansen (1991).

Model diagnoses show that there are no significant structural breaks left and that autocorrelation, heteroscedasticity and non-normality of the residuals do not seem to pose substantial problems. A bootstrapped likelihood ratio test indicated that overidentifying restrictions are overly tight. However, the resulting exactly identified model suffered from more severe problems and the results of generalized impulse response functions were therefore computed on the basis of the overidentified model for the benchmark case. However, we used the exactly identified model for robustness checks of the results. All in all, the use of a structural vector error correction model with long-run restrictions for the purpose of modeling the dynamic interactions between the two economies is supported and the impulse responses reveal a high degree of interconnectedness of Eastern Europe and the Euro area.

In general, our results show responses that confirm standard economic intuition. Output levels in EU-12 and CEE-5 respond positively to output shocks in the corresponding foreign region with the impact being similarly strong in Eastern Europe as in the Euro area. This emphasizes the importance of Eastern Europe as an extended market for the EU-12. Another important result is that we identify the presence of multiplier effects in Eastern Europe with mixed evidence for a similar effect in the Euro area. Furthermore, we find that interest rates in the Euro area show a strong response to shocks in output, no matter if domestic or foreign shocks are considered. We regard this as some evidence for the European Central Banks' desire towards price stability. The analysis of interest rate shocks shows strong responses in output of both economies when EU-12 interest rates are concerned but only weak effects on output for shocks in Eastern European interest rates. While increases in EU-12 interest rates translate into rising CEE-5 interest rates, the reverse is not the case. Finally, with respect to relative price and exchange rate shocks, we find offsetting effects that tend to prevent substantial changes in relative competitiveness.

Acknowledgments

We would like to thank Jesus Crespo Cuaresma, Julia Woerz and Stefan Humer for helpful comments and suggestions as well as Ulrike Strauß for her help in data collection.

Appendix

A Dynamic Optimization of the Representative Consumer

The Lagrangian of the consumer optimization problem reads

$$\begin{aligned} L &= \sum_{t=0}^{\infty} \beta^t \{ C_t^{\alpha} C_t^{*1-\alpha} + \lambda_t [(1+r_t)K_{t-1} + w_t L_t + \frac{1+i_t}{1+\pi_t} B_{t-1} + \\ &\quad + \frac{1+i_t^*}{1+\pi_t^*} \frac{B_{t-1}^*}{e_t} + \frac{M_{t-1}}{1+\pi_t} - C_t - \frac{P_t^*}{e_t} C_t^* - B_t \\ &\quad - \frac{B_t^*}{e_t} - K_t - M_t] + \mu_t [\frac{M_{t-1}}{1+\pi_t} - C_t - \frac{P_t^*}{e_t} C_t^*] \}. \end{aligned} \tag{23}$$

The corresponding first order conditions are

$$\frac{\partial L}{\partial C_t} \stackrel{!}{=} 0 \quad \Rightarrow \quad \beta^t [\alpha C_t^{\alpha-1} C_t^{*1-\alpha} - \lambda_t - \mu_t] = 0, \tag{24}$$

$$\frac{\partial L}{\partial C_t^*} \stackrel{!}{=} 0 \quad \Rightarrow \quad \beta^t [C_t^{\alpha}(1-\alpha) C_t^{*(-\alpha)} - \lambda_t \frac{P_t^*}{e_t} - \mu_t \frac{P_t^*}{e_t}] = 0, \tag{25}$$

$$\frac{\partial L}{\partial M_t} \stackrel{!}{=} 0 \quad \Rightarrow \quad \beta^{t+1} \left[\frac{\lambda_{t+1}}{1+\pi_{t+1}} + \frac{\mu_{t+1}}{1+\pi_{t+1}} \right] - \beta^t \lambda_t = 0, \tag{26}$$

$$\frac{\partial L}{\partial K_t} \stackrel{!}{=} 0 \quad \Rightarrow \quad \beta^{t+1} \lambda_{t+1} (1+r_{t+1}) - \beta^t \lambda_t = 0, \tag{27}$$

$$\frac{\partial L}{\partial B_t} \stackrel{!}{=} 0 \quad \Rightarrow \quad \beta^{t+1} \lambda_{t+1} \frac{1+i_{t+1}}{1+\pi_{t+1}} - \beta^t \lambda_t = 0, \tag{28}$$

$$\frac{\partial L}{\partial B_t^*} \stackrel{!}{=} 0 \quad \Rightarrow \quad \beta^{t+1} \lambda_{t+1} \frac{1+i_{t+1}^*}{1+\pi_{t+1}^*} \frac{1}{e_{t+1}} - \beta^t \frac{\lambda_t}{e_t} = 0. \tag{29}$$

Equations (27) and (28) lead to

$$1 + r_t = \frac{1+i_t}{1+\pi_t} \tag{30}$$

which is the Fisher Inflation Parity (FIP). Equations (28) and (29) lead to

$$\frac{1+i_t}{1+\pi_t} = \frac{1+i_t^*}{1+\pi_t^*} \frac{e_{t-1}}{e_t} \tag{31}$$

which is the Interest Rate Parity (IRP). The first order conditions for consumption yield

$$C_t = \frac{\alpha}{1-\alpha}\frac{P_t^*}{e_t}C_t^*. \tag{32}$$

Plugging the expressions for C_t and C_t^* into the budget constraint and utilizing the following definitions

$$\begin{aligned} S_t &= S_t(r_t, i_t, i_t^*, \pi_t, \pi_t^*) \\ &= B_t + \frac{B_t^*}{e_t} + M_t + K_t, \end{aligned} \tag{33}$$

$$\begin{aligned} I_t &= I_t(r_t, i_t, i_t^*, \pi_t, \pi_t^*) \\ &= w_t L_t + (1+r_t)K_{t-1} + \frac{M_{t-1}}{1+\pi_t} + \frac{1+i_t}{1+\pi_t}B_{t-1} \\ &\quad + \frac{1+i_t^*}{1+\pi_t^*}\frac{B_{t-1}^*}{e_t}, \end{aligned} \tag{34}$$

where S_t denotes a household's savings and I_t refers to its income, yields demand for goods produced at home and abroad

$$C_t = \alpha(I_t - S_t), \tag{35}$$

$$C_t^* = (1-\alpha)\frac{I_t - S_t}{P_t^*}. \tag{36}$$

These equations imply that a share α of household's income net of savings is spent on the domestically produced aggregate, whereas a fraction $1-\alpha$ is spent on the aggregate produced abroad. Since preferences of households in the two economies are symmetric, the consumer price indices in both countries are weighted averages of the price levels for the goods produced at home and abroad with α and $(1-\alpha)/e_t$ representing the weights at home and $e_t\alpha$ and $1-\alpha$ representing the weights abroad. Therefore

$$\begin{aligned} CPI_t &= \alpha + (1-\alpha)\frac{P_t^*}{e_t} \\ CPI_t^* &= e_t\alpha + (1-\alpha)P_t^* \end{aligned}$$

holds, where CPI_t and CPI_t^* denote the consumer price indices in the domestic and foreign economy, respectively. Consequently,

$$CPI_t = \frac{CPI_t^*}{e_t} \tag{37}$$

has to be fulfilled. This equation represents the Purchasing Power Parity (PPP) relationship.

B Data

We employ aggregate quarterly data for the EU-12 countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Luxembourg, the Netherlands, Italy, Portugal and Spain) and the CEE-5 countries (Czech Republic, Hungary, Poland, Slovakia and Slovenia) from 1995 to 2009. We use the following definitions

y_t: Logarithm of real GDP per capita index of EU-12

y_t^*: Logarithm of real GDP per capita index of CEE-5

i_t: Logarithm of nominal 3 month money market interest rate index of EU-12

i_t^*: Logarithm of nominal 3 month money market interest rate index of CEE-5

p_t^*: Logarithm of CEE-5 Consumer Price Index (CPI)

$p_t - p_t^*$: Price differential between EU-12 and CEE-5 in terms of CPIs

e_t: Logarithm of the nominal exchange rate index between EU-12 and CEE-5

P_t^o: Logarithm of the Brent spot price index of crude oil

where the base of indices is the first quarter of 1995 and we used the relative size of a countries' GDP to calculate the quarterly weight when we had to construct an aggregate series out of individual countries' data series. For the exchange rate we used weighted percentage changes of national currencies as compared to the Euro in order to construct an index of an artificial currency for the CEE-5 countries. Most of the data stem from Eurostat, except of the CPI, where we collected data from the International Financial Statistics of the IMF, and the Brent spot price of crude oil which was gathered from the Energy Information Administration.

Unit root tests in general suggest treating all variables as integrated of order one ($I(1)$), except CEE-5 consumer prices which are indicated to be integrated of order two ($I(2)$). This means that CEE-5 inflation is $I(1)$ and can hence be used in the vector error correction part of our model together with all the other data which is also $I(1)$. Since unit root tests did not find any indication of EU-12 inflation to be $I(1)$, we were not able to use this variable in the z_t vector and hence changed the theoretically suggested FIP relationship to hold in Eastern Europe instead of the Euro area. Additional more detailed information with regards to the data series we use and the results of the unit root tests are available from the authors upon request.

C Tables

Table 1: Lag order selection

	AIC	BIC
2 LAGS	-43.15478	-39.42466
3 LAGS	-43.17237	-37.65255
4 LAGS	-44.08962	-36.74772
5 LAGS	-44.69158	-35.49434

Table 2: Portmanteau Test on Autocorrelation

LAG	$\Delta(Y_{EA})$	$\Delta(I_{EA})$	$\Delta(P_{EE})$	$\Delta(I_{EE})$	$\Delta(PD)$	$\Delta(E)$	$\Delta(Y_{EE})$
1	0.445	0.025	0.431	0.542	0.981	0.32	0.438
2	0.741	0.064	0.095	0.785	0.54	0.317	0.545
3	0.67	0.131	0.195	0.882	0.581	0.425	0.135
4	0.794	0.116	0.108	0.738	0.201	0.166	0.06
5	0.868	0.028	0.157	0.357	0.278	0.256	0.045
6	0.826	0.047	0.209	0.231	0.351	0.365	0.054
7	0.889	0.074	0.226	0.307	0.444	0.381	0.076
8	0.509	0.111	0.305	0.353	0.536	0.414	0.103
9	0.435	0.135	0.388	0.376	0.625	0.387	0.14
10	0.41	0.189	0.444	0.411	0.684	0.479	0.185
11	0.262	0.215	0.436	0.499	0.762	0.472	0.246
12	0.296	0.271	0.345	0.542	0.731	0.481	0.316
13	0.41	0.308	0.141	0.553	0.614	0.378	0.354
14	0.262	0.363	0.186	0.631	0.687	0.449	0.418
15	0.296	0.353	0.223	0.628	0.739	0.318	0.402

Table 3: Model Fit, Normality Test and White Test

	$\Delta(Y_{EA})$	$\Delta(I_{EA})$	$\Delta(P_{EE})$	$\Delta(I_{EE})$	$\Delta(PD)$	$\Delta(E)$	$\Delta(Y_{EE})$
$\bar{R}^2$	0.496007	0.686718	0.202989	0.369729	0.113996	0.387678	0.474091
Jarque-Bera	0.1656	0.3671	0.0943	0.2196	0.0459	0.0677	0.1791
White	0.1948	0.019	0.136	0.466	0.0603	0.0797	0.2243

References

Arghyroua, M. G., Gregorioub, A., and Kontonikasc, A. (2009). Do real interest rates converge? Evidence from the European Union. *Journal of International Financial Markets, Institutions and Money*, Vol. 3:447–460.

Barigozzi, M., Conti, A. M., and Luciani, M. (2011). Measuring Euro Area Monetary Policy Transmission in a Structural Dynamic Factor Model. European Economy. Economic Papers. 441.

Barro, R. J. and Sala-i-Martin, X. S. (2004). *Economic Growth*. The MIT Press. Cambridge, Mass.

Beirne, J. and Bijsterbosch, M. (2009). Exchange Rate Pass-through in Central and Eastern European Member States. European Central Bank. Working Paper Series No. 1120.

Benkovskis, K., Bessonovs, A., Feldkircher, M., and Wörz, J. (2011). The Transmission of Euro Area Monetary Shocks to the Czech Republic, Poland and Hungary: Evidence from a FAVAR Model. *Focus on the European Economic Integration*, pages 8–36.

Blanchard, O. J. (2003). *Macroeconomics*. Prentice Hall. Upper Saddle River, NJ.

Boivin, J., Giannoni, M. P., and Mojon, B. (2009). How Has the Euro Changed the Monetary Transmission Mechanism? In Daron Acemoglu, K. R. and Woodford, M., editors, *NBER Macroeconomics Annual 2008, Volume 23*. University of Chicago Press.

Breuss, F. (2001). Macroeconomic effects of EU enlargement for old and new members. WIFO Working Papers 143.

Cecioni, M. and Neri, S. (2011). The monetary transmission mechanism in the euro area: has it changed and why? Working Papers Banca D'Italia.

Christoffel, K., Coenen, G., and Warne, A. (2008). The new Area-Wide Model of the euro area: a micro-founded open-economy model for forecasting and policy analysis. European Central Bank. Working Paper Series No. 944.

Clower, R. (1967). A reconsideration of the microfoundations of monetary theory. *Western Economic Journal*, Vol. 6:1–9.

Creel, J. and Levasseur, S. (2005). Monetary Policy Transmission in the CEECs: How Important are the Differences with the Euro Area. OFCE Working Paper No 2.

Crespo Cuaresma, J., Eller, M., and Mehrotra, A. (2011). The Economic Transmission of Fiscal Policy Shocks from Western to Eastern Europe. *Focus on the European Economic Integration*, pages 44–68.

Cuestas, J. C. (2009). Purchasing power parity in central and eastern european countries: an analysis of unit roots and nonlinearities. *Applied Economics Letters*, Vol. 16(No. 1):87–94.

Darvas, Z. (2006). Monetary Transmission in the New EU Member States: Evidence from Time-Varying Coefficient Vector Autoregression. *Focus on European Economic Integration*, pages 140–157.

Égert, B., Crespo-Cuaresma, J., and Reininger, T. (2006). Interest Rate Pass-Through in Central and Eastern Europe: Reborn from Ashes Merely to Pass Away? William Davidson Institute Working Paper Number 851.

Égert, B. and MacDonald, R. (2008). Monetary Transmission Mechanism in Central and Eastern Europe: Surveying the Surveyable. OECD Economics Department Working Papers no. 654.

European Central Bank (2010). Monetary policy transmission in the euro area, a decade after the introduction of the euro.

European Commission (2008). Employment in Europe 2008. Report of the European Commission. Directorate-General for Employment, Social Affairs and Equal Opportunities.

Gaggl, P., Kaniovski, S., Prettner, K., and Url, T. (2009). The short and long-run interdependencies between the Eurozone and the USA. *Empirica*, Vol. 36(No. 2):209–227.

Garratt, A., Lee, K., Pesaran, M. H., and Shin, Y. (1999). A structural cointegrating VAR approach to macroeconometric modelling. available on: http://www.econ.cam.ac.uk/faculty/pesaran/ni99.pdf.

Garratt, A., Lee, K., Pesaran, M. H., and Shin, Y. (2003). A long run structural macroeconometric model of the UK. *Economic Journal*, Vol. 113(No. 487):412–455.

Garratt, A., Lee, K., Pesaran, M. H., and Shin, Y. (2006). *Global and National Macroeconometric Modelling: A Long-Run Structural Approach*. Oxford University Press. New York.

Jiménez-Rodriguez, R., Morales-Zumaquero, A., and Égert, B. (2010). The VARying Effect of Foreign Shocks in Central and Eastern Europe. CESifo Working Paper No. 3080.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, Vol. 12:231–254.

Johansen, S. (1991). Estimation and hypothesis testing of cointegrating vectors in Gaussian vector autoregressive models. *Econometrica*, Vol. 59:1551–1580.

Koop, G., Pesaran, H., and Potter, M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, Vol. 74:119–147.

Matkowski, Z. and Próchniak, M. (2007). Economic Convergence Between the CEE-8 and the European Union. *Eastern European Economics*, Vol. 45(No. 1).

Parente, S. T. and Prescott, E. C. (1994). Barriers to technology adoption and development. *The Journal of Political Economy*, Vol. 102(No. 2):298–321.

Passamani, G. (2008). The process of convergence towards the euro for the Visegrad-4 countries. University of Trento, Department of Economics Working Papers 0825.

Peersman, G. and Smets, F. (2001). The Monetary Transmission Mechanism in the Euro Area: More Evidence from VAR Analysis. Working Paper No. 91.

Pesaran, M. H. and Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. *Economic Letters*, Vol. 58(No. 1):17–29.

Prettner, K. and Kunst, R. M. (2011). The Dynamic Interrelations between Unequal Neighbors: An Austro-German Case Study. *Empirical Economics*. forthcoming.

van Els, P., Locarno, A., Mojon, B., and Morgan, J. (2003). New macroeconomic evidence on monetary policy transmission in the euro area. *Journal of the European Economic Association*, Vol. 1:720–730.

Weber, A. A., Gerke, R., and Worms, A. (2009). Has the monetary transmission process in the euro area changed? Evidence based on VAR estimates. Working Papers No. 276.

Table 4: Reduced form error correction specification for the benchmark model

	$\Delta(Y^{EA})$	$\Delta(I^{EA})$	$\Delta(\Delta P^{EE})$	$\Delta(I^{EE})$	$\Delta(PD)$	$\Delta(E)$	$\Delta(Y^{EE})$
CE1	0.0218	0.0981	0.0146	0.3715	-0.0142	-0.0997	-0.0250
	-0.0189	-0.2933	-0.0133	-0.2392	-0.0125	-0.0880	-0.0169
	[1.1527]	[0.3346]	[1.0997]	[1.5531]	[-1.1340]	[-1.1333]	[-1.4747]
CE2	-0.0060	-0.1662	0.0000	-0.0881	0.0003	-0.0389	-0.0171
	-0.0049	-0.0763	-0.0035	-0.0623	-0.0033	-0.0229	-0.0044
	[-1.2241]	[-2.1764]	[0.0020]	[-1.4160]	[0.1002]	[-1.6988]	[-3.8905]
CE3	-0.0048	-0.0146	0.0045	0.1029	-0.0045	-0.0073	-0.0041
	-0.0031	-0.0484	-0.0022	-0.0394	-0.0021	-0.0145	-0.0028
	[-1.5388]	[-0.30090]	[2.0695]	[2.6086]	[-2.1709]	[-0.5042]	[-1.4721]
CE4	-0.0336	-0.1978	-0.0182	-2.0503	0.0224	-0.2823	0.0026
	-0.0548	-0.8507	-0.0385	-0.6936	-0.0363	-0.2552	-0.0491
	[-0.6128]	[-0.2326]	[-0.4715]	[-2.9559]	[0.6168]	[-1.1062]	[0.0537]
$\Delta(Y^{EA}_{t-1})$	-0.1918	3.5291	0.1882	0.2323	-0.0727	-0.0268	0.1266
	-0.1472	-2.2848	-0.1035	-1.8630	-0.0975	-0.6854	-0.1319
	[-1.3032]	[1.5446]	[1.8188]	[0.1247]	[-0.7451]	[-0.0391]	[0.9599]
$\Delta(IR^{EA}_{t-1})$	0.0001	0.2602	-0.0090	-0.0063	0.0079	0.0388	0.0014
	-0.0083	-0.1285	-0.0058	-0.1048	-0.0055	-0.0385	-0.0074
	[0.0089]	[2.02524	[-1.5422]	[-0.0598]	[1.4427]	[1.0059]	[0.1875]
$\Delta(P^{EE}_{t-1})$	0.1823	5.3970	-0.2644	1.5839	-0.1967	-0.2190	0.7733
	-0.2853	-4.4296	-0.2006	-3.6119	-0.1891	-1.3289	-0.2557
	[0.6388]	[1.2184]	[-1.3180]	[0.4385]	[-1.0403]	[-0.1648]	[3.0245]
$\Delta(IR^{EE}_{t-1})$	0.0225	0.3096	-0.0005	0.4099	0.0039	-0.1066	0.0162
	-0.0123	-0.1907	-0.0086	-0.1555	-0.0081	-0.0572	-0.0110
	[1.8285]	[1.6235]	[-0.0545]	[2.6355]	[0.4730]	[-1.8636]	[1.4747]
$\Delta(PD_{t-1})$	0.2883	6.5954	0.0094	-0.8120	-0.4095	-2.2154	0.7583
	-0.3262	-5.0636	-0.2294	-4.1289	-0.2161	-1.5191	-0.2923
	[0.8839]	[1.3025]	[0.0411]	[-0.1967]	[-1.8948]	[-1.4584]	[2.5943]
$\Delta(E_{t-1})$	-0.0731	-1.5575	0.0354	-0.1436	-0.0302	0.1899	0.0090
	-0.0308	-0.4775	-0.0216	-0.3894	-0.0204	-0.1433	-0.0276
	[-2.3749]	[-3.2617]	[1.6361]	[-0.3688]	[-1.4833]	[1.3252]	[0.3256]
$\Delta(Y^{EE}_{t-1})$	0.4443	3.0881	0.0709	-2.7285	-0.1602	-2.1409	0.0147
	-0.1786	-2.7730	-0.1256	-2.2611	-0.1184	-0.8319	-0.1601
	[2.4872]	[1.1136]	[0.5642]	[-1.2067]	[-1.3537]	[-2.5735]	[0.0919]
$\bar{R}^2$	0.496007	0.686718	0.202989	0.369729	0.113996	0.387678	0.474091