

Prettner, Catherine; Prettner, Klaus

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How Interdependent are Eastern European Economies and the Euro Area?

Catherine Prettnner, Klaus Prettnner

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

How Interdependent are Eastern European Economies and the Euro Area?

Catherine Prettner^a and Klaus Prettner^b

a) WU, Vienna University of Economics and Business

Department of Economics

Augasse 2-6

A-1090, Vienna, Austria

email: catherine.prettner@wu.ac.at

b) University of Göttingen

Platz der Göttinger Sieben 3

37073 Göttingen, Germany

email: klaus.prettner@wiwi.uni-goettingen.de

phone: +49 551 39 10617

Corresponding author

Abstract

This article investigates the interrelations between the Euro area and five Central and Eastern European economies. Using an open economy framework, we derive theoretical restrictions to be imposed on the cointegration space of a structural vector error correction model. We employ generalized impulse response analysis to assess the effects of shocks in output, interest rates, the exchange rate, and relative prices on both areas. The results show strong international spillovers in output with the magnitude being similarly strong in both areas. Furthermore, we find multiplier effects in Central and Eastern Europe and some evidence for the European Central Bank's desire toward price stability.

JEL classification: C11, C32, F41

Keywords: European Economic Integration, Structural Vector Error Correction Model, Generalized Impulse Response Analysis, International Transmission of Shocks

1 Introduction

Since the fall of the Iron Curtain, there has been a remarkable pace at which integration between Western Europe and Eastern Europe 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, six of these countries even managed to adopt the Euro as their single currency.

The process of economic integration unfolded in several areas: While the Central and Eastern European (CEE) countries predominantly benefited from high Western FDI inflows and the prospect of EU accession, the old EU-15 member states gained by having access to new unsaturated markets (see for example Breuss, 2001; Matkowski and Próchniak, 2007). At the same time, barriers to labor mobility between the EU-15 and the CEE countries were continuously removed (European Commission, 2008) and several agreements have achieved the elimination of trade barriers with a positive impact on economic growth and welfare in both regions (Egger and Larch, 2011). Furthermore, increased international fragmentation of production due to outsourcing and offshoring of firms located in old EU member countries to low-wage new member states is widely seen to have enhanced the international competitiveness of EU firms (Guerrieri and Caffarelli, 2012).

The global economic and financial crisis has demonstrated that the increased interconnectedness of European economies, besides all advantages, also bears risks — especially the risk of contagion during recessions. While the presence of foreign-owned banks through FDI is often seen to have mitigated the adverse impact of the crisis in the CEE countries (see Berglöf et al., 2010), a high degree of trade openness passed on the drop in industry production in the old EU member states to the CEE countries (Keppel and Wörz, 2010).

Despite all these interrelations, the macroeconomic interdependencies between the EU-15 and the new CEE member states have not been thoroughly investigated in the literature, which is mainly due to a lack of sufficiently accurate data and the unsatisfactorily short coverage of time series (Benkovskis et al., 2011). It is, however, of utmost importance to have accurate tools at hand to assess the economic implications of international shocks in an increasingly interdependent Europe (see also EBRD, 2012; IMF, 2012, for a discussion). We attempt to contribute by outlining an appropriate framework for investigating the interrelations between the 12 initial member countries of the Euro area and the five Eastern European countries Czech Republic, Hungary, Poland, Slovakia, and Slovenia (henceforth CEE-5). In so doing we make use of aggregate Euro area data for GDP, interest rates, and prices and construct a corresponding data file for the

CEE-5 that additionally contains a price differential variable and an exchange rate between the Euro and the artificially calculated aggregate currency of the CEE-5.¹ We use this dataset to analyze the effects of shocks in output and in interest rates on the corresponding other region as well as the effects of shocks in the exchange rate and in relative prices on both regions. As a robustness check, we repeat our analysis for the largest economies of our CEE-5 aggregate — The Czech Republic, Hungary, and Poland — separately.

The methodology we rely on is based upon a series of papers (Pesaran and Shin, 1998; Garratt et al., 1999, 2003, 2006), in which 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 advantages of this model class over other approaches like vector autoregressive models (VARs), structural vector autoregressive models (SVARs) and standard vector error correction models (VECs) are that theoretically derived long-run relationships — which are deemed to be more credible than theoretically derived 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 assumptions and modeling choices.

Currently, to the best of our knowledge, there exists no paper that applies a similar modeling strategy like Garratt et al. (2006) to the CEE region.² The contribution of our paper is therefore twofold: First, we construct a dataset for the CEE-5 that is suited to study the interrelations between these economies and the Euro area and second, we use state-of-the-art econometric techniques to minimize the effects of arbitrary assumptions and modeling choices.

Our paper proceeds as follows: Section 2 discusses the related literature, Section 3 is devoted to a description of the underlying theoretical framework, Section 4 describes and assesses our econometric specification, in Section 5 we present the results and our robustness checks, and Section 6 concludes.

2 Related Literature

The monetary transmission mechanism in CEE countries and the business-cycle correlation between the CEE economies and the Euro area have been studied extensively (see Fidrmuc and Korhonen, 2006; Égert et al., 2007; Égert and MacDonald, 2009, for surveys regarding the business-cycle correlation, the interest rate pass-through, and the monetary transmission mechanism in CEE, respectively). However, only a few papers consider the dynamic effects of foreign shocks on CEE economies.

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

²One study worth mentioning in this context is Passamani (2008), who set up a structural cointegrated VAR model for the Czech Republic, Hungary, Poland, and Slovakia, with the Euro area as foreign region. However, they do not consider the effects of international shocks, which is the focus of our work.

Jiménez-Rodríguez et al. (2010) assess 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. The analysis shows that a shock in the foreign interest rate leads to a fall in industrial production in all ten CEE countries and to a fall in prices in most of them. Moreover, an increase in foreign industrial production triggers an increase in domestic industrial production and a real appreciation of domestic currencies. The CEE countries show a high degree of homogeneity, indicating a good pre-condition 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. 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 a fiscal expansion in Germany triggers expansionary fiscal policy measures in all five CEE countries. Most recently, Backé et al. (2013) and Feldkircher (2013) have contributed substantially toward the understanding of the spillover effects of output and interest rate shocks to the CEE countries by employing a global VAR (GVAR) model. They find evidence for positive output spillover effects and negative interest rate effects from Western Europe to the CEE countries.

This short overview indicates that the existing empirical work is either based on time-series applications without theoretical foundations or otherwise shocks are identified via theoretical *short*-run restrictions. Garratt et al. (2006) argue that this strategy has the disadvantage that there is not much consensus among economists on short-run economic theory implying that identifying restrictions based on these theories are incredible. Instead, they advocate to use long-run economic theory for identifying restrictions to be imposed on the cointegration space of a SVECM. There are two recent contributions based upon the insights of Garratt et al. (2006) which analyze the effects of shocks between two economic areas: Gaggi 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 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, Prettnner

and Kunst (2012) modify the framework of Garratt et al. (2006) to account for the high degree of labor market integration of these two countries. Their analysis shows that economic shocks in Germany have significant and sizable impacts on the Austrian economy, while corresponding shocks to Austrian variables affect the German economy to a much lesser extend. To the best of our knowledge, there exists no paper that applies a similar modeling strategy like Garratt et al. (2006) to the CEE region. We aim to fill this gap and thereby complement the work of Backé et al. (2013) and Feldkircher (2013) to enhance our knowledge on the transmission of shocks between the Euro area and the CEE countries.

3 The Theoretical Model

In this section we derive restrictions on the cointegration space of the SVECM. In so doing we generalize the model used by Prettner and Kunst (2012) to allow for two different currencies in the two economic areas under investigation.

3.1 Consumption Side

Assume that there are two economies, each of which is populated by a representative household who chooses sequences of consumption goods produced at home and abroad to maximize its discounted stream of lifetime utility

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

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. 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 ensuring that its expenditures and savings in period t do not exceed its income. Furthermore, households are subject to a cash-in-advance constraint in the spirit of Clower (1967) such that individuals are only allowed to buy consumption goods with money and not with wealth that is invested in capital or bonds. The two constraints of the household can be written as

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

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

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 (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 government 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 implying that the cash-in-advance constraint is binding. Altogether, this leads to the following results of the dynamic optimization problem

$$CPI_t = \frac{CPI_t^*}{e_t}, \quad (4)$$

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

$$1 + r_t = \frac{1 + i_t}{1 + \pi_t}, \quad (6)$$

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 real return on investment between home and foreign bonds. The third equation represents the Fisher Inflation Parity (FIP), stating that investments in government bonds and in physical capital should deliver the same real return.

3.2 Production Side

The production side of the two economies closely follows Prettner and Kunst (2012) who build their description upon Garratt et al. (2006) and Barro and Sala-i-Martin (2004). Output at home is produced according to

$$Y_t = A_t L_t f(k_t), \quad (7)$$

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 a fraction δ of the total population N_t such that $L_t = \delta N_t$. Consequently, the unemployment rate is equal to $1 - \delta$. Furthermore, we assume that there are technology adoption barriers (cf. Parente and Prescott, 1994) such that

$$\eta A_t = \theta A_t^* = \bar{A}_t, \quad (8)$$

where \bar{A}_t is the technological level in the rest of the world and $1 > \eta > 0$ and $1 > \theta > 0$ measure incompleteness in technology adoption and diffusion between the rest of the world and the two economies under consideration. Putting things together and dividing domestic by foreign output gives

$$\frac{y_t}{y_t^*} = \frac{\theta \delta}{\eta \delta^*} \frac{f(k_t)}{f(k_t^*)}, \quad (9)$$

where y_t denotes per capita output. Equation (9) describes an output gap (OG) relation in the sense that long-run 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.

3.3 Stochastic Representations of the Restrictions

Taking logarithms of Equations (4), (5), (6), and (9) and rearranging yields

$$\log(CPI_t) = \log(CPI_t^*) - \log(e_t), \quad (10)$$

$$\log(1 + i_t) - \log(1 + i_t^*) = \log(1 + \pi_t) - \log(1 + \pi_t^*) + \log(e_{t-1}) - \log(e_t) \quad (11)$$

$$\log(1 + i_t) - \log(1 + \pi_t) = \log(1 + r_t), \quad (12)$$

$$\log(y_t) - \log(y_t^*) = \log[f(k_t)] + \log(\theta) + \log(\delta) - \log[f(k_t^*)] - \log(\eta) - \log(\delta^*), \quad (13)$$

which are deterministic relationships holding in a long-run equilibrium. In the short run — during adjustment processes — 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). Consequently, the stochastic counterparts to Equations (10), (11), (12), and (13) in terms of the endogenous

variables of the SVECM as described in Appendix B read

$$p_t - p_t^* + e_t = b_{1,0} + \epsilon_{1,t+1}, \quad (14)$$

$$i_t - \Delta p_t = b_{2,0} + \epsilon_{2,t+1}, \quad (15)$$

$$i_t - i_t^* = b_{3,0} + \epsilon_{3,t+1}, \quad (16)$$

$$y_t - y_t^* = b_{4,0} + \epsilon_{4,t+1}, \quad (17)$$

where p_t and p_t^* denote the logarithm of home and foreign consumer price indices, e_t refers to the logarithm of the exchange rate index, i_t and i_t^* represent the logarithm of home and foreign nominal interest rate indices, and y_t and y_t^* refer to the logarithm of home and foreign output indices. The theoretical considerations of Section 3 imply that the estimates of $b_{1,0}$ and $b_{2,0}$ should 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 interregional differences in the logarithm of the structural determinants of the output gap (technology, capital, and labor-force participation).

4 Econometric Implementation

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

$$A \Delta z_t = \tilde{a} + \tilde{b}t - \tilde{\Pi}z_{t-1} + \sum_{i=1}^{p-1} \tilde{\Gamma}_i \Delta z_{t-i} + \tilde{u}_t, \quad (18)$$

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). To obtain the reduced form, Equation (18) has to be premultiplied by A^{-1} such that

$$\Delta z_t = a + bt - \Pi z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + u_t, \quad (19)$$

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 cointegrated and deviations from these stationary linear combinations can be interpreted 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 toward the 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 orthogonalizing the cointegrating vectors by setting the j th entry in the j th column vector of β to one and the other first $r-1$ entries to zero. This approach, however, does not provide a clear economic interpretation. Consequently, we will instead follow Garratt et al. (2006) and use the theoretical restrictions derived in Section 3 for identification of the cointegrating relations.

The data that we use are described in Appendix B. The vector of endogenous variables is $z_t' = [y_t, i_t, \Delta p_t^*, i_t^*, (p_t - p_t^*), e_t, y_t^*]$ with p_t and p_t^* denoting the logarithm of home and foreign consumer price indices, e_t referring to the logarithm of the exchange rate index, i_t and i_t^* representing the logarithm of home and foreign nominal interest rate indices, and y_t and y_t^* denoting the logarithm of home and foreign output indices. This implies that Δp_t^* refers to foreign inflation and $p_t - p_t^*$ to the price differential.³ Our particular reduced form model can therefore be written as

$$\Delta z_t = a - \alpha\beta'z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \Psi \Delta P_t^o + \epsilon_t, \quad (20)$$

where we allow the logarithm of the oil price index P_t^o to be an exogenous variable that affects the endogenous variables contemporaneously, and Ψ_i represents the vector of the associated coefficients. Furthermore, the overidentifying matrix β'_{oi} is given by Equations (14), (15), (16), and (17) as

$$\beta'_{\text{oi}} = \begin{pmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & -1 \end{pmatrix}. \quad (21)$$

The first row of this matrix refers to the PPP, the second row to the foreign FIP, the third row to the IRP

³Note that we use foreign inflation because the results of unit root tests indicated that Euro area inflation is $I(0)$, which rules out to include this series in the SVECM. Consequently, we implement the CEE-5 FIP relationship instead of the Euro area FIP relationship as a restriction on the cointegration space.

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 including a time trend in the cointegrating relations is to account for the convergence process of the CEE economies to the Euro area (see for example Égert et al., 2007; Matkowski and Próchniak, 2007).⁴

We base the choice regarding the lag order on the Bayesian Information Criterion (BIC) of VAR models in levels and 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 trace test on the number of cointegrating relations is therefore based on a VAR(2) model. The results are displayed in Table 2 in Appendix C and suggest the presence of four such relations which coincides with our theoretical considerations. The residual analyses carried out after the estimation of a corresponding SVECM are summarized in Tables 3 and 4 in Appendix C and show that there are no serious problems regarding non-normality of the residuals, autocorrelation, and heteroscedasticity in such a specification.⁵ Furthermore, the results of a CUSUM test, which are available upon request, do not indicate the presence of structural breaks. Despite the satisfying performance of the model in these tests, we carry out robustness checks with regard to alternative model specifications in Subsection 5.4. In this subsection we also discuss the results of the model estimated for the Czech Republic, Hungary, and Poland separately, instead of using the aggregate CEE-5 series. The tests for autocorrelation, normality of the residuals, and for structural breaks with respect to each of the countries indicate that the model works well also for the non-aggregated data series. We do not face substantial problems regarding autocorrelation or structural breaks neither for Hungary, nor for the Czech Republic, nor for Poland. The results of the error correction specification of the baseline model are presented in Table 5 in Appendix C.

Imposing all four relations derived in Section 3 on the cointegration space results in 28 restrictions on

⁴It is well known that the uncovered interest parity is hard to establish empirically. There are, however, a couple of studies that find support this theoretical predication [see e.g. Lee (2011) for a recent empirical investigation of a large set of developing and developed countries or Chinn (2006) for a review of the literature on the UIP in the long horizon in emerging markets]. Similarly, the PPP or the law of one price is a straightforward theoretical concept but empirical studies yield conflicting results (see Taylor, 2003, for a critical review of the literature). A recent study by He et al. (2013) investigates the validity of the PPP for seven Eastern European economies and Russia and finds that the PPP holds between most of these countries.

⁵The 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 homoscedasticity for all equations except the one referring to the Euro area's interest rate. The potential non-normality of the residuals for the price differential equation and the potential heteroscedasticity in the residuals of the equation for the Euro area's interest rate are both not problematic because parameter estimates are still unbiased and consistent. Furthermore, since we use a bootstrapping procedure to calculate the generalized impulse response functions, biased estimates for standard errors are less of a concern.

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 the matrix β , where we allow for partial adjustment and lift some of the zero restrictions following Garratt et al. (2006).⁶ However, the use of an exactly identified matrix comes with several disadvantages. First, residual analysis indicates the presence of autocorrelation in case of the exactly identified model, which leads to biased and inconsistent parameter estimates. Second, the precision of the estimates declines because the implementation of an exactly identified version implies the estimation of 12 additional parameters. Third, besides of introducing a discrepancy between the theoretical model and the empirical implementation, the application of any exactly identified matrix is an arbitrary choice. Consequently, we opt for incorporating the matrix that imposes the theoretical relations from Section 3 as baseline specification and to use the results 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 differ substantially (see Section 5.4).

5 The Dynamic Effects of International Shocks

In this section, we follow Koop et al. (1996) and Pesaran and Shin (1998) and 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 use of GIRFs circumvents the need for applying the Choleski decomposition and hence reduces the dependence of the results on the arbitrary ordering of endogenous variables in the z_t vector.

5.1 Shocks to the Euro Area

We start with the responses to a 1 percent shock in Euro area GDP, for which the results are shown in Figure 1. Note that the solid line refers to the point estimate of the GIRF in levels, while the dashed lines refer to 95 percent confidence intervals obtained by 2000 replications of a non-parametric bootstrapping procedure with replacement. The GIRF 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 that also include the 1970s and 1980s (e.g. Gaggl et al., 2009), we do not observe a multiplier effect in the Euro area. In response to the positive shock in output, the interest rate in the

⁶In particular, we lift the zero restrictions on $\beta_{12}, \beta_{13}, \beta_{14}, \beta_{27}, \beta_{36}, \beta_{42}, \beta_{45}, \beta_{46}, \beta_{47}$.

Euro area increases slightly, but the effect is not significant at the 5 percent level except between quarters eight and eleven after the shock. The shock in Euro area GDP not only has an impact on domestic output but also results in an immediate increase in CEE-5 output by 0.4 percent, yet the dynamics are reinforced in the subsequent quarters. The order of magnitude of this response is in line with the findings of the IMF (2012), Backé et al. (2013), and Feldkircher (2013).⁷ Altogether the positive spillovers to Eastern Europe stay significant for approximately two and a half years.

Figure 2 displays the effects of a shock to the interest rate of the Euro area. First of all, there is a strong impact on the interest rate in the Euro area itself in the first two quarters after the shock. The effect peaks at an increase of 1.6 percent in the third quarter. 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 the interest rate of the Euro area with the effect becoming significant in the fourth quarter after the shock. In the long-run, the response of the CEE-5 interest rate turns insignificant again. An interesting result is that the shock to the interest rate has a small dampening effect on Euro area output setting in after three quarters and getting stronger and significant over time with the response of CEE-5 GDP following a similar pattern. Our result of the point estimate is qualitatively and quantitatively in line with the effects reported by Feldkircher (2013). In the long run and for both areas, the responses of output turn insignificant confirming neutrality of monetary policy. We do not find evidence for an appreciation of the nominal exchange rate in response to monetary tightening which is in contrast to the results of Barigozzi et al. (2011). The reason might be that our two-country model allows domestic *and* foreign variables to respond to the interest rate shock. Observing an increase in the interest rate in both areas therefore implies that the nominal exchange rate remains unaffected.

By and large, the responses to a shock in the interest rate of the Euro area are in line with the literature. With respect to the effect on output, most studies report a decline setting in after two to six quarters and a return 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), and Gaggli et al. (2009), where the effect is permanent in the last contribution]. Similar to Benkovskis et al. (2011), we do not only observe a decline in Euro area GDP, but also a spillover effect to the CEE-5 region resulting in a decline in CEE-5 output by the same order of magnitude as in the Euro area. As compared to other studies (van Aarle et al., 2003; Weber et al., 2011; European Central Bank, 2010; Cecioni and Neri, 2011), we do not observe a price puzzle, that is, an increase in consumer prices in response to a monetary tightening.

⁷Koukouritakis et al. (2013) use an approach similar to Feldkircher (2013) to analyse the effects of spillovers from Western Europe to Bulgaria, Croatia, Cyprus, Greece, Romania, Slovenia, and Turkey.

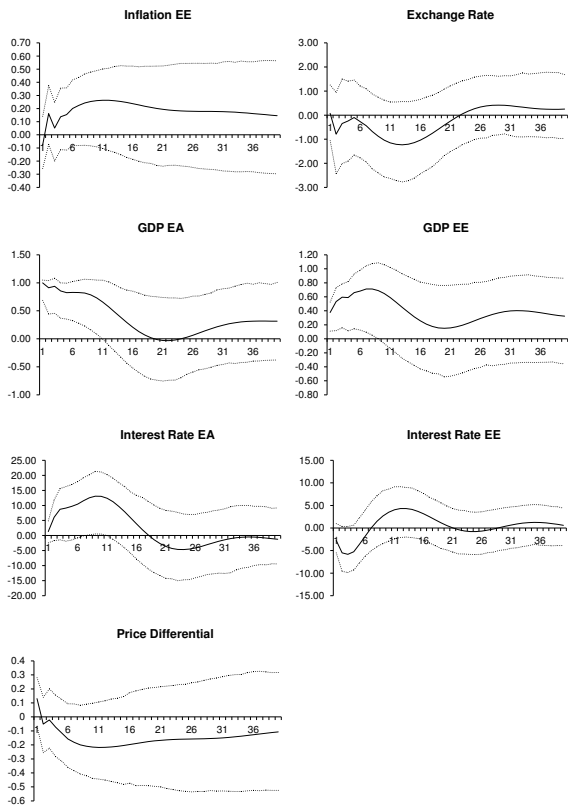


Figure 1: GIRFs of a 1 percent shock to Euro area GDP

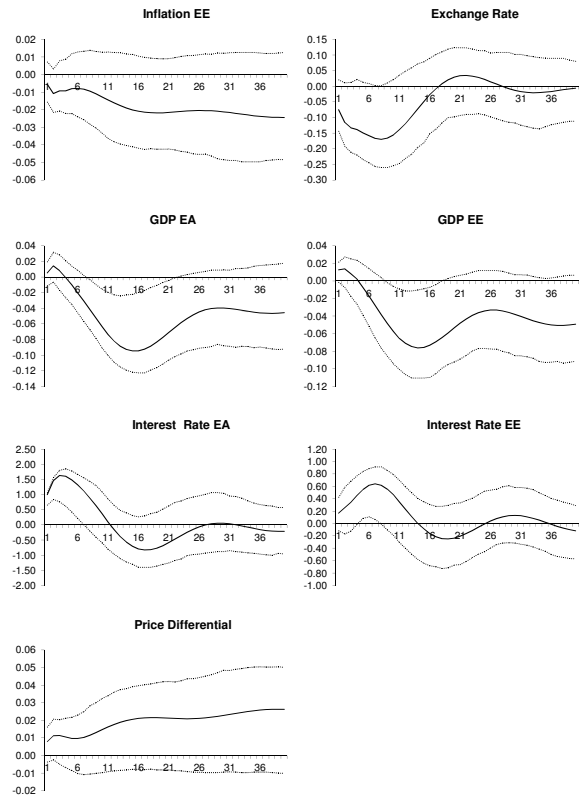


Figure 2: GIRFs of a 1 percent shock to the interest rate of the Euro area

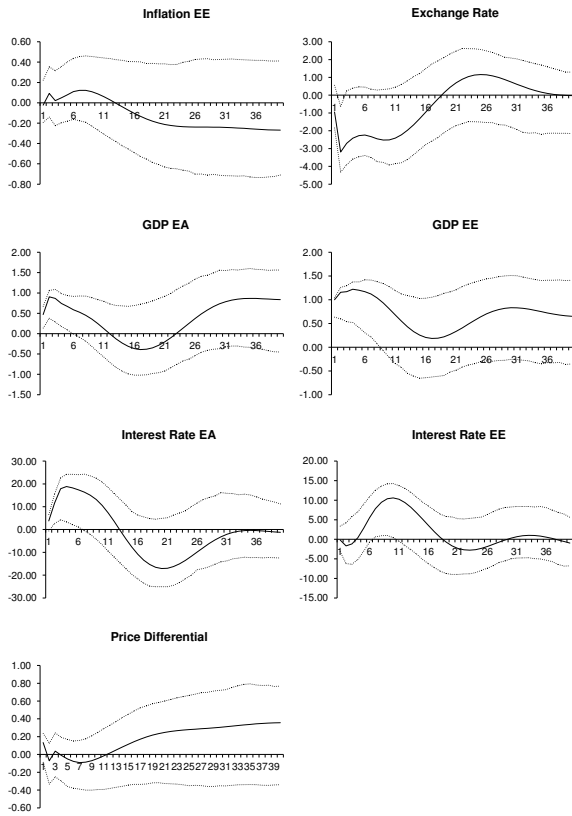


Figure 3: GIRFs of a 1 percent Shock to CEE-5 GDP

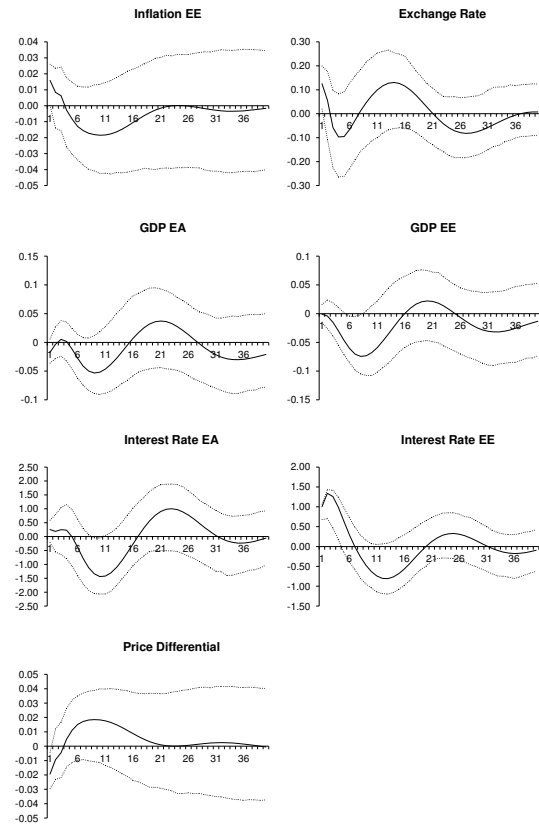


Figure 4: GIRFs of a 1 percent Shock to CEE-5 interest rates

5.2 Shocks to Eastern Europe

Figure 3 shows the GIRFs of a 1 percent shock in CEE-5 output. In response to this shock, CEE-5 output increases by even more in the successive quarters indicating the presence of a multiplier effect in Eastern Europe. The initial 1 percent shock translates into an increase of approximately 1.2 percent after one year. Subsequently, the response of output starts to slowly decay from the peak effect and turns insignificant after around two years. The impact on Euro area output reveals that there are substantial positive spillover effects which are approximately as strong as in the reverse case. Starting from a direct increase of Euro area GDP amounting to 0.5 percent in the first quarter after the shock, the effect peaks at an overall 0.9 percent in the third quarter. The positive response of Euro area output stays significant on the 5 percent level but only for around two years. This could be explained by the significant positive reaction of the interest rate in the Euro area hinting toward a strong desire of the European Central Bank for price stability.

According to the point estimate, the shock in CEE-5 GDP furthermore results in an appreciation of the currencies of these countries by 3 percent 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: the response of inflation in CEE-5 only shows a slight and insignificant upward pressure on prices. While the interest rate in CEE-5 is not increasing significantly after the shock, it does so in the Euro area for almost two years. As before, a potential explanation is that the European Central Bank has a strong desire toward stable prices.

The responses to a CEE-5 interest rate shock are given in Figure 4. In contrast to a shock in the interest rate of the Euro area, the corresponding shock in CEE-5 only leads to a significant response of the Eastern European interest rate itself but does not seem to transmit to the Euro area. This is hardly surprising given the relative importance of the two economic areas.

5.3 Shocks to the Exchange Rate and to Relative Prices

Figure 5 shows the responses to a positive 1 percent shock in the exchange rate, which is tantamount to an 1 percent appreciation of the Euro. After the immediate impact, there is a further appreciation to 1.1 percent 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 rate in the Euro area as well as the one in the CEE-5. While the interest rate in the Euro area decreases significantly in the first four quarters by approximately 2.6 percent, the interest rate in the CEE-5 tends to increase significantly by over 1 percent for around three quarters. The decrease in relative prices implies that products sold in the Euro area become less expensive relative to Eastern European products. While being in line with standard economic arguments, the dampening effect of an appreciation on inflation is, however, relatively small as compared to those found in other studies on the exchange rate pass through in CEE (see for example Beirne and Bijsterbosch, 2011). The positive effect on Eastern European inflation indicates that the more expensive imports from the Euro area contribute to a rising price level there. The responses of prices and interest rates partly offset the loss in competitiveness induced by a Euro appreciation, and hence the real GDPs of the Euro area and of the CEE-5 do not react significantly.

Finally, we compute the responses to a positive shock in relative prices in Figure 6. Unsurprisingly, such a shock significantly impacts upon the relative price level itself and on Eastern European inflation. As a consequence of lower inflation, the CEE-5 interest rate declines, while the interest rate of the Euro area tends to increase, albeit insignificantly so. A potential explanation is that the a significant depreciation of the Euro in the quarter after the shock partly offsets the increase in the relative price level such that there is no need for the European Central Bank to raise the interest rate.

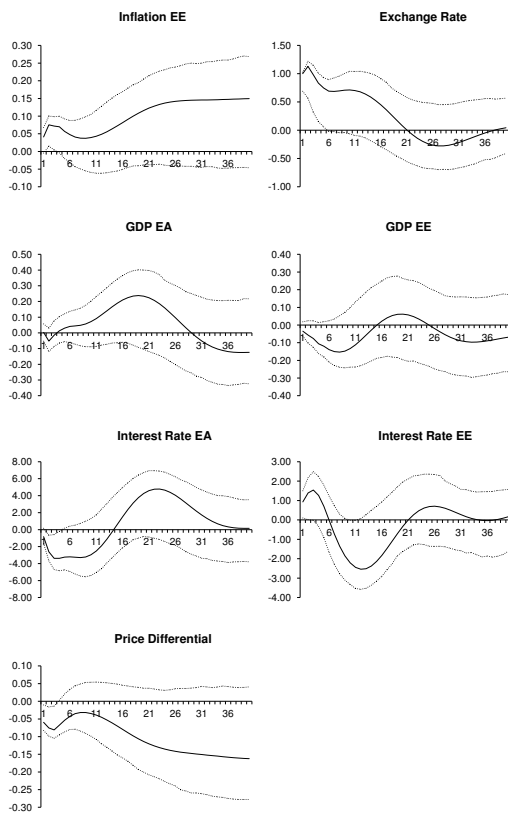


Figure 5: GIRFs of a 1 percent shock to the exchange rate

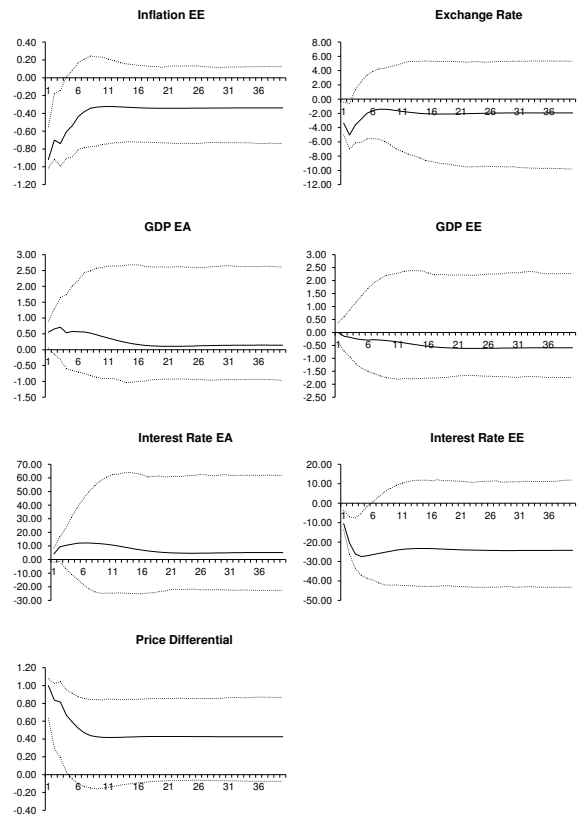


Figure 6: GIRFs of a 1 percent shock to the price differential

5.4 Robustness Checks

In this subsection we analyze the robustness of our results to different specifications of the model and to a dis-aggregation of the CEE-5 into its most important components. The corresponding calculations, GIRFs, and test results are available upon request.

When choosing the lag order in Equation (19), 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 GIRFs to the ones described above. They showed the same sign for all kinds of shocks discussed in the previous section. However, the results changed in two respects. First, the phase-out of a one-time shock followed a much more oscillating pattern and second, the responses to shocks diminished very slowly. In our view, this indicates that the VEC(2) model is close to becoming unstable, which supports the choice of a smaller model, especially in light of the short data series available.

As discussed in Section 4, 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 computed the GIRFs of the exactly identified model. There were no major changes and all GIRFs showed the same sign and very similar shapes and time patterns as in the benchmark case. However, in contrast to the benchmark case, the response of Euro area output showed a multiplier effect that increased output above the original shock in the following quarters. Furthermore, the effects of the interest rate shock in the Euro area were more pronounced in the first quarters following the shock. In case of CEE-5 shocks, the increase in inflation following a positive output shock was significant and the CEE-5 interest rate increased stronger in response to its own shock in the second and third quarter as compared to the benchmark case.

In Section 5 we discussed the impact of international shocks when considering the CEE-5 as a single region. We now compare our results to those when investigating the largest countries of the CEE-5 separately. Overall, the country-specific responses in the Czech Republic, in Poland, and in Hungary to Euro area shocks were very similar to those of the CEE-5 aggregate, but some country-specifics are notable. First, in Poland and in the Czech Republic, the spillover effect of a Euro area output shock was not significant. This indicates that the strong response in the CEE-5 output aggregate originates to a large extent from Hungary, Slovenia, and Slovakia. Furthermore, an interest rate shock in the Euro area led to a depreciation of the Czech koruna after five quarters, an effect that was neither observed for the Hungarian forint nor for the Polish zloty nor for the artificial aggregate CEE-5 currency. Finally, the transmission of an interest rate shock in the Euro area, which we observed for the aggregate CEE-5, remained significant for Poland and the Czech Republic

(peaking after 4-6 quarters), but not for Hungary.

When investigating the impact of CEE shocks to the Euro area, we saw that, unsurprisingly, single Eastern European countries did not have such a large impact as the aggregate CEE-5 region. An output shock in the Czech Republic had an insignificant effect on output in the Euro area. By contrast, positive shocks to output in Hungary and Poland had a significant impact on Euro area output, but the magnitude of this response was much smaller than in case of a shock to aggregate CEE-5 output. Furthermore, in contrast to an increase in the interest rate in the CEE-5 aggregate, an interest rate shock in just one country did not have a significant impact on inflation or the exchange rate. The dampening effect of an interest rate increase on domestic output, however, remained visible for all three countries.

Overall, the qualitative results of the benchmark model seem to be robust against the suggested re-specifications. While the signs, shapes, and time patterns of the GIRFs remained very similar to those obtained in the benchmark case, the significance of them did sometimes change. The only substantial differences in shapes and time patterns occurred when increasing the lag order, which, however, came at the price of estimating a SVECM that is close to becoming unstable.

6 Conclusions

We investigate the interrelations between initial members of the Euro area and five important Central and Eastern European economies. In so doing we employ 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 circumvented 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. Model diagnoses show that there are no significant structural breaks and that autocorrelation, heteroscedasticity, and non-normality of the residuals do not seem to pose substantial problems for the research question at hand. Furthermore, the robustness checks with respect to re-specifications of the model and with respect to applying it to individual Eastern European countries instead of the aggregate region, show that the results are very similar to the benchmark specification.

Our results imply a high degree of interconnectedness between Central and Eastern Europe and the Euro area. In general, our results confirm standard economic intuition. Output levels in the Euro area and in Central and Eastern Europe respond positively to output shocks in the corresponding other region with the impact being similarly strong in Central and Eastern Europe as in the Euro area. This emphasizes the

importance of Central and Eastern Europe as an extended market for the Euro area. Another important result is that we identify the presence of a multiplier effect in Central and Eastern Europe with mixed evidence for a similar effect in the Euro area. Furthermore, we find that the interest rate in the Euro area shows 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 Bank's desire toward price stability. The analysis of interest rate shocks shows strong responses of output in both regions for Euro area interest rate movements but only weak effects on output for changes in Central and Eastern European interest rates. Furthermore, increases in Euro area interest rates translate into rising Central and Eastern European interest rates, whereas the reverse is not the case. Finally, with respect to relative price and exchange rate shocks, we find offsetting effects of inflation, the exchange rate and interest rates that tend to prevent substantial changes in the relative competitiveness of the two areas.

Acknowledgments

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

Appendix

A Dynamic Optimization of the Representative Consumer

The Lagrangian of the consumer optimization problem reads

$$\begin{aligned} \mathcal{L} = \sum_{t=0}^{\infty} \beta^t & \left\{ C_t^\alpha C_t^{*1-\alpha} + \lambda_t \left[(1+r_t)K_{t-1} + w_t L_t + \frac{1+i_t}{1+\pi_t} B_{t-1} + \frac{1+i_t^*}{1+\pi_t^*} \frac{B_{t-1}^*}{e_t} + \frac{M_{t-1}}{1+\pi_t} \right. \right. \\ & \left. \left. - C_t - \frac{P_t^*}{e_t} C_t^* - B_t - \frac{B_t^*}{e_t} - K_t - M_t \right] + \mu_t \left[\frac{M_{t-1}}{1+\pi_t} - C_t - \frac{P_t^*}{e_t} C_t^* \right] \right\}. \end{aligned} \quad (22)$$

The corresponding first order conditions are

$$\frac{\partial \mathcal{L}}{\partial C_t} \stackrel{!}{=} 0 \Rightarrow \beta^t (\alpha C_t^{\alpha-1} C_t^{*1-\alpha} - \lambda_t - \mu_t) = 0, \quad (23)$$

$$\frac{\partial \mathcal{L}}{\partial C_t^*} \stackrel{!}{=} 0 \Rightarrow \beta^t \left[C_t^\alpha (1 - \alpha) C_t^{*(-\alpha)} - \lambda_t \frac{P_t^*}{e_t} - \mu_t \frac{P_t^*}{e_t} \right] = 0, \quad (24)$$

$$\frac{\partial \mathcal{L}}{\partial M_t} \stackrel{!}{=} 0 \Rightarrow \beta^{t+1} \left(\frac{\lambda_{t+1}}{1 + \pi_{t+1}} + \frac{\mu_{t+1}}{1 + \pi_{t+1}} \right) - \beta^t \lambda_t = 0, \quad (25)$$

$$\frac{\partial \mathcal{L}}{\partial K_t} \stackrel{!}{=} 0 \Rightarrow \beta^{t+1} \lambda_{t+1} (1 + r_{t+1}) - \beta^t \lambda_t = 0, \quad (26)$$

$$\frac{\partial \mathcal{L}}{\partial B_t} \stackrel{!}{=} 0 \Rightarrow \beta^{t+1} \lambda_{t+1} \frac{1 + i_{t+1}}{1 + \pi_{t+1}} - \beta^t \lambda_t = 0, \quad (27)$$

$$\frac{\partial \mathcal{L}}{\partial B_t^*} \stackrel{!}{=} 0 \Rightarrow \beta^{t+1} \lambda_{t+1} \frac{1 + i_{t+1}^*}{1 + \pi_{t+1}^*} \frac{1}{e_{t+1}} - \beta^t \frac{\lambda_t}{e_t} = 0. \quad (28)$$

Equations (26) and (27) lead to

$$1 + r_t = \frac{1 + i_t}{1 + \pi_t}, \quad (29)$$

which is the Fisher Inflation Parity (FIP). Equations (27) and (28) lead to

$$\frac{1 + i_t}{1 + \pi_t} = \frac{1 + i_t^*}{1 + \pi_t^*} \frac{e_{t-1}}{e_t}, \quad (30)$$

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

$$C_t = \frac{\alpha}{1 - \alpha} \frac{P_t^*}{e_t} C_t^*. \quad (31)$$

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

$$S_t = S_t(r_t, i_t, i_t^*, \pi_t, \pi_t^*) \equiv B_t + \frac{B_t^*}{e_t} + M_t + K_t, \quad (32)$$

$$I_t = I_t(r_t, i_t, i_t^*, \pi_t, \pi_t^*) \equiv w_t L_t + (1 + r_t) K_{t-1} + \frac{M_{t-1}}{1 + \pi_t} + \frac{1 + i_t}{1 + \pi_t} B_{t-1} + \frac{1 + i_t^*}{1 + \pi_t^*} \frac{B_{t-1}^*}{e_t}, \quad (33)$$

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

$$C_t = \alpha(I_t - S_t), \quad C_t^* = (1 - \alpha) \frac{I_t - S_t}{P_t^*}. \quad (34)$$

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 consumption 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

$$CPI_t = \alpha + (1 - \alpha)\frac{P_t^*}{e_t}, \quad CPI_t^* = e_t\alpha + (1 - \alpha)P_t^*$$

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

$$CPI_t = \frac{CPI_t^*}{e_t} \tag{35}$$

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

B Data

We employ aggregate quarterly data for the founding members of the Euro area (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 Euro area

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 Euro area

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 Euro area and CEE-5 in terms of CPIs

e_t : Logarithm of the nominal exchange rate index between Euro area 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 use the relative size of a country's GDP to calculate the quarterly weight when constructing an aggregate series out of the individual countries' data. For the exchange rate we use weighted percentage changes of national currencies as compared to the Euro to construct an index of an artificial currency for the CEE-5 countries. Most of the data stems 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 obtained 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 appear to be integrated of order two [$I(2)$]. This means that CEE-5 inflation is $I(1)$ and can be used in the vector error correction part of our model together with all the other data series that are also $I(1)$. Since unit root tests did not find any indication of Euro area inflation to be $I(1)$, we did not use this variable in the z_t vector and changed the theoretically suggested FIP relationship to hold in Eastern Europe instead of the Euro area. Additional more detailed information regarding the data series and the results of the unit root tests are available from the authors upon request.

C Tables

Table 1: Lag order selection based on VAR models in levels

	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: Trace test on the number of cointegrating relations

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.794	260.904	150.559	0.000
At most 1 *	0.684	170.732	117.708	0.000
At most 2 *	0.482	105.118	88.804	0.002
At most 3 *	0.451	67.673	63.876	0.023
At most 4	0.286	33.542	42.915	0.310
At most 5	0.140	14.303	25.872	0.633
At most 6	0.095	5.685	12.518	0.501

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 3: 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 4: Model fit, normality test and White test

	$\Delta(Y_{EA})$	$\Delta(I_{EA})$	$\Delta(P_{EE})$	$\Delta(I_{EE})$	$\Delta(PD)$	$\Delta(E)$	$\Delta(Y_{EE})$
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

Table 5: 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 -0.0189 [1.1527]	0.0981 -0.2933 [0.3346]	0.0146 -0.0133 [1.0997]	0.3715 -0.2392 [1.5531]	-0.0142 -0.0125 [-1.1340]	-0.0997 -0.0880 [-1.1333]	-0.0250 -0.0169 [-1.4747]
CE2	-0.0060 -0.0049 [-1.2241]	-0.1662 -0.0763 [-2.1764]	0.0000 -0.0035 [0.0020]	-0.0881 -0.0623 [-1.4160]	0.0003 -0.0033 [0.1002]	-0.0389 -0.0229 [-1.6988]	-0.0171 -0.0044 [-3.8905]
CE3	-0.0048 -0.0031 [-1.5388]	-0.0146 -0.0484 [-0.30090]	0.0045 -0.0022 [2.0695]	0.1029 -0.0394 [2.6086]	-0.0045 -0.0021 [-2.1709]	-0.0073 -0.0145 [-0.5042]	-0.0041 -0.0028 [-1.4721]
CE4	-0.0336 -0.0548 [-0.6128]	-0.1978 -0.8507 [-0.2326]	-0.0182 -0.0385 [-0.4715]	-2.0503 -0.6936 [-2.9559]	0.0224 -0.0363 [0.6168]	-0.2823 -0.2552 [-1.1062]	0.0026 -0.0491 [0.0537]
$\Delta(Y_{t-1}^{EA})$	-0.1918 -0.1472 [-1.3032]	3.5291 -2.2848 [1.5446]	0.1882 -0.1035 [1.8188]	0.2323 -1.8630 [0.1247]	-0.0727 -0.0975 [-0.7451]	-0.0268 -0.6854 [-0.0391]	0.1266 -0.1319 [0.9599]
$\Delta(IR_{t-1}^{EA})$	0.0001 -0.0083 [0.0089]	0.2602 -0.1285 [2.02524]	-0.0090 -0.0058 [-1.5422]	-0.0063 -0.1048 [-0.0598]	0.0079 -0.0055 [1.4427]	0.0388 -0.0385 [1.0059]	0.0014 -0.0074 [0.1875]
$\Delta(P_{t-1}^{EE})$	0.1823 -0.2853 [0.6388]	5.3970 -4.4296 [1.2184]	-0.2644 -0.2006 [-1.3180]	1.5839 -3.6119 [0.4385]	-0.1967 -0.1891 [-1.0403]	-0.2190 -1.3289 [-0.1648]	0.7733 -0.2557 [3.0245]
$\Delta(IR_{t-1}^{EE})$	0.0225 -0.0123 [1.8285]	0.3096 -0.1907 [1.6235]	-0.0005 -0.0086 [-0.0545]	0.4099 -0.1555 [2.6355]	0.0039 -0.0081 [0.4730]	-0.1066 -0.0572 [-1.8636]	0.0162 -0.0110 [1.4747]
$\Delta(PD_{t-1})$	0.2883 -0.3262 [0.8839]	6.5954 -5.0636 [1.3025]	0.0094 -0.2294 [0.0411]	-0.8120 -4.1289 [-0.1967]	-0.4095 -0.2161 [-1.8948]	-2.2154 -1.5191 [-1.4584]	0.7583 -0.2923 [2.5943]
$\Delta(E_{t-1})$	-0.0731 -0.0308 [-2.3749]	-1.5575 -0.4775 [-3.2617]	0.0354 -0.0216 [1.6361]	-0.1436 -0.3894 [-0.3688]	-0.0302 -0.0204 [-1.4833]	0.1899 -0.1433 [1.3252]	0.0090 -0.0276 [0.3256]
$\Delta(Y_{t-1}^{EE})$	0.4443 -0.1786 [2.4872]	3.0881 -2.7730 [1.1136]	0.0709 -0.1256 [0.5642]	-2.7285 -2.2611 [-1.2067]	-0.1602 -0.1184 [-1.3537]	-2.1409 -0.8319 [-2.5735]	0.0147 -0.1601 [0.0919]
R^2	0.496007	0.686718	0.202989	0.369729	0.113996	0.387678	0.474091

References

- Backé, P., Feldkircher, M., and T, S. (2013). Economic Spillovers from the Euro Area to the CESEE Region via the Financial Channel: A GVAR Approach. *Focus on European Economic Integration*, Q4/2013.
- 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. (2011). Exchange rate pass-through in central and eastern european eu member states. *Journal of Policy Modeling*, Vol. 33(No. 2):241–254.
- 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.
- Berglöf, E., Korniyenko, Y., Plekhanov, A., and Zettelmeyer, J. (2010). Understanding the Crisis in Emerging Europe. *Public Policy Review*, Vol. 6(No. 5):985–1008.
- 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 on Old and New Members. *WIFO Monatsberichte (monthly reports)*, Vol. 74(No. 11):655–666.
- Cecioni, M. and Neri, S. (2011). The monetary transmission mechanism in the euro area: has it changed and why? Working Papers Banca D’Italia.
- Chinn, M. D. (2006). The (partial) rehabilitation of interest rate parity in the floating rate era: Longer horizons, alternative expectations, and emerging markets. *Journal of International Money and Finance*, Vol. 81(No. 1):163–192.
- Clower, R. (1967). A reconsideration of the microfoundations of monetary theory. *Western Economic Journal*, Vol. 6:1–9.
- 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.

- EBRD (2012). Transition Report 2012 - Integration Across Borders. European Bank for Reconstruction and Development.
- Égert, B., Crespo-Cuaresma, J., and Reiningger, T. (2007). Interest rate pass-through in central and Eastern Europe: Reborn from ashes merely to pass away? *Journal of Policy Modeling*, Vol. 29(No. 2):209–225.
- Égert, B. and MacDonald, R. (2009). Monetary Transmission Mechanism in Central and Eastern Europe: Surveying the Surveyable. *Journal of Economic Surveys*, Vol. 23(No. 2):277–327.
- Egger, P. and Larch, M. (2011). An assessment of the Europe agreements effects on bilateral trade, GDP, and welfare. *European Economic Review*, Vol. 55(No. 2):263–279.
- European Central Bank (2010). Monetary policy transmission in the euro area, a decade after the introduction of the euro. url: http://www.ecb.europa.eu/pub/pdf/other/mb201005en_pp85-98en.pdf.
- European Commission (2008). Employment in Europe 2008. Report of the European Commission. Directorate-General for Employment, Social Affairs and Equal Opportunities.
- Feldkircher, M. (2013). A Global Macro Model for Emerging Europe, OeNB Working Paper 185/2013.
- Fidrmuc, J. and Korhonen, I. (2006). Meta-analysis of the business cycle correlation between the euro area and the CEECs. *Journal of Comparative Economics*, Vol. 34:518–537.
- Gaggl, P., Kaniowski, S., Prettnner, 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 macroeconomic 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 macroeconomic 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.
- Guerrieri, P. and Caffarelli, F. V. (2012). Trade Openness and International Fragmentation of Production in the European Union: The New Divide. *Review of International Economics*, Vol. 20(No. 3):535–551.
- He, H., Omid, R., and Chang, C. T. (2013). Purchasing power parity in transition countries: Old wine with new bottle. *Japan and the World Economy*, Vol. 28:24–32.

- IMF (2012). Spillover Report, IMF Policy Papers.
- Jiménez-Rodríguez, 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.
- Keppel, C. and Wörz, J. (2010). The Impact of the Global Recession in Europe - The Role of International Trade. Chapters in SUERF Studies, SUERF - The European Money and Finance Forum.
- Koop, G., Pesaran, H., and Potter, M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, Vol. 74:119–147.
- Koukouritakis, M., Papadopoulos, A., and Yannopoulos, A. (2013). Linkages between the Eurozone and the south-eastern European countries: a global VAR analysis, Bank of Greece Working Paper 163/2013.
- Lee, B.-J. (2011). Uncovered Interest Parity: Cross-Sectional Evidence. *Review of International Economics*, Vol. 19(No. 2):219–231.
- 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. *Economics Letters*, Vol. 58(No. 1):17–29.
- Prettner, K. and Kunst, R. M. (2012). The Dynamic Interrelations between Unequal Neighbors: An Austro-German Case Study. *Empirical Economics*, Vol. 43(No. 2):741–761.

- Taylor, M. P. (2003). Purchasing Power Parity. *Review of International Economics*, Vol. 11(No. 3):436–452.
- van Aarle, B., Garretsen, H., and Gobbin, N. (2003). Monetary and fiscal policy transmission in the Euro-area: evidence from a structural VAR analysis. *Journal of Economics and Business*, Vol. 55:609–638.
- 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. (2011). Changes in euro area monetary transmission? *Applied Financial Economics*, Vol. 21(No. 3):131–145.