Linkages between the Eurozone and the South-Eastern European Countries: A Global VAR Analysis

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Abstract: In the present paper we assess the impact of the Eurozone's economic policies on specific South-Eastern European countries, namely Bulgaria, Croatia, Cyprus, Greece, Romania, Slovenia and Turkey. Since these countries are connected to the EU or the Eurozone and the economic interdependence among them is evolving, we implemented the Global VAR model. Our results indicate that all sample countries, except Turkey, react in a similar manner to changes (a) in the macroeconomic policies of the Eurozone, and (b) in the nominal exchange rate of the euro against the US dollar. There is evidence of linkages among the EU or Eurozone members of the region, and between each of them and the Eurozone.

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1. Introduction

In the last two decades the world economy has experienced a number of fundamental changes, which radically altered the ways that economies function. The most important one is the high degree of interdependence among economies. Globalisation and free capital movements have resulted in a large degree of integration and interdependence of capital markets and the banking sector. These changes have led to an expansion of trade and of movements of production activities of multinational corporations. All these make imperative that the domestic economies should be studied from a global perspective. At the same time, at a regional level conditions have evolved to facilitate the response to these developments. This evolution has resulted in changes in the composition of output and movements of trade globally.

Concurrently, new and large economic players, like China, have emerged exercising an increasing influence around the world. The emerging economies have also become more integrated into the trade and financial markets, with the simultaneous increased patterns of regionalisation. The above changes may have altered in a fundamental way the magnitude of economic shocks, their duration and the way they are transmitted globally.

Most of the models that have been used for the study of domestic economies are not well-suited to investigate the global dimensions of these issues, and the way economies react to economic and financial interdependencies. Such problems are mostly investigated in many cases in an ad hoc manner and the models employed have not consistently incorporated suitable mechanisms to account for these. The models were of structural form, but in the last decades they have been displaced by vector autoregressive (VAR) models. The use of VARs and the subsequent cointegration analysis have resulted in long-run relations between various variables in the same economy, as suggested by economic theory. However, many long-run relations in one country may be influenced and affected by variables from other regions. One of the problems with the VAR methodology is that it works with a limited number of variables. But in order to incorporate a reasonable number of variables to account for global effects, large dimensionally system are required.

A very important step in this direction is the development of Global VAR (GVAR) modelling developed by Pesaran, Schuermann and Weiner (2004, henceforth PSW), which facilitated the study of international linkages. Their work has further expanded and evolved both at the theoretical and the empirical levels. For instance, Pesaran and Smith (2006) derived the VARX* models as the solution of dynamic stochastic general equilibrium model.

An example of GVAR's use on economic policy is the work by Pesaran, Smith and Smith (2005), in which they investigated what would have happened if the UK joined the euro in 1999. At the empirical level, the GVAR methodology has been used to examine the interdependencies of economies worldwide. Thus, it was used to investigate the changing degree of the dominance of the USA economy and its effect on other regions (Dées and Sain-Guilhem, 2009), the role of China and its increased influence around the world (Feldkircher and Korhonen, 2012), the linkages in the euro area (Dées, di Mauro, Pesaran and Smith, 2005), world trade flows (Bussiére, Chudik and Sestieri, 2012), and regional financial effects (Galesi and Sgherri, 2009).

In the present paper we investigate the impact of the Eurozone's economic policies on specific economies of South-Eastern Europe, namely Bulgaria, Croatia, Cyprus, Greece, Romania, Slovenia and Turkey. The economic interdependence among these economies has been intensified during the last two decades, while all of them are with one way or another connected to the European Union (EU) and the Eurozone. For example, Bulgaria and Romania joined the EU in 2007 after a long transition period from centrally-planned to free market economies; Croatia will join the EU in 2013 having also followed a long transition period; Cyprus is a Eurozone member since 2008; Greece is a Eurozone member since 2001; Slovenia is a Eurozone member since 2007 and Turkey has settled a customs union with the EU in 1996 and is under negotiations for EU membership in the future. The latter country also had a stand-by agreement with the International Monetary Fund (IMF) for a number of years. Thus, there is a need of detailed investigation of the economic policies of the above countries, as well as the effects of the Eurozone policies. The GVAR model allows us to carry out this task, as it avoids all limitations that arise by the use of single VAR models and provides a consistent and flexible framework.

In brief, our results from the dynamic analysis indicate that the implementation of the Eurozone policies have similar effects on the economies of the countries under consideration, except for Turkey in the cases of real effective exchange rate and harmonised consumer price index. The same conclusion can be drawn regarding the effects of changes in the nominal exchange rate of the euro against the US dollar.

The structure of the paper is organised as follows. Section 2 illustrates the framework of the Global VAR modelling, while section 3 reports the data and the model specification. Section 4 analyses the empirical results along with a range of empirical tests, in order to ensure the statistical validity of our estimated model. Section 5 presents the dynamic analysis, while section 6 draws some concluding remarks.

2. The GVAR Model

2.1 Country-specific Models and Trade Weights

The model developed by PSW (2004) begins with country-specific models and assumes that there exist $N+1$ countries in the global economy. These countries are indexed by $i = 0,1,2,...,N,$ adopting country 0 as the reference country. For each country, the country-specific variables are related to the global variables. The latter are measured as country-specific weighted averages of foreign variables. In general, deterministic variables and global (weakly) exogenous variables are also included in each country specific model. In brief, for a first-order dynamic specification that relates the $k_i \times 1$ vector of country specific variables (denoted by $\mathbf{x}_{it}$) to a $k_i^* \times 1$ vector of foreign variables specific to country i (denoted by $\mathbf{x}_{it}^*$), the VARX*(1,1) model is the following:

$$\mathbf{x}_{it} = \boldsymbol{\alpha}_{i0} + \boldsymbol{\alpha}_{i1}t + \boldsymbol{\Phi}_i \mathbf{x}_{i,t-1} + \boldsymbol{\Lambda}_{i0}\mathbf{x}_{it}^* + \boldsymbol{\Lambda}_{i1}\mathbf{x}_{i,t-1}^* + \boldsymbol{\varepsilon}_{it}, \; t = 1,2,...,T, \; N = 0,1,2,...,N, \tag{1}$$

where $\boldsymbol{\Phi}_i$ is a $k_i \times k_i$ matrix of lagged coefficients, $\boldsymbol{\Lambda}_{i0}$ and $\boldsymbol{\Lambda}_{i1}$ are $k_i \times k_i^*$ matrices of coefficients related to foreign variables, and $\boldsymbol{\varepsilon}_{it}$ is a $k_i \times 1$ vector of idiosyncratic country-specific shocks. The latter are serially uncorrelated with zero mean and a non-singular covariance matrix, or $\boldsymbol{\varepsilon}_{it} \sim iid\left(\mathbf{0}, \boldsymbol{\Sigma}_{ii}\right)$.[1]

2.2 Solution of the GVAR Model

The contemporaneous dependence between the domestic and the foreign variables ($\mathbf{x}_{it}$ and $\mathbf{x}_{it}^*$, respectively) requires that the country-specific VAR models, which are presented in equation (1), must be solved simultaneously for all of the domestic variables $\mathbf{x}_{it}$, $i = 0,1,2,...,N.$ The GVAR model is constructed by the country-specific models in the following way: Firstly, we define the $\left(k_i + k_i^*\right) \times 1$ vector $\mathbf{z}_{it} = \begin{bmatrix} \mathbf{x}_{it} \\ \mathbf{x}_{it}^* \end{bmatrix}$ and then rewrite equation (1) as

[1] PSW (2004) indicate that for the idiosyncratic shocks there is allowance of limited correlation across countries, while the assumption regarding time invariance of the country-specific covariance matrices can be relaxed.

$$\mathbf{A}_i \mathbf{z}_{it} = \boldsymbol{\alpha}_{i0} + \boldsymbol{\alpha}_{i1} t + \mathbf{B}_i \mathbf{z}_{i,t-1} + \boldsymbol{\varepsilon}_{it}, \tag{2}$$

where $\mathbf{A}_i = \left(\mathbf{I}_{k_i} - \boldsymbol{\Lambda}_{i0}\right)$ and $\mathbf{B}_i = \left(\boldsymbol{\Phi}_i, \boldsymbol{\Lambda}_{i1}\right)$. The dimensions of both $\mathbf{A}_i$ and $\mathbf{B}_i$ matrices are of $k_i \times \left(k_i + k_i^*\right)$ dimension, while $\mathbf{A}_i$ has a full row rank, namely $rank\left(\mathbf{A}_i\right) = k_i$. Secondly, we collect all of the country-specific variables in the $k \times 1$ global vector $\mathbf{x}_t = \left(\mathbf{x}'_{0t}, \mathbf{x}'_{1t}, ..., \mathbf{x}'_{Nt}\right)'$, where $k = \sum_{i=0}^{N} k_i$ is the total number of endogenous variables in the global model. Then, the country-specific variables can all be written in terms of $\mathbf{x}_t$ as $\mathbf{z}_{it} = \mathbf{W}_i \mathbf{x}_t$, where $\mathbf{W}_i$ is the $\left(k_i + k_i^*\right) \times k$ 'link' matrix of fixed (known) constants defined in terms of the country-specific weights w_{ij}. For our model, these weights are analysed in the next section.

Based on the above, equation (2) can be written as follows:

$$\mathbf{A}_i \mathbf{W}_i \mathbf{x}_t = \boldsymbol{\alpha}_{i0} + \boldsymbol{\alpha}_{i1} t + \mathbf{B}_i \mathbf{W}_i \mathbf{x}_{t-1} + \boldsymbol{\varepsilon}_{it}, \tag{3}$$

where both $\mathbf{A}_i \mathbf{W}_i$ and $\mathbf{B}_i \mathbf{W}_i$ matrices are of $k_i \times k$ dimension. Stacking these equations we can write

$$\mathbf{G} \mathbf{x}_t = \boldsymbol{\alpha}_0 + \boldsymbol{\alpha}_1 t + \mathbf{H} \mathbf{x}_{t-1} + \boldsymbol{\varepsilon}_t, \tag{4}$$

where $\boldsymbol{\alpha}_0 = \begin{bmatrix} \boldsymbol{\alpha}_{00} \\ \boldsymbol{\alpha}_{10} \\ \vdots \\ \boldsymbol{\alpha}_{N0} \end{bmatrix}$, $\boldsymbol{\alpha}_1 = \begin{bmatrix} \boldsymbol{\alpha}_{01} \\ \boldsymbol{\alpha}_{11} \\ \vdots \\ \boldsymbol{\alpha}_{N1} \end{bmatrix}$, $\boldsymbol{\varepsilon}_t = \begin{bmatrix} \boldsymbol{\varepsilon}_{0t} \\ \boldsymbol{\varepsilon}_{1t} \\ \vdots \\ \boldsymbol{\varepsilon}_{Nt} \end{bmatrix}$, $\mathbf{G} = \begin{bmatrix} \mathbf{A}_0 \mathbf{W}_0 \\ \mathbf{A}_1 \mathbf{W}_1 \\ \vdots \\ \mathbf{A}_N \mathbf{W}_N \end{bmatrix}$, $\mathbf{H} = \begin{bmatrix} \mathbf{B}_0 \mathbf{W}_0 \\ \mathbf{B}_1 \mathbf{W}_1 \\ \vdots \\ \mathbf{B}_N \mathbf{W}_N \end{bmatrix}$. $\mathbf{G}$ matrix is of $k \times k$ dimension and in general will be of full rank and hence non-singular. Thus, the GVAR model can be written as

$$\mathbf{x}_t = \mathbf{G}^{-1} \boldsymbol{\alpha}_0 + \mathbf{G}^{-1} \boldsymbol{\alpha}_1 t + \mathbf{G}^{-1} \mathbf{H} \mathbf{x}_{t-1} + \mathbf{G}^{-1} \boldsymbol{\varepsilon}_t. \tag{5}$$

2.3 Error-Correction in the Global Model

The error-correction representation of equation (1) is given by

$$\Delta \mathbf{x}_{it} = \boldsymbol{\alpha}_{i0} + \boldsymbol{\alpha}_{i1} t - \left(\mathbf{I}_{k_i} - \boldsymbol{\Phi}_i\right) \mathbf{x}_{i,t-1} + \left(\boldsymbol{\Lambda}_{i0} + \boldsymbol{\Lambda}_{i1}\right) \mathbf{x}^*_{i,t-1} + \boldsymbol{\Lambda}_{i0} \Delta \mathbf{x}^*_{it} + \boldsymbol{\varepsilon}_{it}. \tag{6}$$

Using $\mathbf{z}_{it} = \begin{bmatrix} \mathbf{x}_{it} \\ \mathbf{x}^*_{it} \end{bmatrix}$, equation (6) can be transformed to

$$\Delta \mathbf{x}_{it} = \boldsymbol{\alpha}_{i0} + \boldsymbol{\alpha}_{i1} t - \left(\mathbf{A}_i - \mathbf{B}_i\right) \mathbf{z}_{i,t-1} + \boldsymbol{\Lambda}_{i0} \Delta \mathbf{x}^*_{it} + \boldsymbol{\varepsilon}_{it}. \tag{7}$$

For country i we set the $k_i \times (k_i + k_i^*)$ matrix $\mathbf{\Pi}_i = \mathbf{A}_i - \mathbf{B}_i$, where its rank (r_i) specifies the number of 'long-run' (cointegrating) relationships among the domestic and the country-specific foreign variables ($\mathbf{x}_{it}$ and $\mathbf{x}_{it}^*$, respectively). Thus, we have

$$\mathbf{A}_i - \mathbf{B}_i = \mathbf{a}_i \boldsymbol{\beta}_i', \tag{8}$$

where $\mathbf{a}_i$ is the $k_i \times r_i$ matrix of adjustment coefficients and $\boldsymbol{\beta}_i$ is the $(k_i + k_i^*) \times r_i$ matrix of cointegrating vectors. Both matrices are of full column rank.

Similarly, the number of cointegrating relationships in the global model is determined by the rank of

$$\mathbf{G} - \mathbf{H} = \begin{bmatrix} (\mathbf{A}_0 - \mathbf{B}_0)\mathbf{W}_0 \\ (\mathbf{A}_1 - \mathbf{B}_1)\mathbf{W}_1 \\ \vdots \\ (\mathbf{A}_N - \mathbf{B}_N)\mathbf{W}_N \end{bmatrix} = \begin{bmatrix} \mathbf{a}_0 \boldsymbol{\beta}_0' \mathbf{W}_0 \\ \mathbf{a}_1 \boldsymbol{\beta}_1' \mathbf{W}_1 \\ \vdots \\ \mathbf{a}_N \boldsymbol{\beta}_N' \mathbf{W}_N \end{bmatrix} = \tilde{\mathbf{a}} \tilde{\boldsymbol{\beta}}', \tag{9}$$

where $\tilde{\mathbf{a}} = \begin{bmatrix} \mathbf{a}_0 & 0 & \cdots & 0 \\ 0 & \mathbf{a}_1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{a}_N \end{bmatrix}$ is a $k \times r$ block-diagonal matrix of the global adjustment coefficients, $\tilde{\boldsymbol{\beta}} = [\mathbf{W}_0' \boldsymbol{\beta}_0, \mathbf{W}_1' \boldsymbol{\beta}_1, ..., \mathbf{W}_N' \boldsymbol{\beta}_N]$, $r = \sum_{i=0}^{N} r_i$ and $rank(\tilde{\mathbf{a}}) = \sum_{i=0}^{N} rank(\mathbf{a}_i) = r$. Regarding the global $k \times r$ cointegrating matrix $\tilde{\boldsymbol{\beta}}$, each of its blocks (i.e. $\mathbf{W}_i' \boldsymbol{\beta}_i$) are of dimension $k \times r_i$ with rank at most equal to r_i. Thus, the rank of matrix $\tilde{\boldsymbol{\beta}}$ will be at most equal to r. This means that the number of cointegrating relationships in the global model cannot exceed the sum of the numbers of cointegrating relationships that exist in the country-specific models. In general, the GVAR model in equation (4) can be solved recursively, and used for generalised impulse response analysis in the usual manner.

3. Data and Model Specification

Our sample consists of monthly data for the period 2000:01-2011:12. We included Bulgaria, Croatia, Cyprus, Greece, Romania, Slovenia and Turkey, along with EMU12 as the base country. We obtained data for real effective exchange rates based on consumer price index (RER), harmonised consumer price index (HCPI), index of industrial production (IP) and interest rates (IR). We used money market rates for all countries, except for Greece and Cyprus, for which these data were not available. For that reason, we used Treasury bill rates

(TB) for Greece and government bond yields (GB) for Cyprus. We also obtained data for the nominal exchange rate of the euro against the US dollar (number of euros per US dollar - NER). All data were obtained from the International Financial Statistics of the IMF, except for the real effective exchange rate for Slovenia and Turkey that was obtained from the Eurostat, the harmonised consumer price index for all countries that was obtained from the Eurostat, and the index of industrial production for the EMU, which excludes construction and was obtained from the Eurostat. All data, except interest rates, were transformed into natural logarithms.

For each of the seven countries (Bulgaria, Croatia, Cyprus, Greece, Romania, Slovenia and Turkey) we set the vector of domestic variable $\mathbf{x}_{it} = (RER_{it}, HCPI_{it}, IR_{it}, IP_{it})'$, with $k_i = 4$, where RER is the real effective exchange rate, HCPI is the harmonised consumer price index, IR is the interest rate, and IP stands for the industrial production. EMU12 has been used as the reference country. Also, the nominal exchange rate of the euro against the US dollar (NER) has been used as global variable. The vector $\mathbf{x}^*_{it}$ of the foreign ('starred') variables has been constructed from the domestic variables, using the following relations that are based on PSW (2004), equation 4:

$$
\begin{aligned}
&\mathbf{x}^*_{it} = (RER^*_{it}, HCPI^*_{it}, IR^*_{it}, IP^*_{it})' \;, \\
&RER^*_{it} = \sum\nolimits_{j=0}^{N} w_{ij}^{RER} RER_{jt,} \\
&HCPI^*_{it} = \sum\nolimits_{j=0}^{N} w_{ij}^{HCPI} HCPI_{jt,} \\
&IR^*_{it} = \sum\nolimits_{j=0}^{N} w_{ij}^{MMR} IR_{jt,} \\
&IP^*_{it} = \sum\nolimits_{j=0}^{N} w_{ij}^{IP} IP_{jt,}
\end{aligned}
\tag{10}
$$

For weights we based on trade weights. Trade data were obtained from the Comtrade database of the United Nations. Note that if we allow trade weights to vary over time could introduce an undesirable degree of randomness in the analysis. For this reason and based on the PSW (2004) analysis, we used fixed trade weights. These fixed trade weights were computed as averages of trade flows for the 2001-2006 period, and are presented in Table 1. The trade shares for each country are presented in columns and show the degree to which one country depends on the remaining ones.[2]

[2] In this study we did not construct a full structural model with many equations in order to capture relationships proposed by economic theory due to data limitation and extreme heterogeneity of the sample countries. Also, for most of the sample countries there is an acute problem of structural uncertainty yet. Thus, our model is a reduced-form one.

In our analysis, we firstly estimate vector error-correction models (VECMs) for each sample country, where the domestic macroeconomic variables (real effective exchange rate, harmonised consumer price index, interest rate and industrial production) are related to corresponding foreign ('starred') variables constructed to match the international trade pattern of the country under consideration. The latter variables are treated as weakly exogenous for all sample countries. For Turkey we excluded domestic and foreign interest rates from the analysis. The reason is that the Turkish interest rate shows anomalies and extreme values for a long period of time, after the economic crisis of 2001 and the involvement of the IMF. For the VECM of the Eurozone only the harmonised consumer price index and the industrial production have been included as 'starred' variables. Finally, the global variable (i.e. the nominal exchange rate of the euro against the US dollar) has been treated as endogenous in the VECM of the Eurozone.

4. Country-specific Cointegration Models

4.1 Unit Root and Cointegration Test Results

Before estimating each country-specific VECMX*, we tested each domestic, foreign and global variable for a unit root, using the Weighted Symmetric ADF (WS-ADF) unit root test introduced by Park and Fuller (1995). This test exploits the time reversibility of stationary autoregressive processes in order to increase their power performance. Leybourne, Kim and Newbold (2005) and Pantula, Gonzalez-Farias and Fuller (1995) provide evidence of superior performance of this test in relation to the standard ADF and the GLS-ADF tests. In order to select the lag length in each regression of the WS-ADF test, we started from 12 lags and employed the Akaike Information Criterion (AIC). The results are presented in table 2 and indicate that almost all of the variables under consideration have a unit root.[3]

Given the fact that almost all of the variables have a unit root, we individually estimate each country-specific cointegration model (VECMX*). Since we are dealing with a small number of time series observations relative to the number of unknown parameters in each model, we started for a VECMX*(3,3) model for each country and chose the lag specification for endogenous and exogenous variables based on the AIC. The cointegration results are presented in table 3, while the selected VECMX* for each country is presented in column 1 of

[3] We also tested all variables for a second unit root. This hypothesis was rejected in all cases. For saving space, these results are not presented here but are available upon request.

this table.[4] Based on the Trace statistic, we find evidence of a single cointegrating vector for each of Bulgaria, Croatia, Cyprus, Greece, Romania, Slovenia and Turkey, either at the 5 or at the 10 per cent level of significance. These results also show evidence of two cointegrating vectors for the EMU12 at the 10 per cent level of significance. Tables 4 and 5 report the solved cointegrating vectors normalised on the real effective exchange rate, while tables 6 and 7 present the adjustment coefficients for the error-correction models.[5,6]

Table 8 reports the average pair-wise cross-section correlations of the residuals of each VECMX* model. The results of this table indicate that the residuals are weakly correlated, and in some cases, completed uncorrelated for all the variables under consideration. Note the inclusion of foreign variables in the estimation of each country-specific model cleans the common factor among the variables, and thus, yields to weakly correlated residuals. This allows us to simulate shocks that are mainly country-specific. We also tested our model for serial correlation in the residuals. Table 9 provides *F*-statistics for tests of serial correlation of order 3 in the residuals of the error-correction regressions for all of the 32 endogenous variables in the GVAR model. As indicated in this table, 24 of the 32 regressions pass the serial correlation test, since for these cases the null hypothesis of no serial correlation cannot be rejected at the 5 per cent level of significance.

4.2 Weak Exogeneity Test Results

Having estimated each country's VECMX* model, the next step in our analysis is to test for weak exogeneity the foreign variables of each country. We implemented the tests developed by Johansen (1992) and Harbo *et al.* (1998), and for each country model we test the joint significance of the estimated error-correcting terms in the marginal models for the foreign variables. To perform this test, we firstly estimated the following regression for each element l of $\mathbf{x}_{it}^{*}$ in each country i model:

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[4] All estimations of the present paper were performed using the econometric package Microfit 5 and the GVAR toolbox 1.1 developed by Smith and Galesi (2011).

[5] Note that it is commonly acceptable that the coefficients of the (Johansen) cointegrating vector are not easily interpretable in many times, without imposing (overidentified) restrictions from economic theory. PSW (2004) use their estimates to generate forecasts without insisting on economic interpretations.

[6] The variables of the countries included in the model have probably experienced a number of structural shifts in their intercept or trend during the sample period, due to specific events that have taken place (e.g. the long transition period from centrally-planned to free markets economies for Bulgaria, Croatia, Romania and Slovenia, the involvement of the IMF in the Turkish Economy, and, of course, the current financial and debt crisis that affected all countries). Due to small sample and technical difficulties regarding the estimation of the GVAR model, we did not account for these potential structural breaks in the current analysis.

$$\Delta x^*_{it,l} = \mu_{il} + \sum_{j=1}^{r_i} \gamma_{ij,l} ECM^j_{i,t-1} + \phi_{il} \Delta \mathbf{x}_{i,t-1} + \theta_{il} \Delta \mathbf{x}^*_{i,t-1} + \varepsilon_{it,l} , \quad (11)$$

where $ECM^j_{i,t-1}$ are the estimated error-correcting terms associated with the r_i cointegrating relations for the country i, with $j = 1,...,r_i$. Then, we performed an *F*-test on the joint hypothesis that $\gamma_{ij,l} = 0$ for each $j = 1,...,r_i$. The weak exogeneity tests are reported in table 10 and indicate that in 23 out of 29 cases weak exogeneity cannot be rejected at the 5 per cent level of significance.

4.3 Contemporaneous Effects of Foreign Variables

In general, the above results allow consistent estimation of the contemporaneous effects of foreign-specific variables on their domestic counterparts (at least for the ones where the residual serial correlation tests showed evidence of no serial correlation). The estimated contemporaneous effects are reported in table 11, along with the corresponding standard errors calculated using the White's heteroskedasticity-consistent variance estimator. These estimates can be viewed as impact elasticities. When significant, all of the estimates have the expected sign, being positive. Also, almost all of them are below unity, indicating that there is no strong immediate reaction of foreign-specific variables on their domestic counterparts. The real effective exchange rate impact elasticities are statistically significant for almost all cases, except for Romania and Turkey. The harmonised consumer price index elasticities are significant only for the cases of EMU12, Slovenia and Turkey, while the interest rate impact elasticity is significant only for Greece. Finally, the industrial production elasticities are significant in all cases.

4.4 Persistence Profiles of the Cointegrating Vectors.

Before proceeding with the dynamic analysis and the estimation of generalised impulse response functions, we estimated the persistence profiles for each cointegrating vector. Persistence profiles refer to the time profiles of the effects of system or variable-specific shocks on the cointegrating relations in the GVAR model (Pesaran and Shin, 1996). They have a value of unity on impact, while they should tend to zero as the horizon $n \to \infty$, if the vector under consideration is a valid cointegrating vector. The persistence profiles also provide information on the speed with which the cointegrating relationships return to their equilibrium states. The estimated persistence profiles for each cointegrating vector of our

GVAR model are presented in Figure 1. As shown, they all tend to zero implying that our cointegrating vectors are valid.

5. Generalised Impulse Response Functions

In this section we undertake the dynamic analysis of the GVAR model using Generalised Impulse Response Functions (GIRFs), as they proposed by Koop, Pesaran and Potter (1996) for non-linear models and further developed in Pesaran and Shin (1998) for vector error-correction models. The methodology of GIRFs differs from that of Orthogonalised Impulse Responses (OIRs) developed by Sims (1980) in the following ways: (a) it does not require any a priori economic-based restrictions and its outcome is invariant to the ordering of the variables in the model, since it does not orthogonalise the residuals of the system, as it takes into account the historical correlations among the variables summarised by the estimated variance-covariance matrix, and (b) since shocks are not identified, it cannot provide information about the causal relationships among the variables. However, the methodology of GIRFs has a comparative advantage with respect to the traditional OIRs in the context of multi-country frameworks such as the GVAR model. It can provide insights on how shocks internationally propagate, by unveiling potential linkages among different national economies. Additionally, it is actually a difficult task to employ traditional OIRs in a GVAR framework, since there is no reasonable way to order the countries in the model. The GIRFs are defined as

$$GIRF\left(y_t, u_t, n\right) = \frac{\mathbf{F}_n \mathbf{G}^{-1} \mathbf{\Sigma}_u s_j}{\sqrt{s_j' \mathbf{\Sigma}_u s_j}}, \qquad (12)$$

where s_j denotes a binary shock indicator vector, n is the shock horizon, $\mathbf{\Sigma}_u$ is the corresponding variance covariance matrix of the GVAR and $\mathbf{F} = \mathbf{G}^{-1}\mathbf{H}$. Note here that the dynamic analysis in a GVAR is carried out on the levels of the variables, which implies that the effects of a given shock are typically permanent.

In the present paper, for illustrative purposes, we investigated the propagation of four different macroeconomic shocks: (a) one positive standard error (s.e.) shock to the EMU12's interest rate, (b) one positive s.e. shock to the nominal exchange rate of the euro against the US dollar, (c) one negative s.e. shock to the EMU12's real effective exchange rate, and (d) one negative s.e. shock to the EMU12's industrial production. Since the number of estimated GIRFs is large for the cases (a), (c) and (d) above, we chose to report those GIRFs referred to Bulgaria as the representative country of the former centrally-planned economies, to Cyprus and Greece that are members of the Eurozone and face severe economic crises, and to Turkey that is an emerging economic power of the region.[7] For the case (b) above, we chose to report those GIRFs referred to the same countries plus the EMU12.

The estimated GIRFs are presented in figures 2 to 5. As shown, for the most of them the range of values is of small magnitude. Also, they are moving quickly to equilibrium (less than twelve months for most of them) and thus, our model seems stable.[8] For the cases of Bulgaria, Cyprus and Greece, each of the four alternative macroeconomic shocks seems to have expected effects on the domestic variables. Also, these GIRFs converge to a stable level in the time horizon that we have used. A few exceptions are the responses of the Cyprus' interest rate to the shocks on the nominal exchange rate of the euro against the US dollar and the EMU12's real effective exchange rate, and the response of the harmonised consumer price index of Greece to the shock on the EMU12's real effective exchange rate. However, even though the GIRFs in these three cases do not seem to converge to a stable level, they are very small in magnitude. In the case of Turkey, only the domestic industrial production seems to have expected responses on each of the four alternative macroeconomic shocks. For the cases of domestic real effective exchange rate and harmonised consumer price index, the GIRFs do not converge to a stable level. A possible explanation for this peculiar result could be attributed to the strong inflationary tendencies in the Turkish economy.

6. Concluding Remarks

In this paper we assessed the impact of the Eurozone's economic policies on specific South-Eastern European countries, namely Bulgaria, Croatia, Cyprus, Greece, Romania, Slovenia and Turkey. Since the economic interdependence among these countries is evolving, we carried out our analysis using the GVAR framework. This approach seems quite appropriate, since it allows for the interdependencies that exist between national and international factors in a consistent manner.

Our results indicate that changes in the macroeconomic policies of the Eurozone lead to similar responses on the economies of the sample countries, except for Turkey in the cases of real effective exchange rate and harmonised consumer price index. Also, the macroeconomic

[7] GIRFs that referred to one positive or one negative s.e. shock to each variable of the EMU12 have been estimated for all countries of our model. For saving space we did not report all GIRFs in the paper, but are available under request.

[8] Also, the global model is dynamically stable, as the eigenvalues of the matrix $\mathbf{G}^{-1}\mathbf{H}$ in equation (5) are on or inside the unit circle.

variables of the economies under consideration react in a similar manner to changes in the nominal exchange rate of the euro against the US dollar.

Overall, the above results indicate that there are linkages (a) among the economies of the South-Eastern Europe, and (b) between each of these economies and the Eurozone. Our evidence also implies that the Eurozone's economic policies affect the EU or Eurozone members of this region in the same way. On the other hand, the Turkish economy seems to behave quite differently to Eurozone's macroeconomic policies.

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Table 1. Trade weights

Country	EMU12 (excluding Greece)	Bulgaria	Croatia	Cyprus	Greece	Romania	Slovenia	Turkey
EMU12 (excluding Greece)	0.0000	0.6738	0.8272	0.6906	0.8402	0.8539	0.8667	0.8884
Bulgaria	0.0575	0.0000	0.0080	0.0121	0.0446	0.0229	0.0062	0.0280
Croatia	0.0688	0.0073	0.0000	0.0027	0.0030	0.0047	0.0946	0.0023
Cyprus	0.0178	0.0049	0.0040	0.0000	0.0295	0.0018	0.0003	0.0082
Greece	0.2036	0.1256	0.0079	0.2766	0.0000	0.0305	0.0063	0.0260
Romania	0.1759	0.0538	0.0124	0.0117	0.0293	0.0000	0.0125	0.0420
Slovenia	0.1183	0.0091	0.1269	0.0037	0.0037	0.0078	0.0000	0.0052
Turkey	0.3580	0.1256	0.0137	0.0027	0.0497	0.0785	0.0133	0.0000

Trade weights are computed as shares of imports and exports, shown in columns by country, such that a column sums to unity.

Table 2. Weighted Symmetric ADF Unit Root Test Results

				Intercept and Trend				
Variable	EMU12	Bulgaria	Croatia	Cyprus	Greece	Romania	Slovenia	Turkey
RER	-1.5329	-2.6092	-0.0431	-2.2363	-1.7748	-1.6461	-2.5899	-1.0437
HCPI	-1.9183	-1.5329	-2.7463	-3.6421*	-2.2435	-4.7381*	-1.0668	-0.4965
IR	-2.6421	-1.9379	-2.4853	-1.0797	-1.6651	-0.0994	-3.7813*	NA
IP	-4.3241*	-1.7164	-0.1063	-0.1806	0.2869	-1.3205	-1.7725	-2.7961
RER*	-0.9368	-1.1645	-1.4063	-1.5685	-1.4619	-1.4209	-1.3444	-1.4447
HCPI*	-0.7752	-2.0757	-1.9434	-1.9694	-2.0136	-1.9978	-1.9870	-1.9688
IR*	-0.3737	-2.2023	-2.6736	-2.1991	-2.7164	-2.3174	-2.1091	NA
IP*	-1.9255	-2.9790	-3.5947*	-2.3464	-3.6361*	-3.6647*	-3.3885*	-3.7872*
NER	-2.0078							
				Intercept				
Variable	EMU12	Bulgaria	Croatia	Cyprus	Greece	Romania	Slovenia	Turkey
RER	-1.4441	-0.0477	0.2066	-1.1987	-0.9080	-0.6974	-2.5085	-0.0439
HCPI	0.6914	-1.4441	0.1446	0.7009	1.9581	-0.1012	0.6385	0.8352
IR	-1.5072	-1.7668	-2.3563	-1.1848	-0.6482	1.6999	-0.7607	NA
IP	-4.1725*	-0.6902	0.5455	-0.6262	1.4289	1.3570	-0.9257	-0.3533
RER*	-0.0090	-0.7909	-1.2402	-1.3203	-1.1843	-1.1190	-1.1708	-1.2978
HCPI*	0.7242	0.6908	0.6469	0.8995	0.6367	0.6880	0.7254	0.6556
IR*	1.6106	-0.3206	-1.3522	-0.8986	-1.2823	-1.4510	-0.9345	NA
IP*	-0.5674	-2.3956	-3.1817*	-2.3520	-2.9722*	-3.1381*	-2.9593*	-3.4383*
NER	-1.2457							

The value in each cell is the Weighted Symmetric ADF unit root test statistic. The 95% critical value for this test is -3.24 for regressions with intercept and trend, and -2.55 for regressions with intercept. * denotes rejection of the unit root hypothesis at the 5% level of significance. NA stands for non-available.

Table 3. Cointegration Test Results

Model		EMU12							
		(excluding Greece)				CV[a] Trace		CV maxλ	
VECMX*(3,2)	p-r	Trace	maxλ			95%	90%	95%	90%
restricted	5	180.91**	90.85**			125.59	118.22	51.04	47.10
trend,	4	90.06*	35.58			92.74	86.78	42.62	39.69
unrestricted	3	54.48	27.43			63.06	58.63	34.93	31.94
intercept	2	27.05	21.13			38.98	35.42	28.06	24.81
	1	5.92	5.92			19.52	16.82	19.52	16.82
Model		Bulgaria				CV Trace		CV maxλ	
	p-r	Trace	maxλ			95%	90%	95%	90%
VECMX*(2,2)	4	137.83**	72.11**			101.62	97.05	47.74	43.68
restricted	3	65.72	35.26			72.05	66.57	38.99	35.98
trend,	2	30.46	22.13			44.78	40.81	30.59	28.08
no intercept	1	8.33	8.33			22.31	19.75	22.31	19.75
Model		Croatia				CV Trace		CV maxλ	
	p-r	Trace	maxλ			95%	90%	95%	90%
VECMX*(3,1)	4	149.02**	89.78**			99.48	95.86	45.38	42.54
restricted	3	59.24	27.38			69.39	65.08	37.88	35.76
intercept,	2	31.86	17.86			43.03	39.58	30.57	27.54
no trend	1	14.01	14.01			22.14	19.71	22.14	19.71
Model		Cyprus				CV Trace		CV maxλ	
	p-r	Trace	maxλ			95%	90%	95%	90%
VECMX*(3,3)	4	108.23*	53.55**			109.93	104.70	50.78	47.05
restricted	3	54.67	36.76			76.34	71.30	41.86	38.60
trend,	2	17.91	11.07			46.74	42.73	32.28	29.28
no intercept	1	6.84	6.84			23.56	20.62	23.56	20.62
Model		Greece		Slovenia		CV Trace		CV maxλ	
VECMX*(3,1)	p-r	Trace	maxλ	Trace	maxλ	95%	90%	95%	90%
restricted	4	120.77**	50.86**	154.25**	84.25**	110.02	105.07	48.10	45.29
trend,	3	69.91	32.13	70.00	34.24	79.28	72.63	41.56	38.52
unrestricted	2	37.78	23.13	35.76	22.80	48.80	45.37	33.72	30.40
intercept	1	14.65	14.65	12.96	12.96	24.44	22.04	24.44	22.04
Model		Romania				CV Trace		CV maxλ	
	p-r	Trace	maxλ			95%	90%	95%	90%
VECMX*(3,3)	4	110.32**	57.46**			108.88	103.71	50.23	45.99
restricted	3	52.86	26.73			74.66	69.92	40.73	38.08
intercept,	2	26.13	18.34			46.26	42.57	32.73	29.65
no trend	1	7.79	7.79			23.66	20.83	23.66	20.83
Model		Turkey				CV Trace		CV maxλ	
VECMX*(3,2)	p-r	Trace	maxλ			95%	90%	95%	90%
unrestricted	3	92.83**	62.78**			59.27	54.92	35.18	31.70
intercept, no	2	30.05	25.03*			36.39	33.15	26.47	24.40
trend	1	5.02	5.02			19.08	16.71	19.08	16.71

[a] CV is for critical values. The 95% and 90% critical values are computed by stochastic simulations using 1000 replications. ** and * denote rejection of the null hypothesis at the 5% and the 10% level of significance, respectively.

Table 4. Estimated Coefficients of the Solved Cointegrating Vectors

Parameter estimates	Bulgaria	Croatia	Cyprus	Greece	Romania	Slovenia	Turkey
β_{RER}	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
β_{HCPI}	0.7766	0.1612	0.8885	0.7270	-3.7554	2.7287	-3.6776
β_{IR}	0.0165	-0.0020	-0.0019	-0.0049	-0.0090	0.0006	NA
β_{IP}	-0.6984	0.7068	0.2170	-0.1890	8.9426	-2.2333	-0.8282
β_{RER*}	0.0796	-0.0616	0.4194	0.4309	0.6293	0.1677	-0.3454
β_{HCPI*}	-0.0119	-0.0853	0.0354	-0.0596	-1.4906	-0.2500	3.1525
β_{IR*}	0.0018	-0.0066	0.0093	-0.0013	-0.0257	0.0227	NA
β_{IP*}	0.7777	-0.4826	-0.5429	0.1794	-3.3158	2.1138	1.4591
β_{NER}	NA	NA	NA	NA	NA	NA	NA
Intercept	NA	3.5353	NA	NA	-0.1386	NA	NA
Trend	0.0045	NA	0.0090	-0.0010	NA	-0.0028	NA

β's are the parameters of the solved cointegrating vectors, normalised on the real effective exchange rate. * indicates foreign variables. NA stands for non-available.

Table 5. Estimated Coefficients of the Solved Cointegrating Vectors

Parameter estimates	EMU12	(excluding Greece)
β_{RER}	1.0000	1.0000
β_{HCPI}	0.0945	-0.0882
β_{IR}	0.0202	-0.0079
β_{IP}	-1.4087	-0.0613
β_{NER}	-0.6085	-0.5849
β_{HCPI*}	0.5689	0.6266
β_{IP*}	0.4581	0.0903
Trend	-0.0039	-0.0033

β's are the parameters of the solved cointegrating vectors, normalised on the real effective exchange rate. * indicates foreign variables.

Table 6. Adjustment Coefficients

Parameter estimates	Bulgaria	Croatia	Cyprus	Greece	Romania	Slovenia	Turkey
α_{RER}	0.0009	-0.0116	-0.0470	-0.0123	-0.0094	-0.0165	-0.0803
α_{HCPI}	-0.0044	0.0061	0.0074	0.0034	-0.0186	-0.0130	-0.0330
α_{IR}	0.3315	0.5981	-0.2173	-0.0555	1.9402	-0.0166	NA
α_{IP}	-0.4504	-0.4660	0.2775	-0.2051	-0.2980	-0.3690	-0.1948

NA stands for non-available.

Table 7. Adjustment Coefficients

Parameter estimates	EMU12	(excluding Greece)
α_{RER}	-0.0175	0.0307
α_{HCPI}	0.0270	0.0082
α_{IR}	-0.2384	-0.0193
α_{IP}	0.4646	0.0660
α_{NER}	0.0202	0.0320

Table 8. Average Pair-wise Cross-section Correlations of the Residuals of each VECMX*

Country	RER	HCPI	IR	IP
EMU12	0.0035	-0.1206	-0.0150	-0.2356
Bulgaria	-0.0497	0.0183	0.0074	0.0678
Croatia	-0.0402	-0.0030	-0.0225	0.1636
Cyprus	-0.0214	0.0263	-0.0298	0.1155
Greece	-0.0749	0.1009	-0.0685	0.0485
Romania	-0.0199	0.0329	-0.0206	0.0269
Slovenia	-0.0302	0.0575	0.0161	-0.0044
Turkey	-0.1249	-0.0201	NA	0.0876

NA stands for non-available.

Table 9. Serial Correlation Tests of the VECMX* Residuals

Country	Δ(RER)	Δ(HCPI)	Δ(IR)	Δ(IP)	Δ(NER)	*F*-statistic 5% CV[a]	d.f.[b]
EMU12 (excluding Greece)	2.4015	1.7842	3.6809*	1.3360	3.0303*	2.6795	3,121
Bulgaria	0.0698	0.6685	1.6595	7.3573*	NA	2.6777	3,124
Croatia	0.7454	1.4064	0.1171	2.7451*	NA	2.6777	3,124
Cyprus	0.6949	2.1153	1.6188	2.6523	NA	2.6828	3,116
Greece	2.7988*	0.4819	1.1564	5.3070*	NA	2.6777	3,124
Romania	0.7600	11.8486*	2.9775*	1.1960	NA	2.6828	3,116
Slovenia	0.3234	1.1804	0.4543	2.5361	NA	2.6777	3,124
Turkey	1.9182	2.2266	NA	1.2499	NA	2.6777	3,124

[a] CV is for critical value. [b] d.f. is for degrees of freedom. The value in each cell is *F*-statistic. * denotes rejection of no serial correlation at the 5% level of significance. NA stands for non-available.

Table 10. Weak Exogeneity Tests of the Country-Specific Foreign Variables

Country	RER*	HCPI*	IR*	IP*	*F*-statistic 5% CV[a]	d.f.[b]
EMU12 (excluding Greece)	NA	1.7554	NA	1.0015	3.0766	2, 113
Bulgaria	0.3725	7.3151*	0.0009	9.2996*	3.9188	1, 122
Croatia	0.3541	7.3542*	5.0989*	15.4934*	3.9215	1, 118
Cyprus	0.8575	2.4599	0.1579	2.9529	3.9307	1, 106
Greece	1.4366	0.1678	3.5834	3.1597	3.9215	1, 118
Romania	0.3235	1.2735	1.1750	0.0059	3.9307	1, 106
Slovenia	0.6050	0.0276	0.3832	16.4533*	3.9215	1, 118
Turkey	1.1687	0.7843	NA	0.2911	3.9201	1, 120

[a] CV is for critical value. [b] d.f. is for degrees of freedom. The value in each cell is *F*-statistic. * denotes rejection of weak exogeneity at the 5% level of significance. NA stands for non-available.

Table 11. Contemporaneous Effects of Foreign-Specific Variables on their Domestic Counterparts

Country	RER	HCPI	IR	IP
EMU12 (excluding Greece)	NA	1.4314*	NA	0.9545*
		(0.3096)		(0.1265)
Bulgaria	0.3184*	-0.1159	0.2361	0.5578*
	(0.0732)	(0.1048)	(0.4502)	(0.0590)
Croatia	0.1233*	0.0998	-2.6136	0.5352*
	(0.0518)	(0.0633)	(1.6822)	(0.0496)
Cyprus	0.5843*	0.1180	0.0230	1.0677*
	(0.0692)	(0.0983)	(0.1119)	(0.0941)
Greece	0.3913*	0.0522	0.5989*	0.5689*
	(0.0201)	(0.0456)	(0.1377)	(0.0435)
Romania	-0.1227	0.0499	-1.2574	0.4409*
	(0.1067)	(0.0664)	(1.6252)	(0.0455)
Slovenia	0.2889*	0.0795*	0.2722	0.9794*
	(0.0312)	(0.0315)	(0.1605)	(0.0332)
Turkey	0.0917	0.1330*	NA	0.2413*
	(0.2993)	(0.0378)		(0.0558)

Numbers in parentheses are standard errors based on White's heteroskedasticity-consistent variance estimator. * denotes statistical significance at the 5% level of significance. NA stands for non-available.

Figure 1. Persistence Profiles of the Effect of System-Wide Shocks to the Cointegrating Relations of the GVAR Model

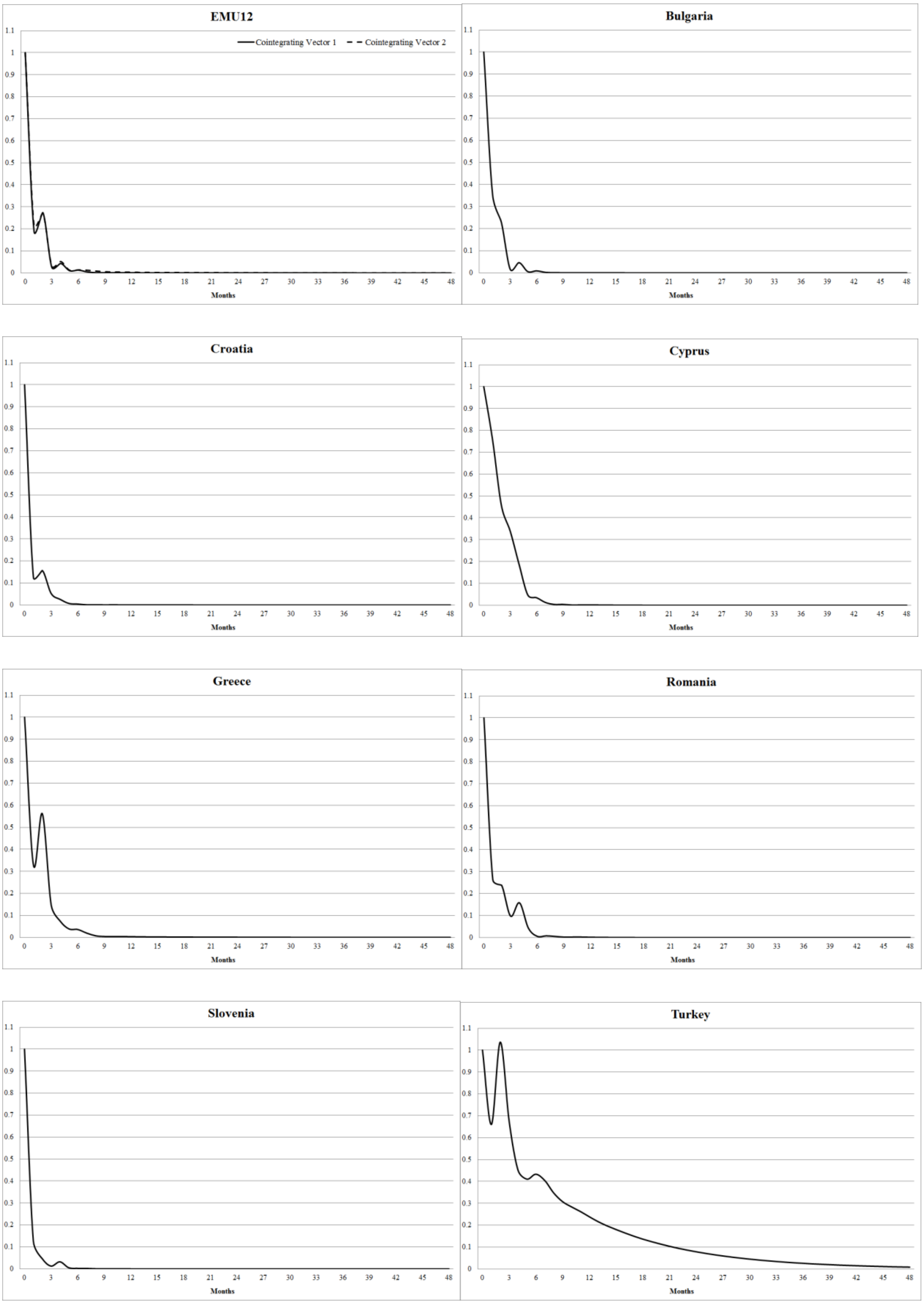


Figure 2. GIRFs of one positive s.e. shock to the EMU12's interest rate

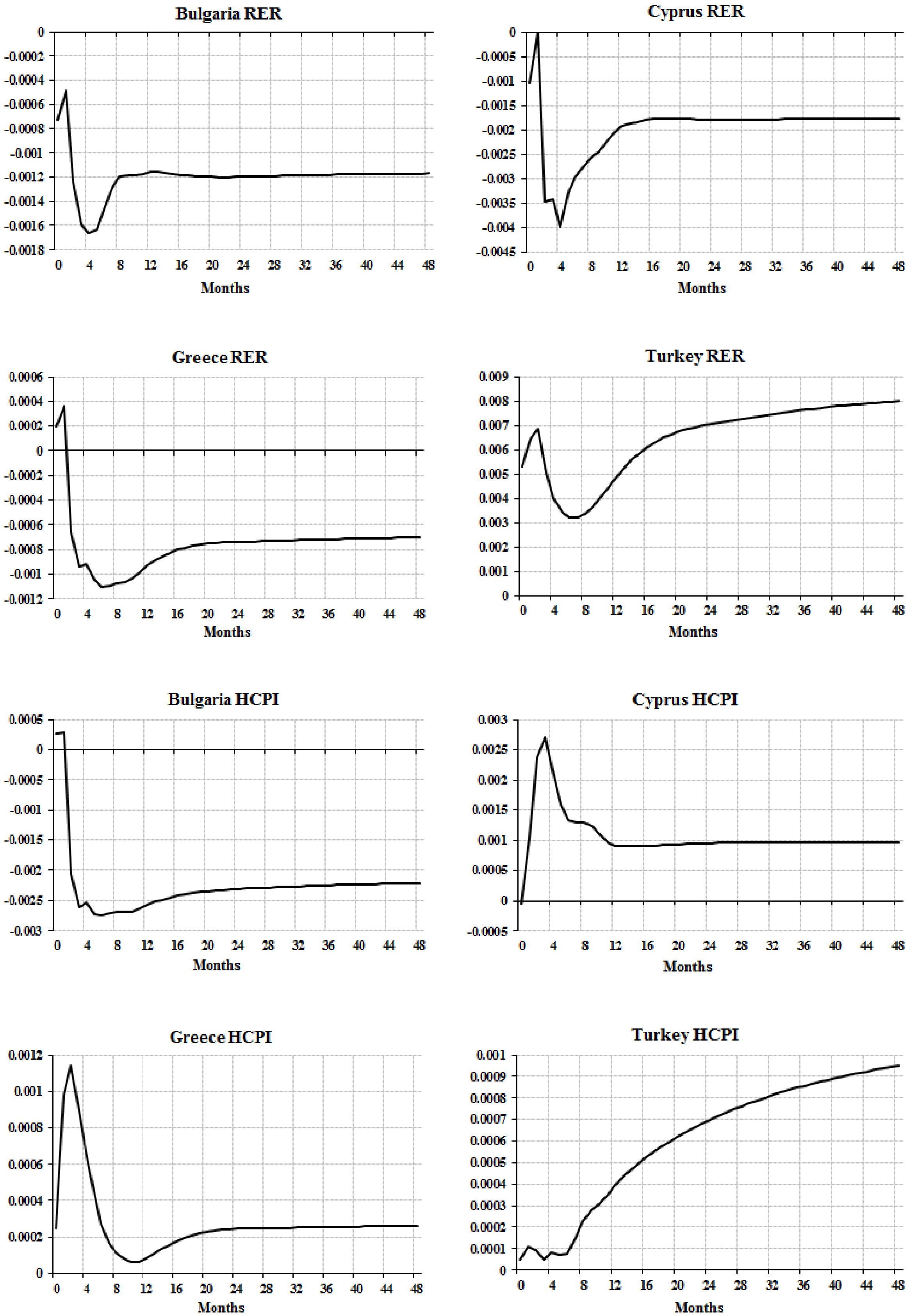


Figure 2. ***(continued)***

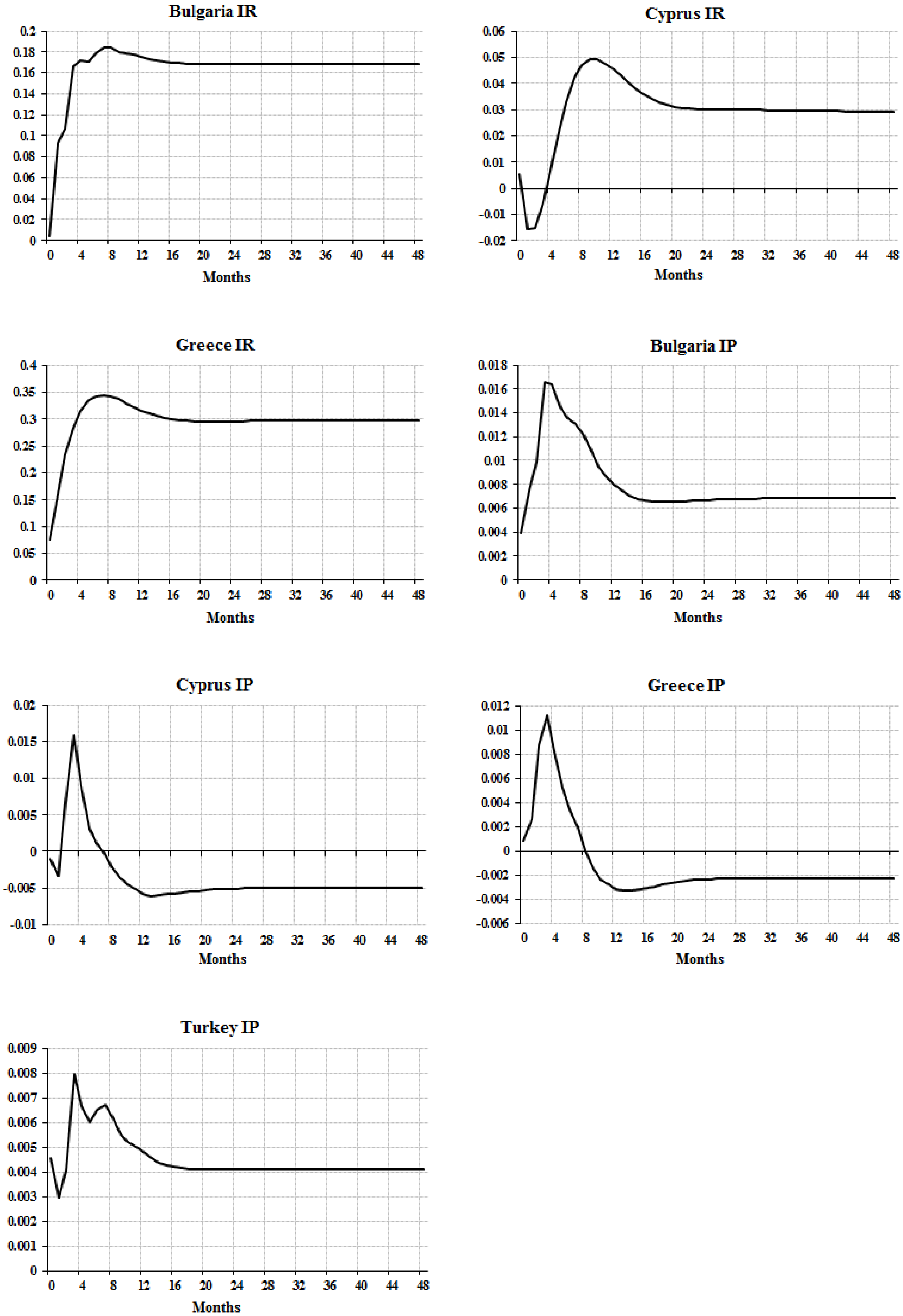


Figure 3. GIRFs of one positive s.e. shock to the nominal exchange rate of the € against $

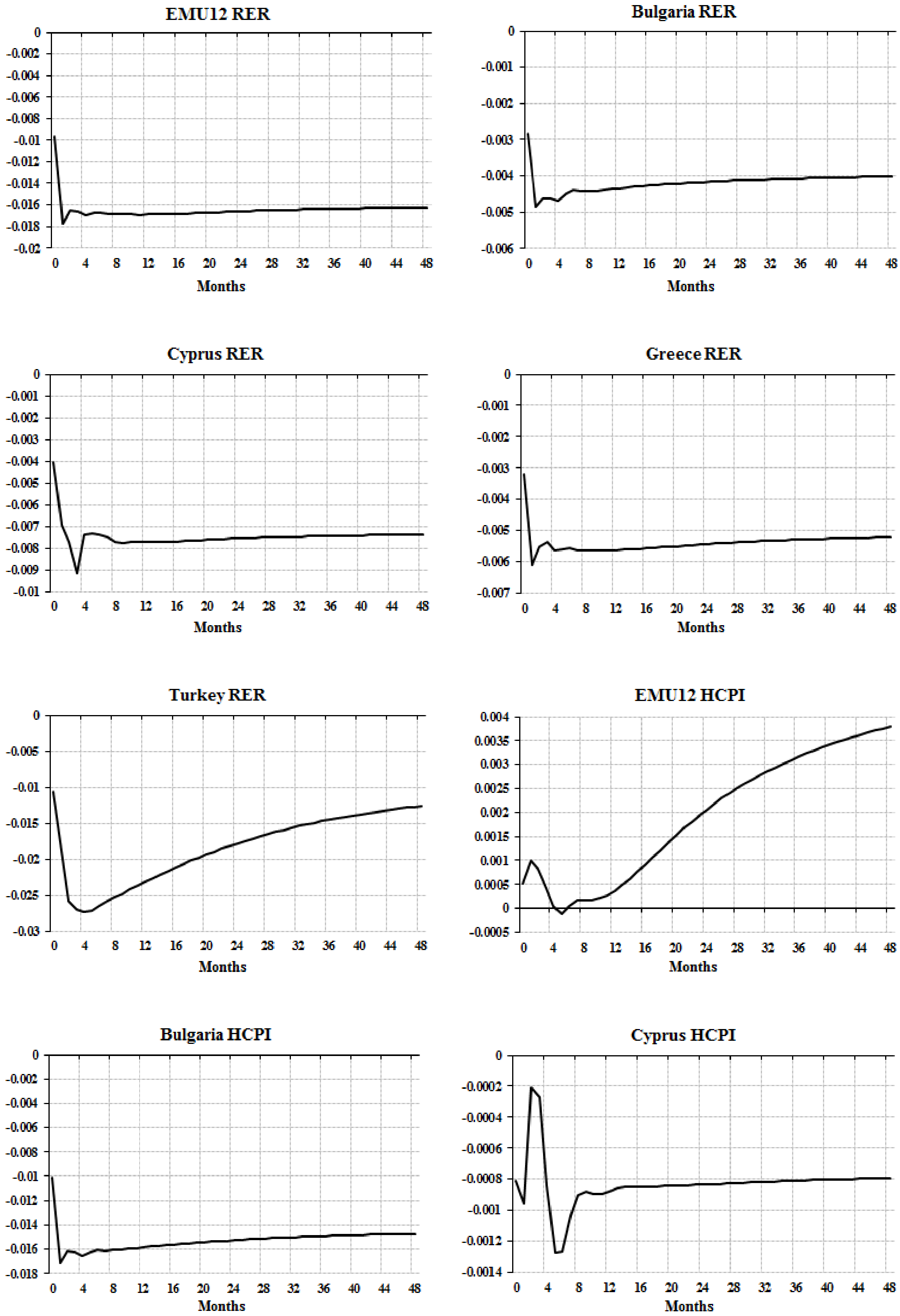


Figure 3. ***(continued)***

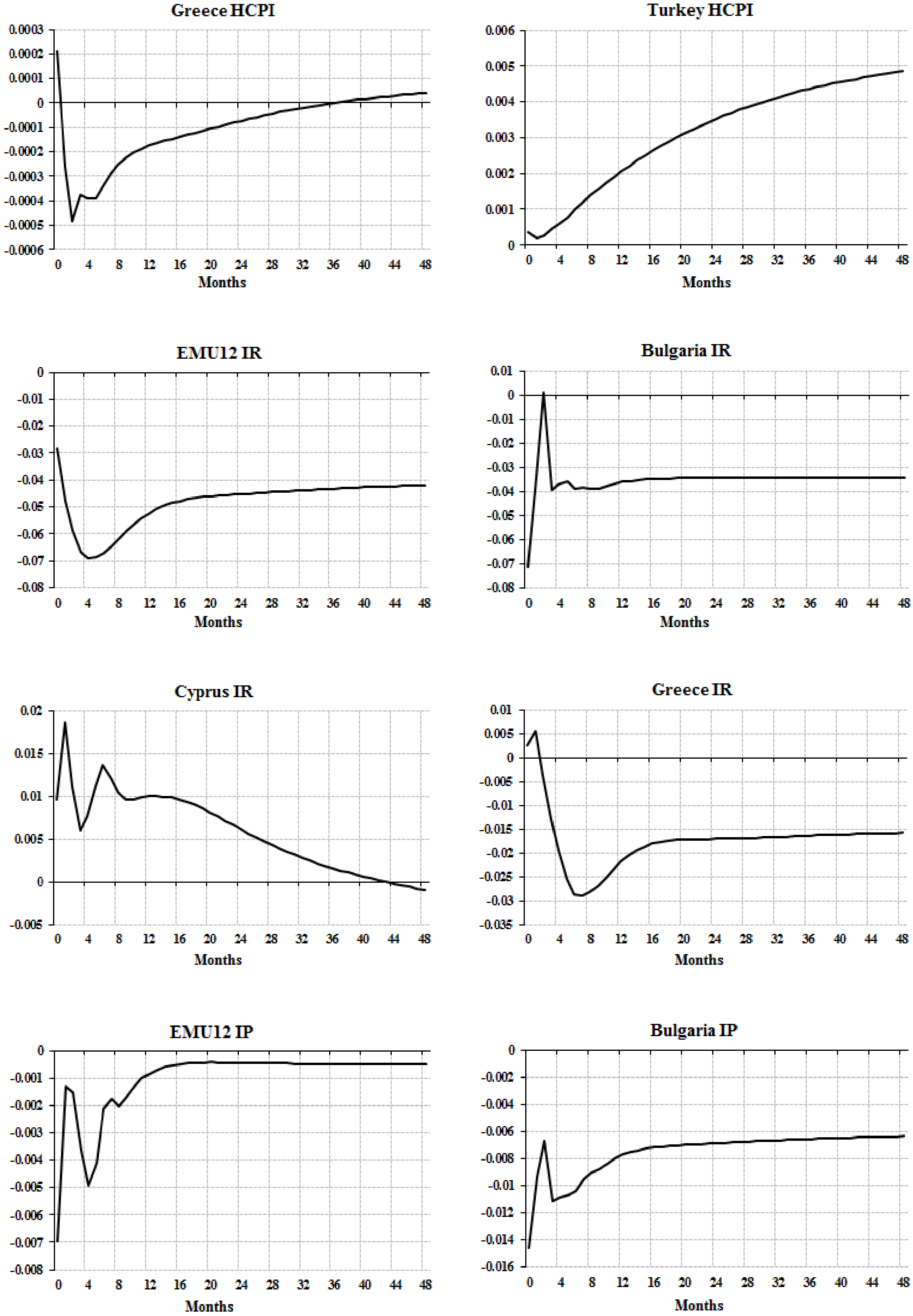
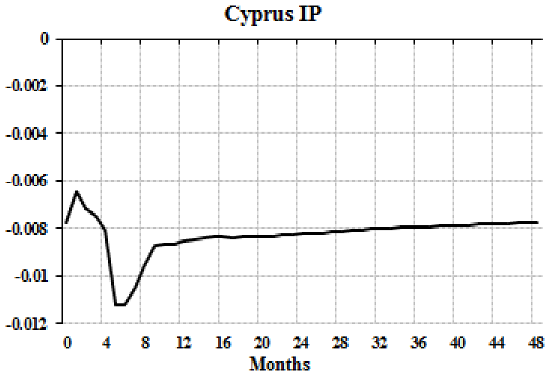
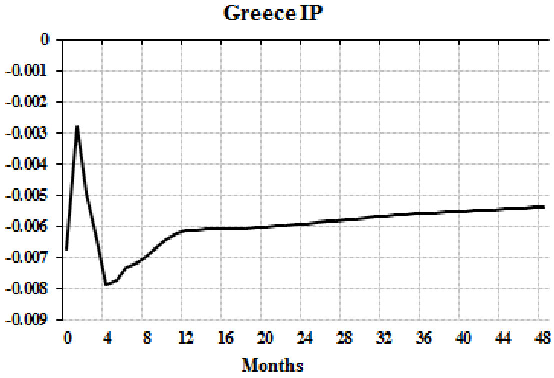


Figure 3. ***(continued)***





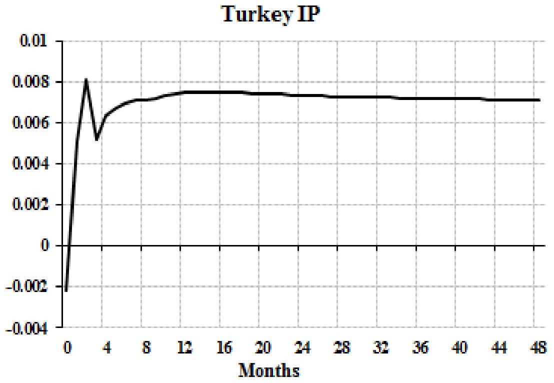


Figure 4. GIRFs of one negative s.e. shock to the EMU12's real effective exchange rate

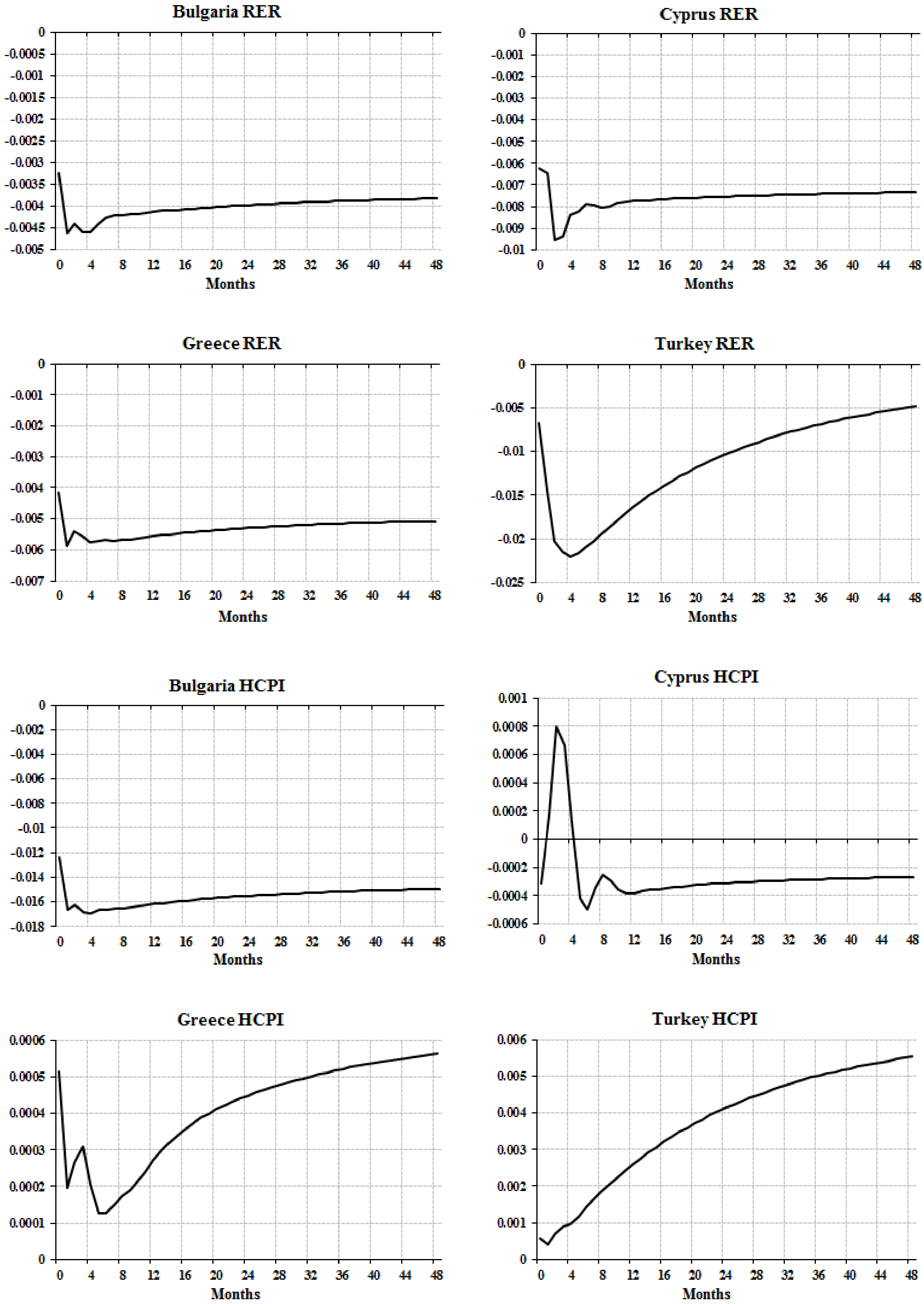


Figure 4. ***(continued)***

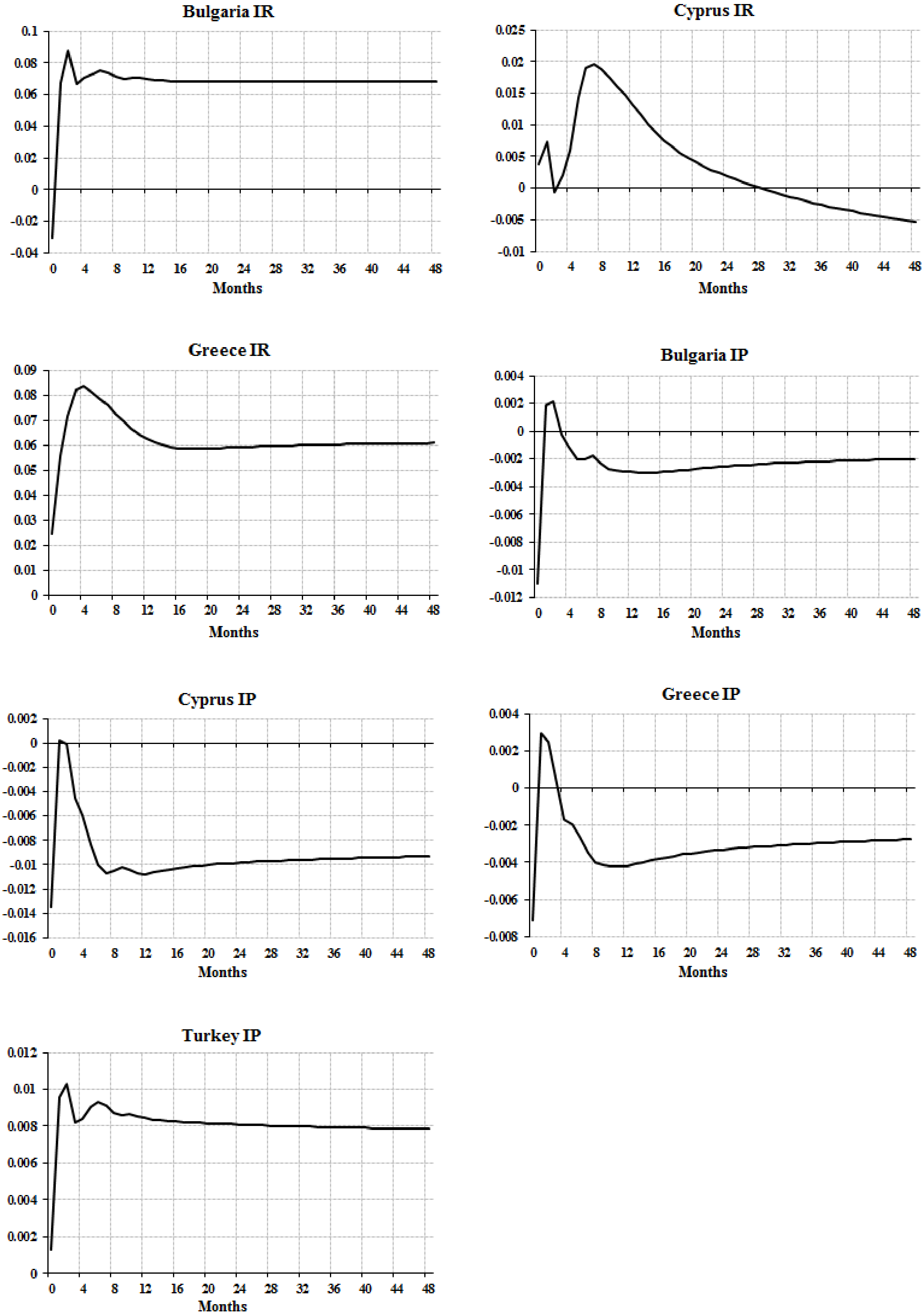


Figure 5. GIRFs of one negative s.e. shock to the EMU12’s industrial production

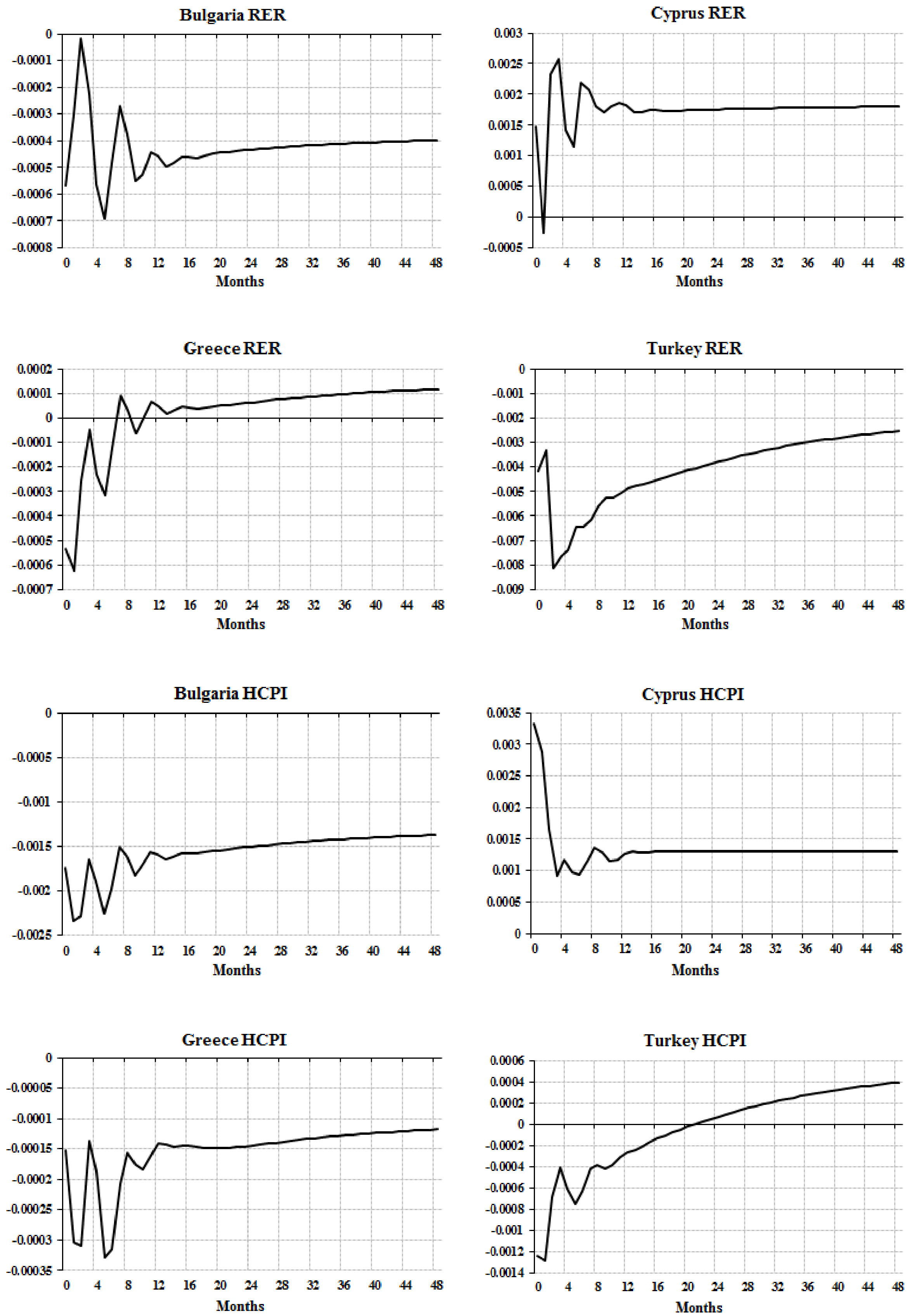


Figure 5. ***(continued)***