The difficult marriage between the real exchange rate and its fundamentals: Have they broken up after the crisis?

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Abstract

In this paper we contribute to the long literature on determining the real exchange rate by using models that incorporate structural breaks and nonlinearities. We estimate cointegrated dynamic ordinary least squares regressions and Bayesian vector autoregressions (VAR), and quantile regressions. We find that the estimated coefficients for the CEECs and for the other member states differ from each other. We also find that the models are different before and after the crisis, and seem to condition the long-run equations for the EU15+Cyprus and Malta.

Key words: Real exchange rates, competitiveness, quantile regression, Bayesian, asymmetric model, structural breaks, European integration.

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1. Introduction

Purchasing power parity (PPP) and the long-run determinants of real exchange rates (RERs) have probably been researched more than any other topic in international finance. This is because the empirical fulfilment of PPP can be understood as a measure of economic integration (Wei and Parsley 1995), while RER can be considered a measure of competitiveness. The theory of PPP states that the RER between two currencies should be equal to one, so it should be possible to buy a similar basket of goods in two different countries for the same amount of money when prices are translated into a common currency. Many authors, like Taylor (2002) among others, have established that if the PPP condition holds, it does so only in the long run. In consequence, analysis of PPP relies on using tests for the order of integration and cointegration techniques, looking for cointegration between prices and nominal exchange rates so as to assess whether the RER is a mean-reverting process.

Many authors have established that in general the PPP hypothesis does not hold even in the long run, and only *qualified* versions of PPP are accepted when structural breaks and nonlinear models are allowed for (Christidou and Panagiotidis 2010, Cuestas 2009, and many others).

So if the RER is a nonstationary process, the next step is to analyse its cointegrating relationships with the long-run fundamentals. It should be remembered that the RER is a measure of the external competitiveness of an economy, and studying its evolution over time can give us policy insights into how it can be improved. A departure from parity implies that the relative competitiveness of a country has changed. Competitiveness is a key factor for enhancing economic growth, especially for members of the Economic and Monetary Union (EMU), who cannot devalue their currencies.

In this paper we analyse the relationship between the RERs of the EU28 and their main fundamentals, and how the relationships may have suffered from changes in the form of structural breaks, the impact of appreciations or depreciations, and the possibility that the actual values of the RER may condition the relationships. The EU28 is a diverse group of countries with different degrees of economic integration and development, and, as shown in Figure 1, the RERs of these target countries have evolved in quite different ways (Cunado 2011). The *old* EU countries show swings in their RERs without any clear pattern of appreciating or depreciating, but it is quite obvious that the Great Recession and the debt crisis had an impact on those RERs (Cuestas, et al. 2014). The RERs of the central and eastern European countries (CEECs) meanwhile show a clear upward trend until 2008 because of the Balassa-Samuelson (Balassa, 1964, and Samuelson, 1964) effect and the dynamic Penn effect (Degler and Staehr 2019). However, all those countries except Czechia and Croatia have to act under the common commitments given by the Euro Plus Pact and the Macroeconomic Imbalance Procedure of the Six Pack (Gabrisch and Staehr 2015). This mechanism targets several measures of competitiveness, highlighting the need to analyse the main fundamentals and potential changes in competitiveness. Central banks in most EU countries produce dedicated policy reports on competitiveness, again highlighting the importance of monitoring it.

The literature on the determinants of the RER is so extensive that a full paper could be devoted to summarising the most relevant contributions. Here we provide only a brief summary of the main determinants of it. As established in Cuestas et al. (2019) *"the long-run relationship is usually obtained using either time series or panel cointegration techniques. Ideally, the selection of these fundamentals should be based on a model for determining exchange rates"*. The starting point of theoretical models is the Mundell-

Fleming model further developed by Frenkel and Razin (1996), which accounts for short-run price stickiness in a stochastic set up. Following in this vein, the Obstfeld and Rogoff (1995) theoretical model is applied by Aguirre and Calderón (2005), who use as fundamentals productivity, net foreign assets, the terms of trade, and government expenditure. A similar list of fundamentals is proposed by Lane and Milesi-Ferretti (2004), who emphasise the role of net foreign assets, and Galstyan and Lane (2009), who highlight the importance of government spending and investment for the evolution of the RER. The importance of the terms of trade in determining the RER has been established by Neary (1988), Amano and van Norden (1995 and 1998), and Benigno and Thoneissen (2003) among others.[1]

Given that it has been established by estimates from panel cointegration techniques based on dynamic ordinary least squares (DOLS) that RERs are not stationary in the EU, we analyse the relationship between the RER (*q*) and its main fundamentals, which are the current account as a proportion of gross domestic product (GDP) (*ca*); real government consumption (*gco*); real gross fixed capital formation as a proxy for investment (*gfcf*); openness (*op*); the terms of trade (*tot*); and real GDP (*y*). We not only estimate the equation for the full panel, but we also separate the panel into the CEECs and the other EU members. This is done because, as established in Christopoulos et al. (2012), the capacity of a country to attract international lending may affect the relationship between the RER and its fundamentals.

We also estimate equations that account for the effect of the Great Recession. In order to do so, we interact the fundamentals with dummy variables for the periods before and after 2008. Since the effect of appreciations and depreciations in the RER can have real

[1] For applications see Gil-Alana et al. (2008) Coleman (2008), and Meshulam and Sanfey (2019) among many others.

effects of different magnitude (Taylor and Peel 2000, Cuestas et al. 2019), we also estimate the models to account for asymmetries of this type by using interaction dummies for periods of depreciation and appreciation (Carmona-González and Díaz-Roldán 2016). All these models are also estimated in a Bayesian vector autoregressive (BVAR) model for robustness.

Finally, the equations are estimated as quantile regressions in order to assess whether various misalignments from parity affect the relationship between the RER and its fundamentals.

The remainder of the paper is organised as follows. In section 2, we summarise the modelling strategy and the econometric methods. In section 3, we present the results, and finally the last section concludes.

2. The modelling

Our model builds upon the long-run equation proposed by Cuestas et al. (2019), who estimate RER models for CEECs using the fundamentals proposed by Berg and Miao (2010) and Vieira and MacDonald (2012). Cuestas et al. (2019) use the interest rate differential, but we use the current account as a proportion of GDP instead. We believe that the current account expresses capital inflows or outflows better than the interest rate differential does.

Our long-run equilibrium RER specification is as follows:

$$q_{ti} = c + \beta_1 ca_{ti} + \beta_2 gco_{ti} + \beta_3 gfcf_{ti} + \beta_4 op_{ti} + \beta_5 tot_{ti} + \beta_6 y_{ti} + \varepsilon_{ti} \quad (1)$$

It is difficult to establish the expected signs for all the coefficients in advance, as in many cases the sign depends on whether the tradeable or the non-tradeable sector dominates. For instance β_5 is expected to have a positive sign (Benigno and Thoneissen

2003), but β_1 should be negative if expenditure on non-tradeables carries a higher weight and positive if tradeables dominate. β_2, β_3 and β_6 should be positive if demand shocks dominate (Galstyan and Lane 2009), but if spending happens proportionally more in the more productive tradeable sector, then β_1 should be positive and β_2, β_3 and β_6 negative. The sign of β_4 is expected to be negative, as the RER depreciates due to imports of cheaper consumption products.

In this paper we analyse the relationship between the RER and its fundamentals using the DOLS estimations proposed by Stock and Watson (1993), to account for the heterogeneity of the panel. To do this we use pooled, pooled weighted, and group mean estimations. Kao and Chiang (2001) establish that DOLS outperforms fully modified least squares and ordinary least squares for estimating panel cointegrated relationships. DOLS relies upon single equation models, with leads and lags of the I(1) explanatory variables in first differences to correct for endogeneity problems. This is how the base for equation (1) is estimated.

As explained in the introduction we also account for the possibility of time varying parameters by estimating a broken equation, with different slopes for the periods before 2008Q1 and after 2007Q4. We do this by interacting two dummy variables with the fundamentals given in equation (1), to estimate the following equation:

$$q_{ti} = c_i + d2008 * (\beta_1 ca_{ti} + \beta_2 gco_{ti} + \beta_3 gfcf_{ti} + \beta_4 op_{ti} + \beta_5 tot_{ti} + \beta_6 y_{ti}) + d2008on * (\beta_7 ca_{ti} + \beta_8 gco_{ti} + \beta_9 gfcf_{ti} + \beta_{10} op_{ti} + \beta_{11} tot_{ti} + \beta_{12} y_{ti}) + \varepsilon_{ti} \qquad (2)$$

where *d2008* is a dummy variable which takes the value 1 for dates from the beginning of the sample until 2007Q4 and 0 otherwise and *d2008on* takes the value 1 from 2008Q1 onwards and 0 otherwise.

As mentioned above, we also account for asymmetric effects depending on whether the RER experienced a depreciation or an appreciation in the preceding period. We estimate the equation:

$$q_{ti} = c_i + apre * (\beta_1 ca_{ti} + \beta_2 gco_{ti} + \beta_3 gfcf_{ti} + \beta_4 op_{ti} + \beta_5 tot_{ti} + \beta_6 y_{ti})$$

$$+depre * (\beta_7 ca_{ti} + \beta_8 gco_{ti} + \beta_9 gfcf_{ti} + \beta_{10} op_{ti} + \beta_{11} tot_{ti} + \beta_{12} y_{ti})$$

$$+ \varepsilon_{ti} \quad (3)$$

where *apre* is a dummy variable that takes the value 1 if the RER appreciated in *t*-1 and 0 otherwise, and *depre* is a dummy variable that takes the value 1 if the RER depreciated in *t*-1 and 0 otherwise.

As a robustness analysis we use BSVAR equations to estimate the models. These models are based on the estimation of structural vector autoregressive (SVAR) models such as:

$$\delta_0 Y_t = \delta(L) Y_t + \varepsilon_t \quad (4)$$

where δ_0 is the matrix of contemporaneous parameters, δ is a matrix of coefficients for the lagged variables, and *L* is the lag operator in polynomial form. As δ_0 cannot be fully identified, we use the generalised impulse response functions proposed by Pesaran and Shin (1998).

We estimate equation (4) using Bayesian methods to obtain

$$\pi(\partial|Y) \propto f(Y|\partial)\pi(\partial) \quad (5)$$

where ∂ is a vector of coefficients, $\pi(\partial \mid Y)$ is the posterior distribution conditional on the sample Y, $f(Y|\partial)$ is the likelihood function, and $\pi(\partial)$ is the prior distribution about the parameters. Bayesian methods confer some advantages over frequentist methods, as they use a set of information that is enriched by priors, and the order of integration of the variables is not relevant for the analysis (Sims 1988).

In time series econometrics it is very common to use the Normal-Wishart (NW) prior, which is based on the Litterman (1986) Minnesota prior. The NW prior assumes that the parameters are normally distributed, that the series are unit root processes and that the residual variance-covariance is not known. The variance of the parameters is calculated as:

$$\sigma_{\delta_{ii}}^2 = \left(\frac{\lambda_1}{l^{\lambda_3}}\right)^2 \quad (6)$$

$$\sigma_{\delta_{ij}}^2 = \left(\frac{\sigma_i^2}{\sigma_j^2}\right)\left(\frac{\lambda_1 \lambda_2}{l^{\lambda_3}}\right) \quad (7)$$

with $\lambda_1 = 0.1$, $\lambda_2 = 1$ and $\lambda_3 = 1$.

Finally, we estimate quantile regressions, which allow us to obtain estimated coefficients conditional on quantiles of the values of the dependent variable. This approach allows us to consider not only models that represent the mean values, but also those with different values for the RER. This means we can estimate the long-run equation for a relatively large deviation from the mean. We can then consider regressions between the independent variable x, and the dependent one y, conditional on y, so $Q_q(y|x)$. The quantile q splits the data into the proportions q below and 1-q above. In quantile regressions, the coefficients are obtained so that they minimise a sum that gives asymmetric penalties (1-q)|e_i| for over-prediction and q|e_i| for under-prediction, where e_i is the model prediction error. In other words, the method for estimating the coefficients for a given quantile minimises the following function:

$$Q(\beta_q) = \sum_{i:y_i \geq x_i'\beta}^{N} q|y_i - x_i'\beta| + \sum_{i:y_i < x_i'\beta}^{N} (1-q)|y_i - x_i'\beta| \qquad (8)$$

3. Empirical analysis

The data for the EU28 countries are downloaded from Eurostat and consist of seasonally unadjusted quarterly series for the log of the real effective exchange rate, *q*, using the consumer price index for the 37 main industrial-country trading partners with an increase indicating an appreciation in real terms; the current account as proportion of GDP, *ca*; the log of real government consumption, *gco*; the log of real gross fixed capital formation, *gfcf*; the log of openness defined as the sum of exports and imports as a proportion of GDP, *op*; the log of the terms of trade measured as the ratio between export prices and import prices, *tot*; and the log of real GDP, *y*, for our target EU28 countries. The data run from 1995Q1 to 2019Q2 with a few exceptions that make the dataset an unbalanced panel.[2]

[2] For Austria, *gco*, *gfcf*, *tot* and *y* start in 1996Q1. For Belgium, the *ca* starts in 2003Q1. For Bulgaria, the *ca* starts in 1998Q1. For Croatia, all variables expect the *rer* start in 2000Q1. For Cyprus, the *ca* starts in 2008Q1. For Denmark, the *ca* starts in 2005Q1. For France, the *ca* starts in 1999Q1. For the UK, the *ca* starts in 1997Q1. For Greece and Ireland, the *ca* starts in 2002Q1. For Italy, the *gco*, *gfcf*, *op*, *tot* and *y* start in 1996Q1. For Latvia, the *ca* starts in 2000Q1. For Malta, all variables start in 2000Q1, except for the *rer* (1995Q1) and the *ca* (2004Q2). For the Netherlands, the *ca* starts in 2003Q2. For Poland and Slovakia, the *ca* starts in 2004Q1. For Portugal, the *ca* starts in 1996Q1. For Romania, the *ca* starts in 1999Q1. For Sweden, the *ca* starts in 1995Q2.

Preliminary analysis suggests that most of the variables are I(1) and the panel cointegration techniques suggest that there is cointegration between them.[3]

All the models include three centred seasonal dummies to account for seasonal effects in the variables. The leads and lags for the DOLS estimations have been obtained using the Bayesian Schwarz information criterion, but omitted to save space. All the DOLS equations have been estimated using heteroskedasticity and autocorrelation corrected (HAC) Newey-West residuals.

In Table 1 we present the results of equation (1) for all the countries, the CEECS, and the EU15+2 group, where the two are Cyprus and Malta, using three different methods of pooled, pooled weighted, and group mean to treat the heterogeneity. The results for all EU28 countries show that although the current account is significant at the 10% level with the pooled estimations, it is not significant with the other two methods. Government consumption does not seem to affect the real exchange rate with the pooled estimations and pooled weighted ones, but it has a positive and significant effect in the group mean estimations. Openness and the terms of trade have a positive and significant effect on the real exchange rate, while real income only shows a significant and positive effect in the pooled weighted regressions. There are some differences between the CEECs and EU15+2 groups, as the effect of the current account for the CEECs appears to be positive and significant with two of the three estimation methods, but it is negative and significant for the EU15+2 group only in the pooled weighted method. Government consumption is only significant for the EU15+2 countries, which may be because investment has been the driving factor in the CEECs. Openness also carries a different sign in the CEECs from that in the EU15+2 countries. This may be a consequence of

[3] Results are available upon request.

the types of capital flow and imported consumption products and services in the two groups. Finally, the estimated coefficient for real income is only significant for the EU15+2 countries. The negative sign implies that supply side type growth is more predominant, as the countries become more competitive when income increases.

In Table 2 we show the results for the periods before and after 2008 separately, and in Table 3 we present the equality tests for the coefficients comparing the periods before and after 2008. From this table we see that the null of equality of the residuals before and after 2008 is strongly rejected in all cases. Table 2 also shows that the adjusted determination coefficients are higher than those in Table 1. This shows evidence of a clear structural break at the beginning of the Great Recession. The signs and significance of the coefficients during the period before 2008Q1 are very similar to those obtained in Table 1, but the variables lose their significance after the crisis. The public sector seems to play an important role in the recovery period though, and so when the real exchange rate is modelled it should be remembered that the Great Recession may have changed the way the RER reacts to its traditional fundamentals, and this may have an impact on models for forecasting exchange rates.

Tables 4 and 5 show the estimations that account for the effect of a depreciation or an appreciation in the RER in the previous period. First, the equality tests show that any difference between the coefficients is mild, at the 10% level for all countries, and is only clearly significant for the EU15+2. This means the results stand in some contrast to those of Carmona-González and Díaz-Roldán (2016), who find that the asymmetric effect tends to disappear within a monetary union (Grauwe and Sénégas 2004).

Next we may present the results of the BVAR models with two lags. Three centred seasonal dummies have been included in all the models along with country fixed effects dummies, which are all treated as exogenous. In Figure 2 we display the impulse response functions (IRFs) for the full model. We observe that the current account has a positive effect on the RER on impact, although in the following periods we observe a depreciation with a long period for recovery. The effect of government consumption is negative on impact, overshooting in the second period and with a depreciation in the following periods and a slow mean reversion. Investment has a negative effect on impact and causes an appreciation in the following periods. The reaction of the RER to an openness shock is very small on impact, with the RER increasing, overshooting, and appreciating over the long run. Terms of trade shocks cause a clear appreciation of the RER with a very slow mean reversion, and finally, a real income shock causes a depreciation on impact but a semi-permanent appreciation in the long run.

The results for the periods before and after 2008, which are displayed in Figures 3 and 4, show differences in the speed of mean reversion, as it seems to be more pronounced and have longer effects in the period before the crisis. In addition, the graphs displayed in Figures 5 and 6 highlight that shocks seem to have a stronger effect in the EU15+2 group than in the CEECs. Figures 7 and 8, which display the IRFs for the CEECs for the periods before and after 2008, show that, as before, it seems that the results are stronger in the period before the crisis than in the period during and after the Great Recession. Similar results are obtained in Figures 9 and 10 for the EU15+2 countries.

Finally, we present the results of the quantile regressions, which also contain three centred seasonal dummies and country fixed effects. In Figure 11 we present the graphs for the estimated coefficients for the different quantiles and in Table 6 we present the equality tests for the coefficients in the 0.25, 0.5 and 0.75 quantiles. From the Wald test we find that the hypothesis of equality is rejected, and that the main differences come from the coefficient of openness. We observe that the effect of openness becomes weaker the more the RER appreciates. This may be because of the type of products imported as the RER becomes stronger for a country, which normally goes hand in hand through the Balassa-Samuelson effect with a higher degree of development. Table 7 shows tests for *U* effects, which seem to be present in this case.

Figure 12 and Table 8 show the estimated coefficients for the different quantiles and equality tests for the CEECs group. The results indicate that the effect of the terms of trade and income on the RER seem to be very sensitive to how far the RER is misaligned from parity. Of particular note, the results suggest that the effect of the terms of trade becomes stronger the more the RER appreciates, while the result is the opposite for real income. Table 9 shows that there is symmetry between the 0.25 and 0.75 quantiles.

In Figure 13 and Tables 10 and 11 we present the estimated coefficients and the equality and symmetry tests for the EU15+2 countries. Overall, we see that the coefficients differ across quantiles for the current account, investment and income. The effect of the current account and investment seems to become less negative for quantiles between 0.2 and 0.5, whereas the coefficient for real income becomes more negative as the quantiles increase.

4. Conclusion

In this paper we aim to analyse how the relationship between the EU28's RERs and their main fundamentals has changed for quarterly data for the period 1995Q1-2019Q2.

We estimate a DOLS cointegrated relationship allowing for breaks in 2008Q1 and conditional on appreciations and depreciations of the real exchange rate, along with BVAR equations. We find that separating the central and eastern European countries from the remaining EU member states leaves them with different coefficients, and that the Great Recession did indeed have an impact on how the main RER fundamentals affect the long run equilibrium RER. We also find evidence of asymmetric effects for the EU15 + Cyprus and Malta, since the coefficients are different when the RER appreciates and depreciates.

Finally, quantile regressions show that how far the RER is misaligned from parity also conditions the long-run equilibrium.

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Table 1: DOLS long run estimated

Variable	All	CEECs	EU15+2	All	CEECs	EU15+2	All	CEECs	EU15+2
		Pooled			Pooled (weighted)			Group Mean	
ca	0.15*	0.52***	-0.08	-0.05	0.60***	-0.25***	0.06	0.05	0.06
	(0.08)	(0.13)	(0.08)	(0.05)	(0.11)	(0.06)	(0.08)	(0.11)	(0.11)
gco	-0.02	-0.03	0.29***	-0.00	-0.05	0.28***	0.16***	0.10	0.19***
	(0.04)	(0.07)	(0.44)	(0.03)	(0.06)	(0.03)	(0.05)	(0.08)	(0.07)
gfcf	0.07***	0.20***	-0.00	0.00	0.18***	-0.05***	0.08**	0.11**	0.07
	(0.03)	(0.05)	(0.02)	(0.02)	(0.04)	(0.01)	(0.04)	(0.05)	(0.05)
op	0.15***	0.14***	-0.04*	0.08***	0.10***	-0.05***	-0.03	0.18**	-0.11***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.01)	(0.03)	(0.04)	(0.04)
tot	0.41***	-0.03	0.00	0.49***	0.06	0.07	0.35***	0.47***	0.27**
	(0.06)	(0.09)	(0.07)	(0.05)	(0.09)	(0.05)	(0.09)	(0.16)	(0.12)
y	0.00	0.03	-0.20***	0.11**	0.08	-0.07*	-0.10	-0.05	-0.12
	(0.06)	(0.09)	(0.06)	(0.05)	(0.07)	(0.05)	(0.09)	(0.10)	(0.14)
Adj-R^2	0.63	0.75	0.53	0.62	0.75	0.51	-	-	-
No. obs.	2281	920	1361	2281	920	1361	2281	920	1361
No. countries	28	11	17	28	11	17	28	11	17

Note: *** significant at the 1%, ** significant at the 5% and * significant at the 10%.

Table 2: DOLS long run estimates break 2008

Variable	All	CEECs	EU15+2	All	CEECs	EU15+2	All	CEECs	EU15+2
Before 2008Q1		Pooled			Pooled (weighted)			Group Mean	
ca	0.38***	0.66***	-0.40***	0.24***	0.62***	-0.43***	0.32*	0.53**	0.17
	(0.11)	(0.18)	(0.15)	(0.09)	(0.15)	(0.12)	(0.17)	(0.22)	(0.25)
gco	0.06	0.00	0.50***	0.04	-0.07	0.44***	0.09	-0.19	0.28
	(0.05)	(0.07)	(0.06)	(0.03)	(0.07)	(0.06)	(0.20)	(0.23)	(0.29)
gfcf	0.15***	0.15**	-0.08*	0.11***	0.18***	-0.09**	-0.02	0.00	-0.03
	(0.04)	(0.06)	(0.05)	(0.03)	(0.06)	(0.04)	(0.06)	(0.07)	(0.10)
op	0.15***	0.08**	-0.00	0.04	0.03	-0.02	0.14**	0.31***	0.02
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.06)	(0.08)	(0.09)
tot	0.44***	0.20	-0.22**	0.54***	0.37***	-0.00	0.56***	0.88***	0.34
	(0.08)	(0.14)	(0.11)	(0.07)	(0.12)	(0.08)	(0.18)	(0.20)	(0.27)
y	-0.15*	-0.12	-0.38***	-0.03	0.06	-0.25***	-0.09	0.22	-0.31
	(0.08)	(0.23)	(0.09)	(0.06)	(0.10)	(0.08)	(0.21)	(0.25)	(0.32)
From 2008Q1									
ca	-0.13	-0.12	0.10	-0.05	0.08	-0.11	-0.03	0.11	-0.12
	(0.12)	(0.23)	(0.11)	(0.06)	(0.20)	(0.09)	(0.10)	(0.11)	(0.15)
gco	0.08	0.24***	0.21***	0.02	0.13*	0.20***	-0.04	0.07	-0.12
	(0.05)	(0.09)	(0.07)	(0.04)	(0.08)	(0.09)	(0.10)	(0.11)	(0.14)
gfcf	0.03	0.07	0.04	0.03	0.12**	-0.02	0.06	0.05	0.07
	(0.04)	(0.06)	(0.03)	(0.03)	(0.06)	(0.03)	(0.04)	(0.05)	(0.07)
op	0.18***	0.10*	-0.06	0.03	0.15***	-0.08**	-0.05	-0.07	-0.03
	(0.03)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.07)
tot	-0.28*	-0.30	0.11	-0.08	-0.25	0.16	-0.07	-0.28*	0.06
	(0.17)	(0.32)	(0.15)	(0.12)	(0.27)	(0.12)	(0.11)	(0.16)	(0.15)
y	-0.06	0.03	-0.22**	0.06	-0.06	-0.11	-0.03	-0.03	-0.03
	(0.07)	(0.09)	(0.09)	(0.06)	(0.08)	(0.08)	(0.11)	(0.12)	(0.17)
Adj-R^2	0.71	0.81	0.63	0.68	0.80	0.59	-	-	-
No. obs.	1863	796	1067	1863	796	1067	2232	918	1314
No. countries	21	9	12	21	9	12	27	11	16

Note: *** significant at the 1%, ** significant at the 5% and * significant at the 10%.

Table 3: DOLS long equality restrictions break 2008 model

	All	CEECs	EU15+2	All	CEECs	EU15+2	All	CEECs	EU+2
		Pooled			Pooled (weighted)			Group mean	
	P-value	P-value	P-value	P-value	P-value	P-value	P-value	P-value	P-value
Test Statistic *F-statistic*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Chi-square	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Normalized Restriction (= 0)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)
ca(t<2008Q1)-	0.51	0.78	-0.49	0.28	0.54	-0.32	0.35	0.42	0.29
ca(t>2007Q4)	(0.14)	(0.25)	(0.14)	(0.11)	(0.19)	(0.11)	(0.20)	(0.24)	(0.30)
gco(t<2008Q1)-	-0.02	-0.23	0.30	0.02	-0.21	0.24	0.13	-0.26	0.40
gco(t>2007Q4)	(0.04)	(0.07)	(0.05)	(0.03)	(0.06)	(0.05)	(0.22)	(0.25)	(0.32)
gfcf(t<2008Q1)-	0.12	0.08	-0.12	0.08	0.06	-0.07	-0.07	-0.05	-0.09
gfcf(t>2007Q4)	(0.03)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.07)	(0.08)	(0.10)
op(t<2008Q1)-	-0.03	-0.02	0.06	0.01	-0.12	0.06	0.19	0.37	0.05
op(t>2007Q4)	(0.02)	(0.04)	(0.02)	(0.02)	(0.04)	(0.02)	(0.07)	(0.09)	(0.10)
tot(t<2008Q1)-	0.72	0.49	-0.32	0.62	0.63	-0.16	0.64	1.17	0.28
tot(t>2007Q4)	(0.19)	(0.36)	(0.19)	(0.13)	(0.30)	(0.15)	(0.21)	(0.25)	(0.30)
y(t<2008Q1)-	-0.08	0.18	-0.15	-0.09	0.12	-0.14	-0.06	0.25	-0.27
y(t>2007Q4)	(0.04)	(0.06)	(0.04)	(0.26)	(0.05)	(0.03)	(0.22)	(0.27)	(0.31)

Table 4: DOLS long run estimates asymmetric model

Variable	All	CEECs	EU15+2	All	CEECs	EU15+2	All	CEECs	EU15+2
Appreciation t-1		Pooled			Pooled (weighted)			Group Mean	
ca	0.26**	0.68***	-0.12	0.06	0.78***	0.31***	-0.15	0.00	-0.25
	(0.10)	(0.15)	(0.11)	(0.07)	(0.14)	(0.09)	(0.11)	(0.15)	(0.16)
gco	-0.07	-0.14*	0.21***	-0.03	-0.17**	0.22***	0.18***	0.14	0.21**
	(0.05)	(0.08)	(0.06)	(0.04)	(0.07)	(0.04)	(0.07)	(0.10)	(0.09)
gfcf	0.16***	0.32***	0.01	0.07***	0.30***	-0.01	0.17***	0.23***	0.14**
	(0.03)	(0.05)	(0.03)	(0.03)	(0.05)	(0.02)	(0.04)	(0.06)	(0.06)
op	0.17***	0.21***	0.00	0.14***	0.15***	0.03**	0.02	0.21***	-0.09*
	(0.02)	(0.03)	(0.02)	(0.01)	(0.03)	(0.1)	(0.04)	(0.06)	(0.05)
tot	0.33***	-0.02	-0.06	0.45***	0.11	0.01	0.24	0.56**	0.03
	(0.09)	(0.14)	(0.12)	(0.08)	(0.13)	(0.08)	(0.16)	(0.26)	(0.21)
y	-0.08	-0.18**	-0.18***	-0.03	-0.13*	-0.17**	-0.28***	-0.26**	-0.29**
	(0.06)	(0.09)	(0.06)	(0.04)	(0.08)	(0.04)	(0.10)	(0.11)	(0.15)
Depreciation t-1									
ca	0.26*	0.66***	-0.15	0.05	0.85***	-0.19**	0.37***	0.33	0.40**
	(0.14)	(0.22)	(0.13)	(0.10)	(0.21)	(0.08)	(0.13)	(0.21)	(0.16)
gco	-0.01	-0.09	0.25***	-0.00	-0.13*	0.21***	0.42***	0.44***	0.41***
	(0.05)	(0.09)	(0.06)	(0.04)	(0.07)	(0.04)	(0.08)	(0.13)	(0.16)
gfcf	0.07**	0.21***	-0.03	0.03	0.17***	-0.02	0.12**	0.03	0.18***
	(0.04)	(0.06)	(0.03)	(0.03)	(0.05)	(0.02)	(0.05)	(0.07)	(0.06)
op	0.17***	0.25***	0.00	0.14***	0.18***	0.02	0.02	0.21***	-0.10**
	(0.02)	(0.04)	(0.02)	(0.01)	(0.03)	(0.01)	(0.04)	(0.06)	(0.05)
tot	0.38***	-0.04	0.10	0.44***	0.10	0.07	0.16	0.13	0.18
	(0.10)	(0.15)	(0.13)	(0.09)	(0.15)	(0.08)	(0.18)	(0.37)	(0.19)
y	-0.06	-0.13	-0.19***	-0.02	-0.05	-0.17***	-0.43***	-0.34**	-0.50***
	(0.06)	(0.09)	(0.06)	(0.04)	(0.08)	(0.04)	(0.11)	(0.15)	(0.15)
Adj-R^2	0.61	0.72	0.47	0.59	0.71	0.46	-	-	-
No. obs.	2202	906	1296	2202	906	1296	2247	906	1341
No. countries	27	11	16	27	11	16	28	11	17

Note: *** significant at the 1%, ** significant at the 5% and * significant at the 10%.

Table 5: DOLS long equality restrictions, asymmetric model

	All	CEECs	EU15+2	All	CEECs	EU15+2	All	CEECs	EU15+2
		Pooled			Pooled (weighted)			Group mean	
	P-value	P-value	P-value	P-value	P-value	P-value	P-value	P-value	P-value
Test Statistic *F-statistic*	0.09	0.20	0.02	0.10	0.17	0.00	0.00	0.02	0.04
Chi-square	0.09	0.20	0.02	0.10	0.17	0.00	0.00	0.01	0.03
Normalized Restriction (= 0)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)	Value (std. Error)
ca(apre)-ca(depre)	-0.00 (0.15)	0.01 (0.25)	0.02 (0.14)	0.01 (0.11)	-0.07 (0.21)	-0.11 (0.10)	-0.52 (0.17)	-0.32 (0.25)	-0.65 (0.23)
gco(apre)-gco(depre)	-0.06 (0.04)	-0.04 (0.07)	-0.04 (0.05)	-0.03 (0.03)	-0.04 (0.07)	0.00 (0.03)	-0.23 (0.08)	-0.29 (0.13)	-0.20 (0.10)
gfcf(apre)-gfcf(depre)	0.09 (0.04)	0.11 (0.06)	0.04 (0.04)	0.04 (0.03)	0.13 (0.06)	-0.00 (0.02)	0.05 (0.05)	0.20 (0.08)	-0.04 (0.06)
op(apre)-op(depre)	0.00 (0.02)	-0.04 (0.05)	-0.00 (0.01)	-0.00 (0.01)	-0.03 (0.04)	0.01 (0.01)	-0.00 (0.05)	-0.00 (0.08)	-0.00 (0.06)
tot(apre)-tot(depre)	-0.05 (0.14)	0.03 (0.22)	-0.16 (0.18)	0.01 (0.13)	0.00 (0.21)	-0.06 (0.11)	0.07 (0.22)	0.43 (0.35)	-0.15 (0.30)
y(apre)-y(depre)	-0.02 (0.04)	-0.05 (0.06)	0.00 (0.03)	-0.01 (0.02)	-0.07 (0.06)	-0.00 (0.02)	0.15 (0.09)	0.08 (0.12)	0.20 (0.12)

Table 6: Equality test quantile regression

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test		34.04	12	0.00
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.25 0.5	*ca*	-0.02	0.03	0.44
	gco	0.02	0.02	0.45
	gfcf	0.02	0.02	0.36
	op	0.03	0.02	0.27
	tot	-0.07	0.05	0.16
	y	-0.03	0.04	0.38
0.5 0.75	*ca*	0.01	0.03	0.76
	gco	-0.01	0.02	0.74
	gfcf	0.00	0.01	0.77
	op	0.04	0.01	0.01
	tot	0.01	0.05	0.78
	y	0.04	0.03	0.18

Table 7: Symmetry test quantile regression

Test Summary		Chi-Sq, Statistic	Chi-Sq, d,f,	Prob,
Wald Test		10.29	6	0.11
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.25 0.75	*ca*	-0.03	0.04	0.49
	gco	0.02	0.03	0.49
	gfcf	0.02	0.02	0.41
	op	-0.01	0.03	0.74
	tot	-0.08	0.07	0.26
	y	-0.08	0.05	0.14

Table 8: Equality test quantile regression CEECs

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test		36.44	12	0.00
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.25 0.5	*ca*	0.01	0.05	0.78
	gco	-0.02	0.03	0.59
	gfcf	-0.01	0.02	0.60
	op	-0.03	0.02	0.12
	tot	-0.14	0.05	0.01
	y	0.14	0.05	0.01
0.5 0.75	*ca*	0.14	0.05	0.01
	gco	-0.03	0.09	0.76
	gfcf	0.03	0.04	0.50
	op	0.03	0.03	0.22
	tot	0.05	0.05	0.31
	y	-0.18	0.20	0.38

Table 9: Symmetry test quantile regression CEECs

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test		5.53	6	0.47
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.25 0.75	*ca*	0.04	0.10	0.68
	gco	-0.04	0.05	0.40
	gfcf	-0.04	0.03	0.21
	op	-0.08	0.06	0.14
	tot	0.04	0.21	0.86
	ca	0.14	0.09	0.12

Table 10: Equality test quantile regression EU15+2

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test		50.26	12	0.00
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.25 0.5	*ca*	-0.06	0.03	0.03
	gco	0.01	0.02	0.63
	gfcf	-0.04	0.01	0.00
	op	0.01	0.01	0.31
	tot	0.03	0.04	0.55
	y	0.08	0.03	0.01
0.5 0.75	*ca*	-0.02	0.04	0.67
	gco	0.04	0.03	0.19
	gfcf	0.00	0.01	0.81
	op	0.02	0.02	0.33
	tot	0.01	0.04	0.78
	y	-0.03	0.05	0.55

Table 11: Symmetry test quantile regression EU15+2

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test		6.64	6	0.35
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.25 0.75	*ca*	-0.05	0.05	0.34
	gco	-0.03	0.04	0.46
	gfcf	-0.03	0.02	0.08
	op	0.00	0.02	0.92
	tot	0.01	0.07	0.84
	y	0.10	0.06	0.07

Figure 1: RER EU28

Figure 2: IRFs BVAR

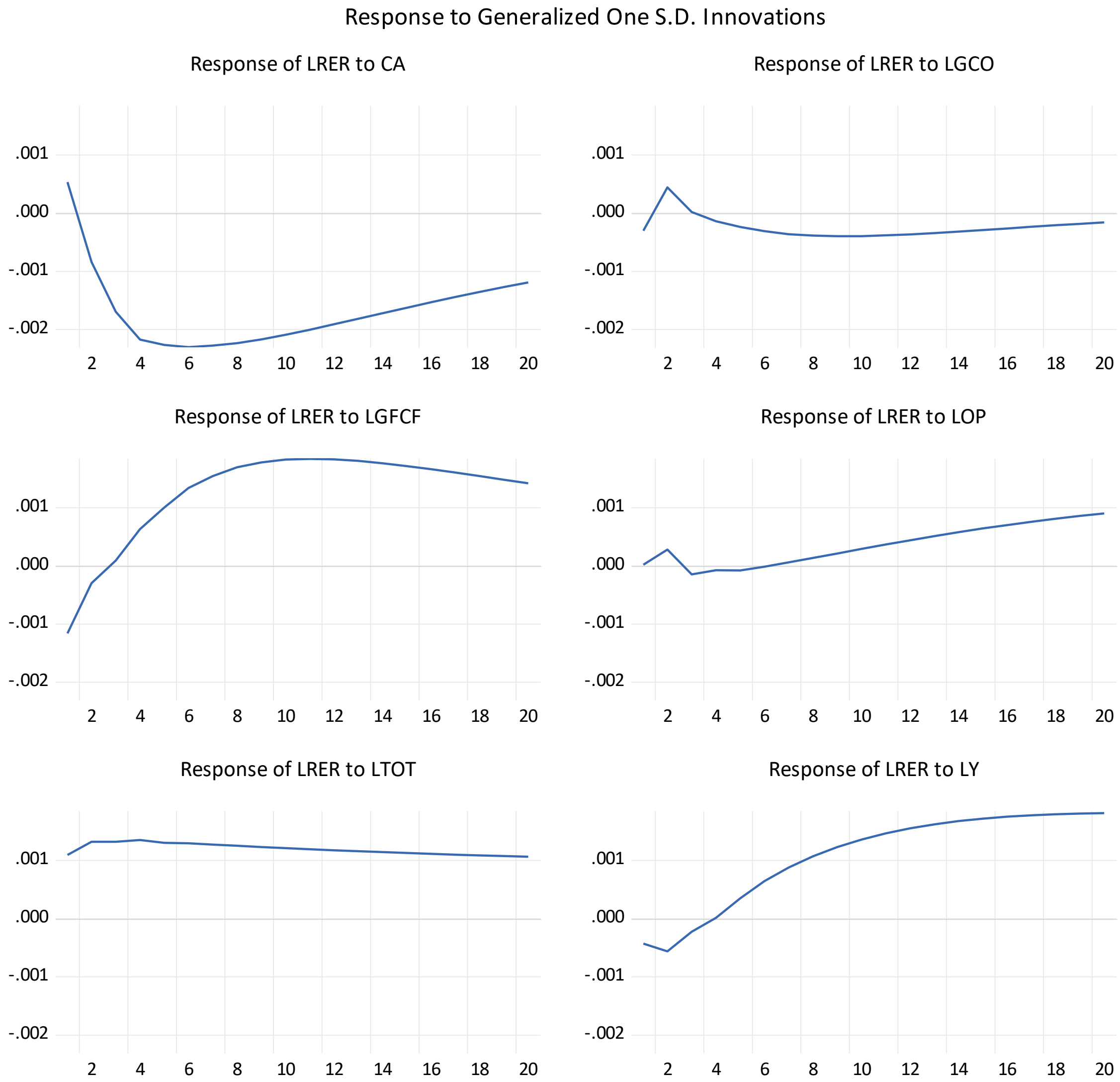


Figure 3: IRFs BVAR before 2008Q1

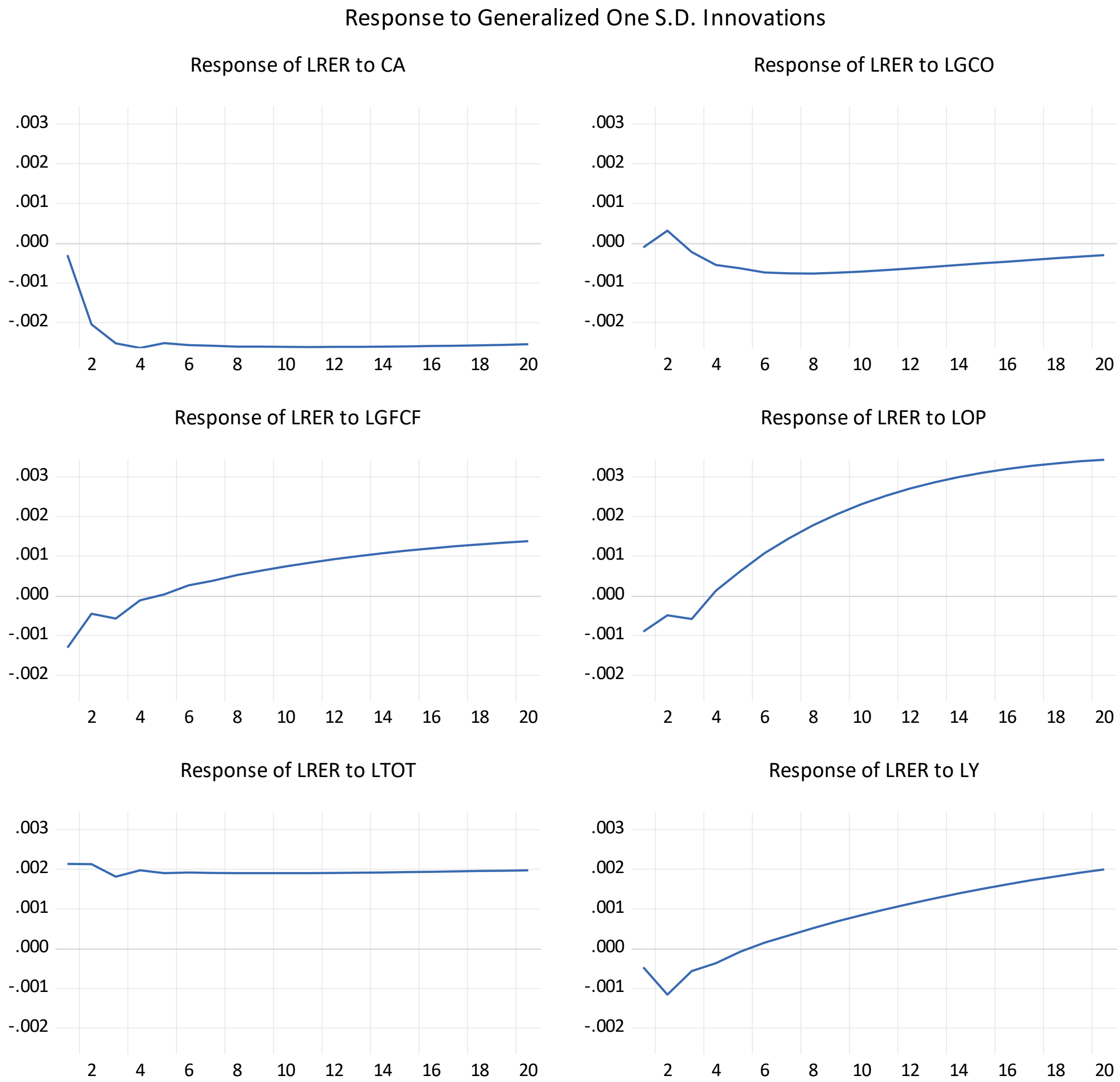


Figure 4: IRFs BVAR from 2008Q1

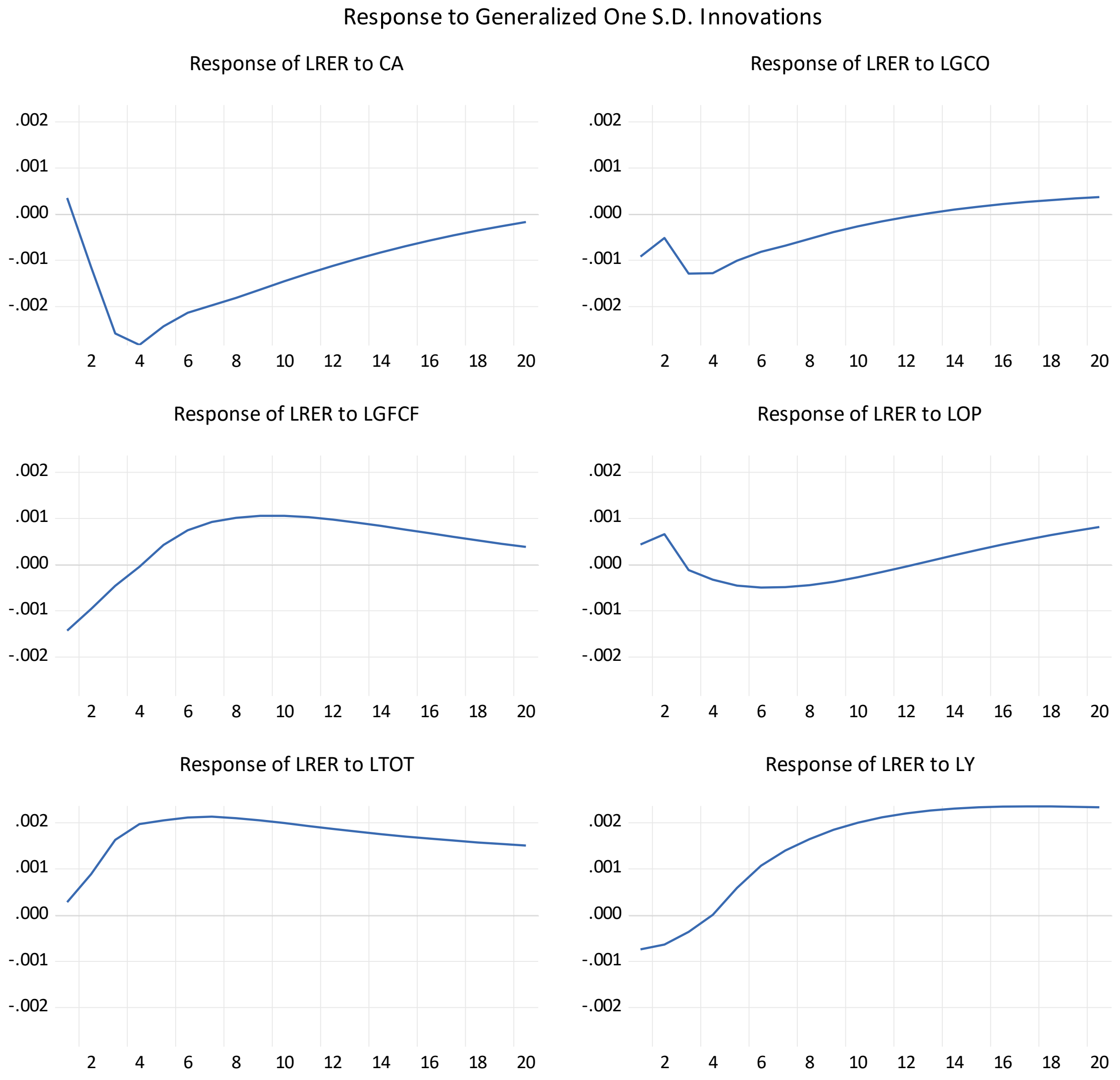


Figure 5: IRFs BVAR CEECs

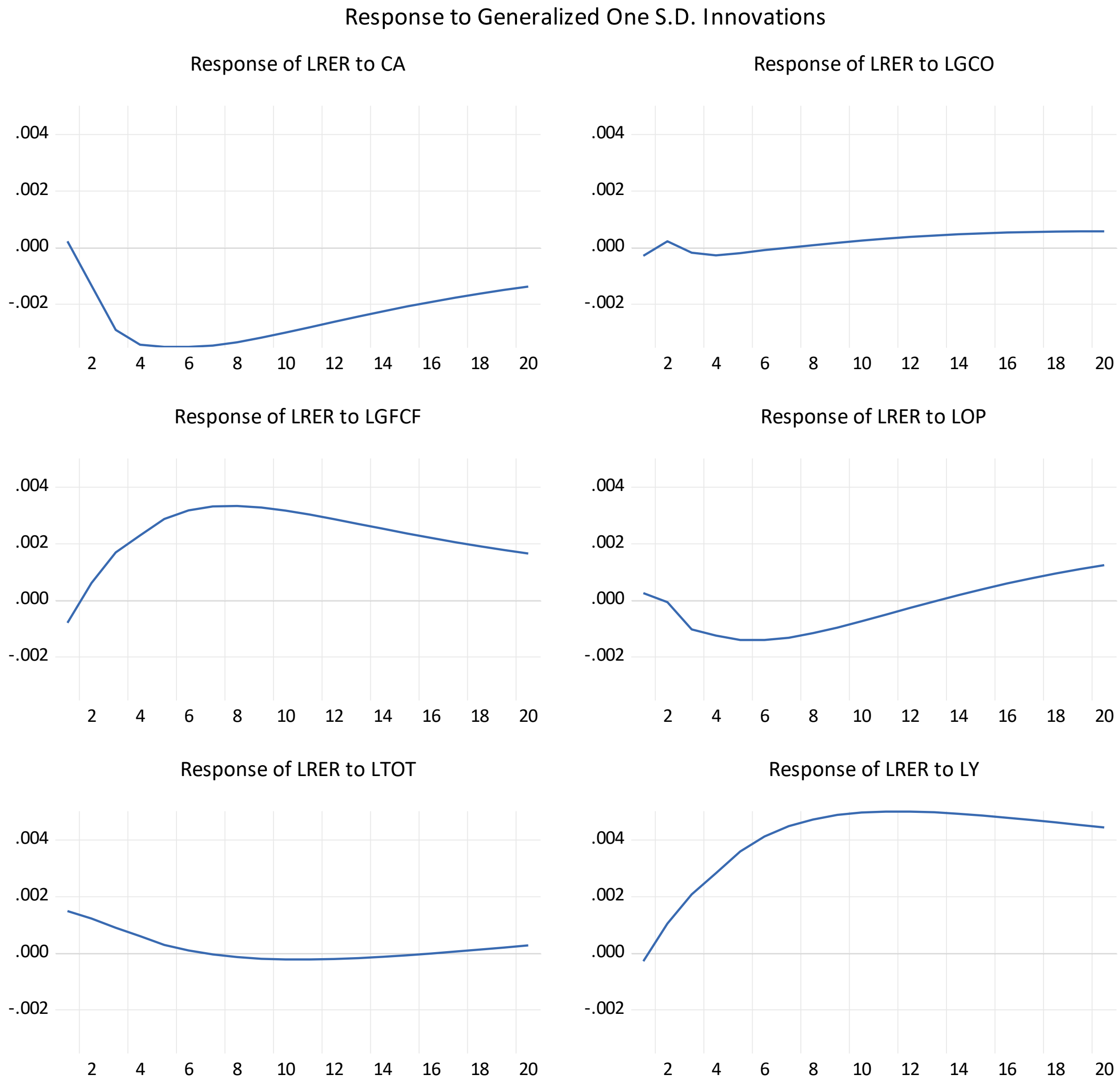


Figure 6: IRFs BVAR EU15+2

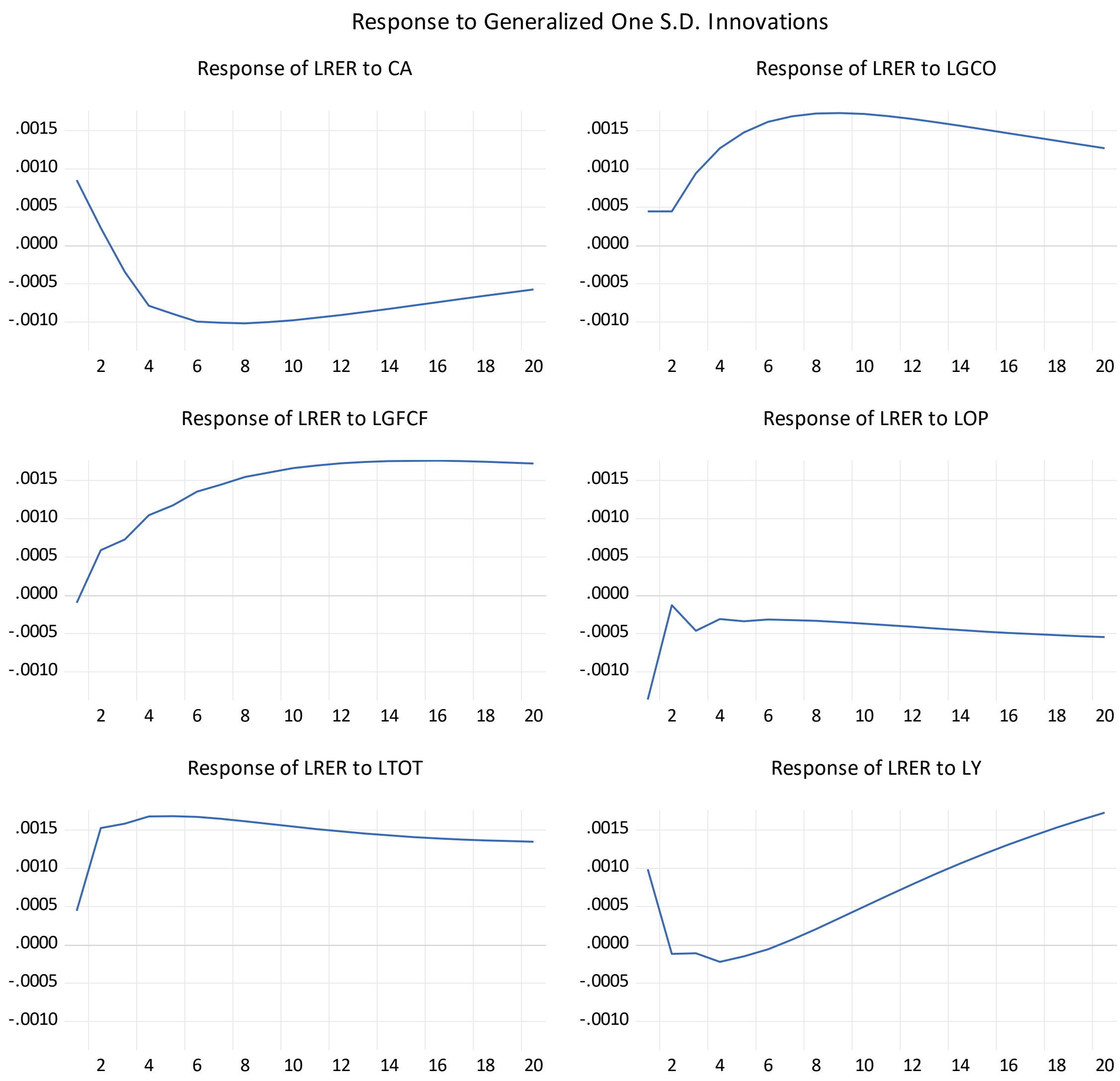


Figure 7: IRFs BVAR before 2008Q1, CEECs

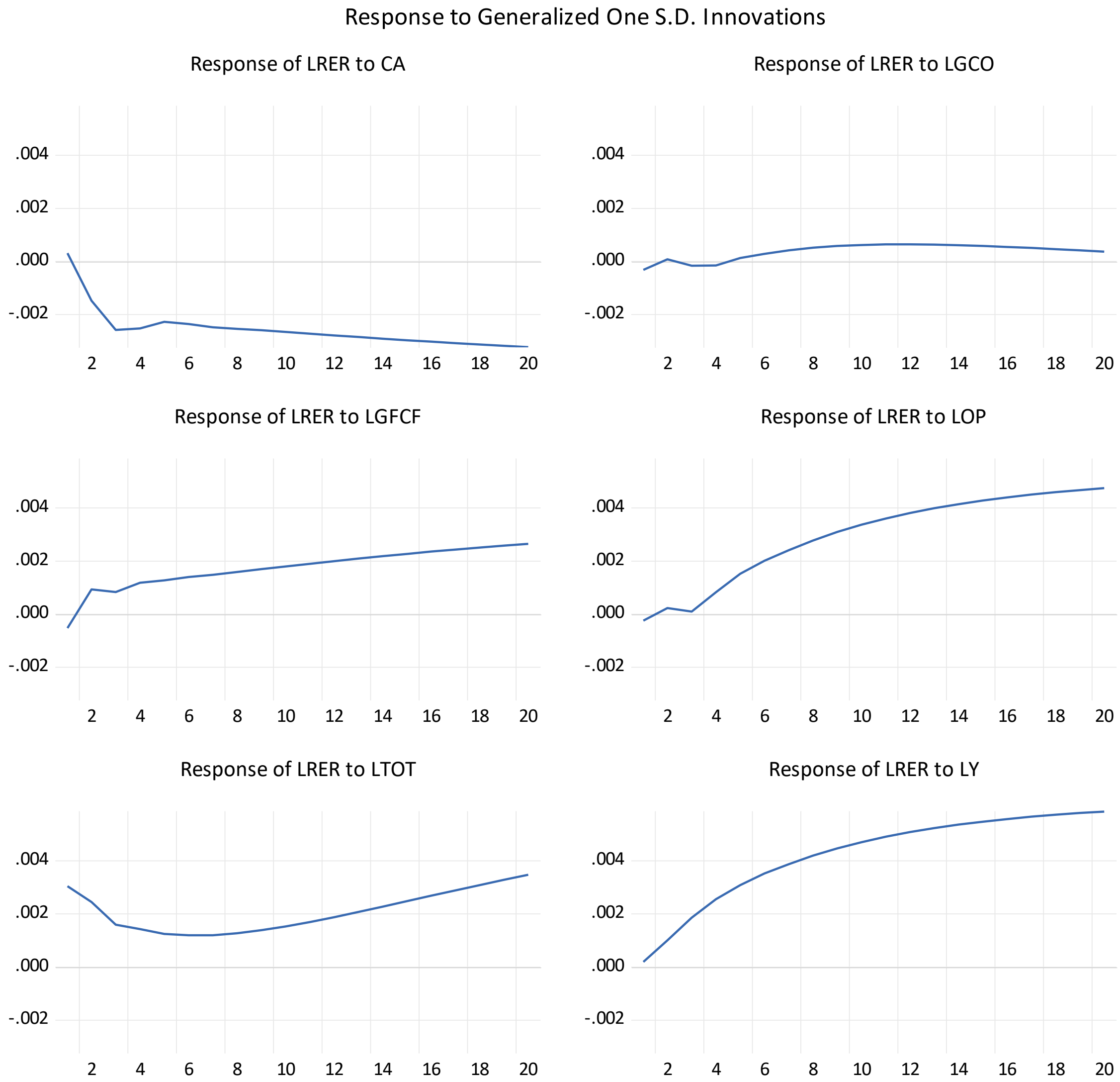


Figure 8: IRFs BVAR from 2008Q1, CEECs

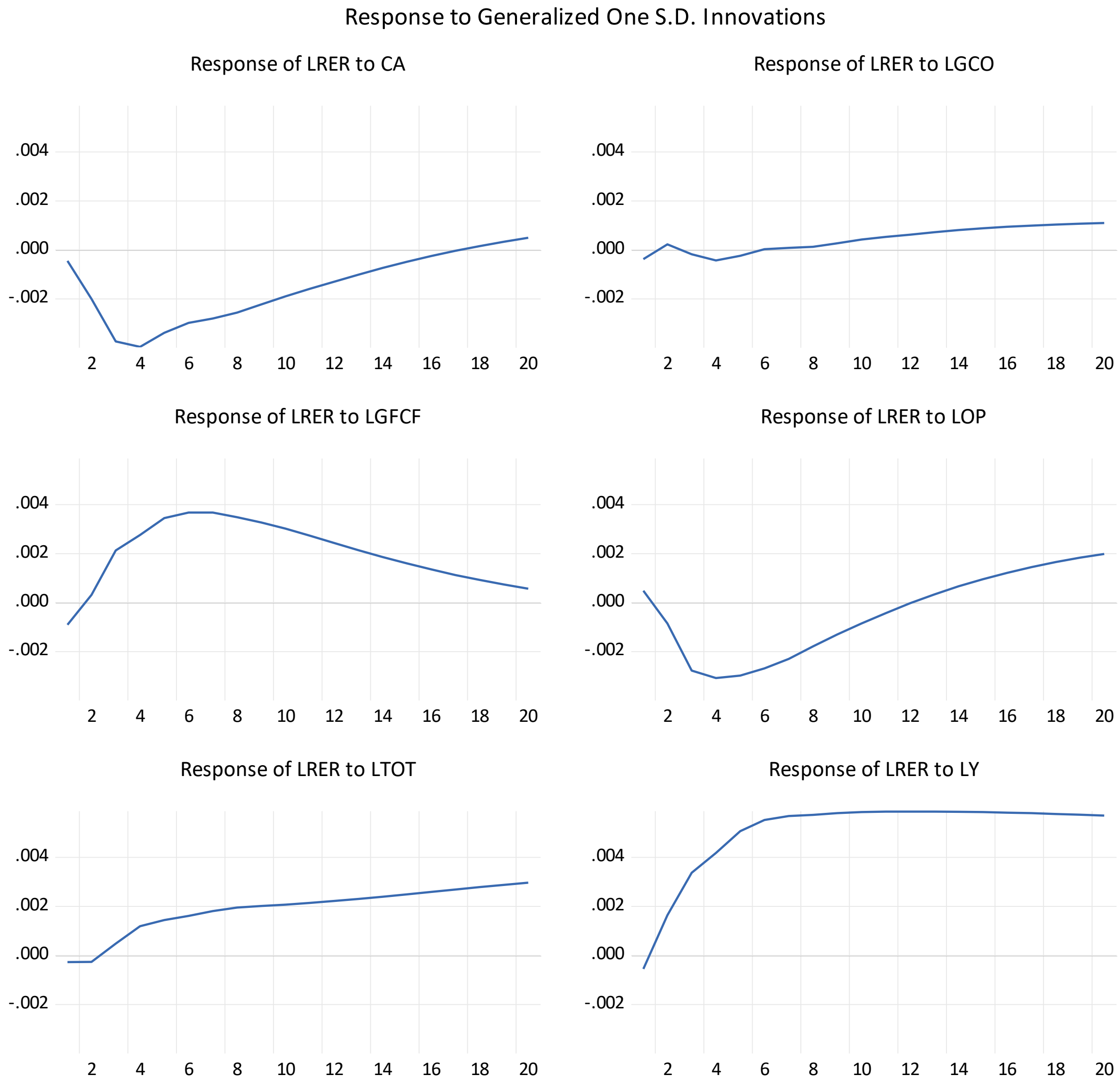


Figure 9: IRFs BVAR before 2008Q1, EU15+2

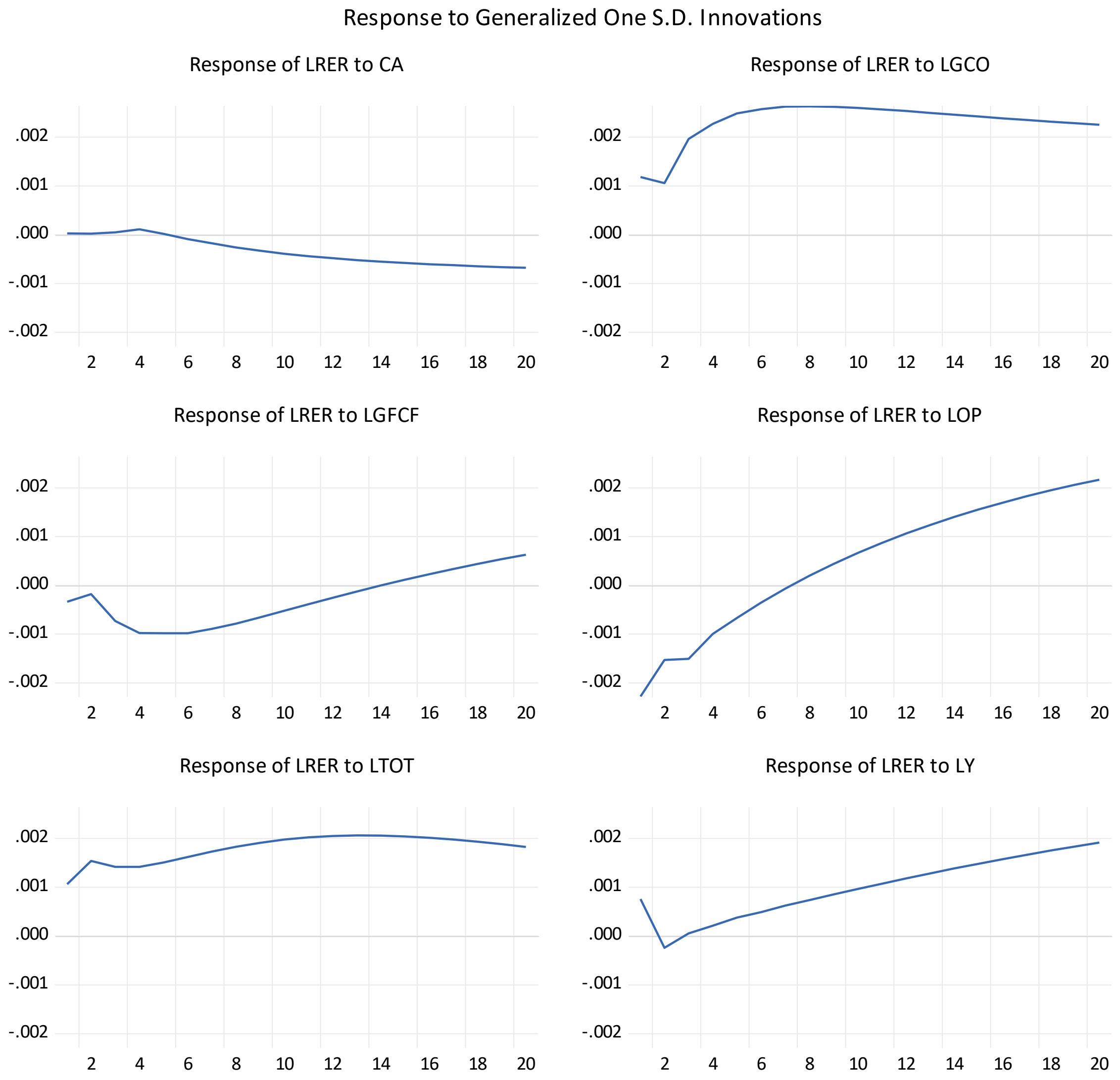


Figure 10: IRFs BVAR from 2008Q1, EU15+2

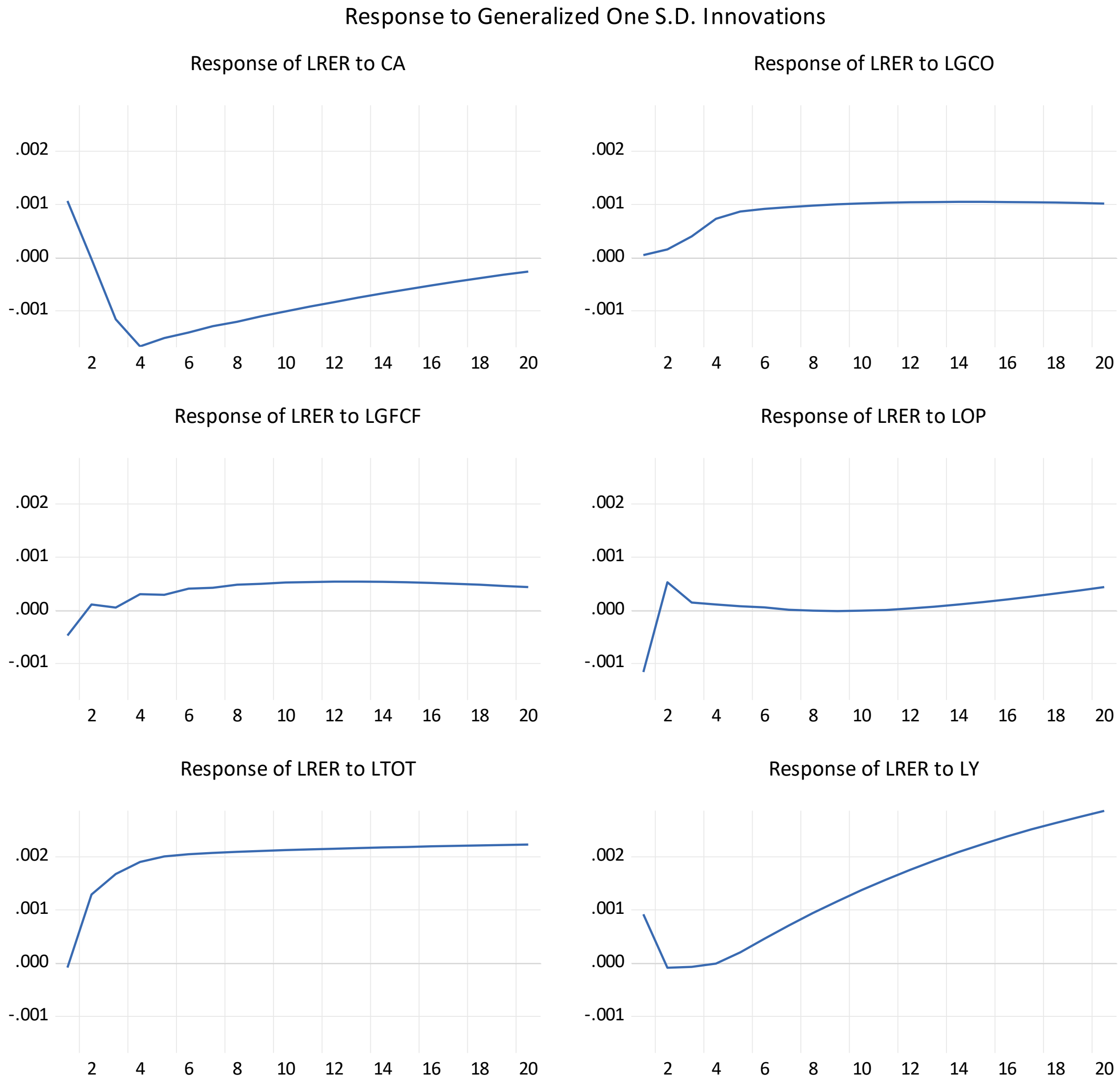
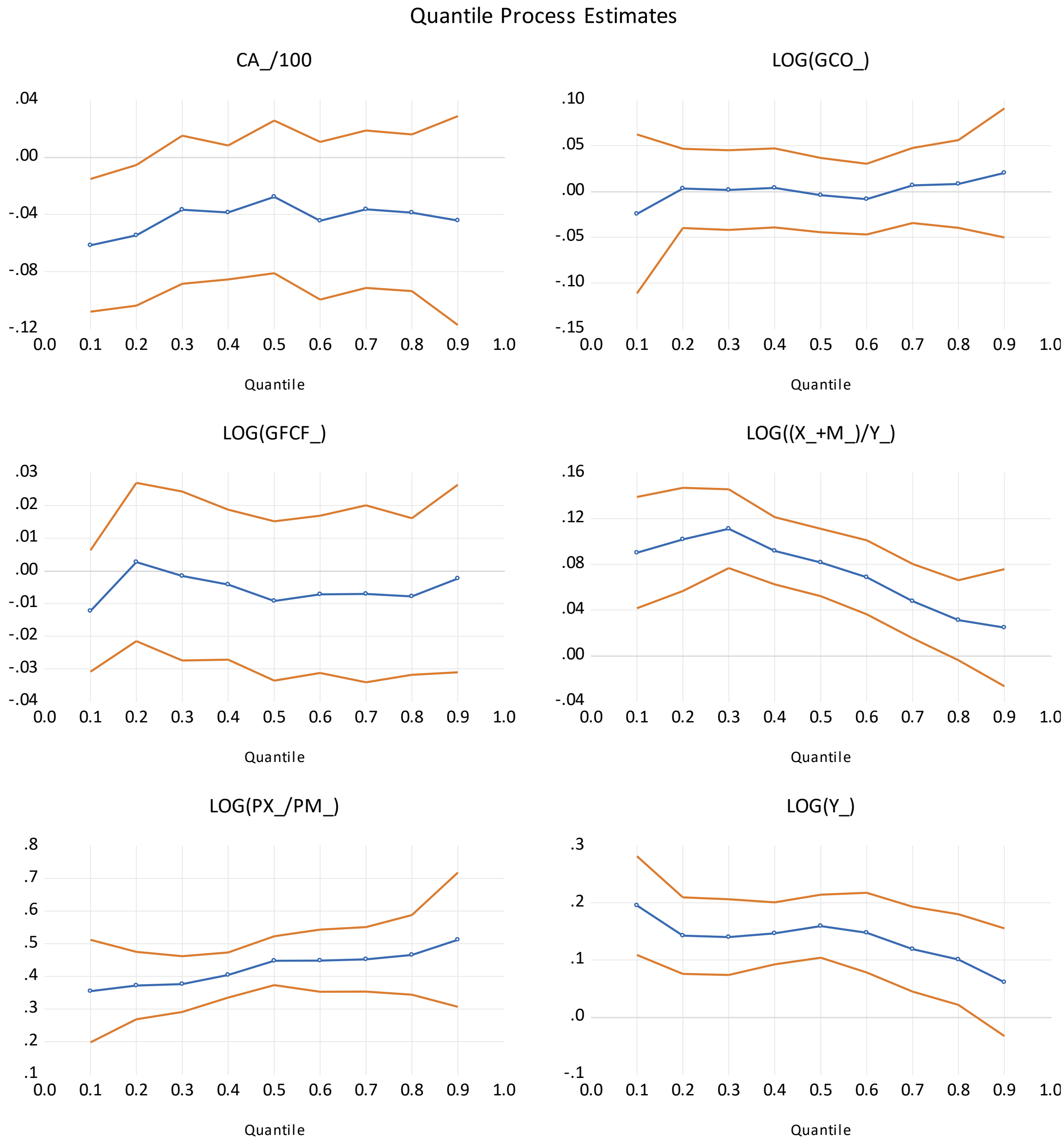
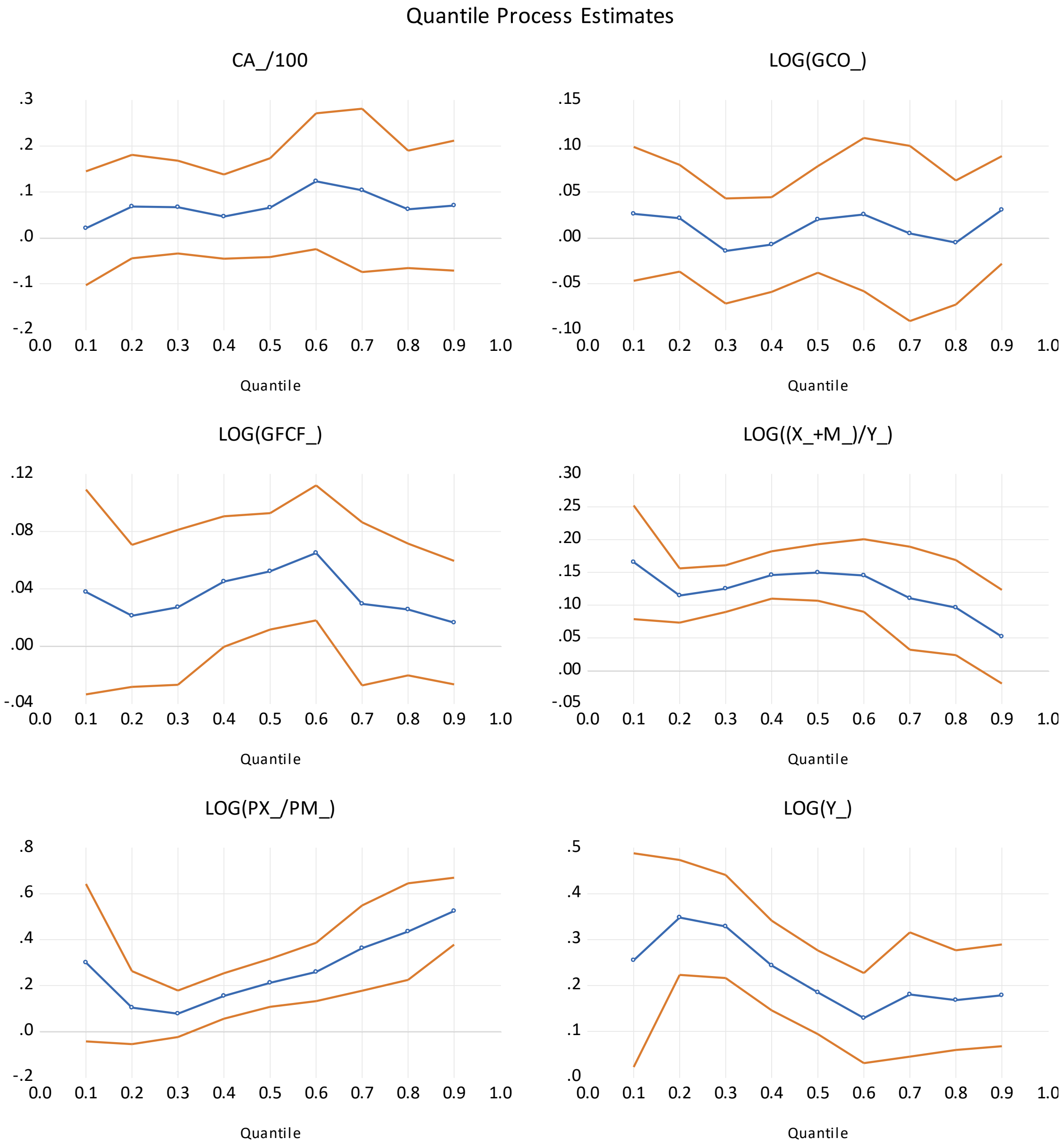


Figure 11: Quantile estimates



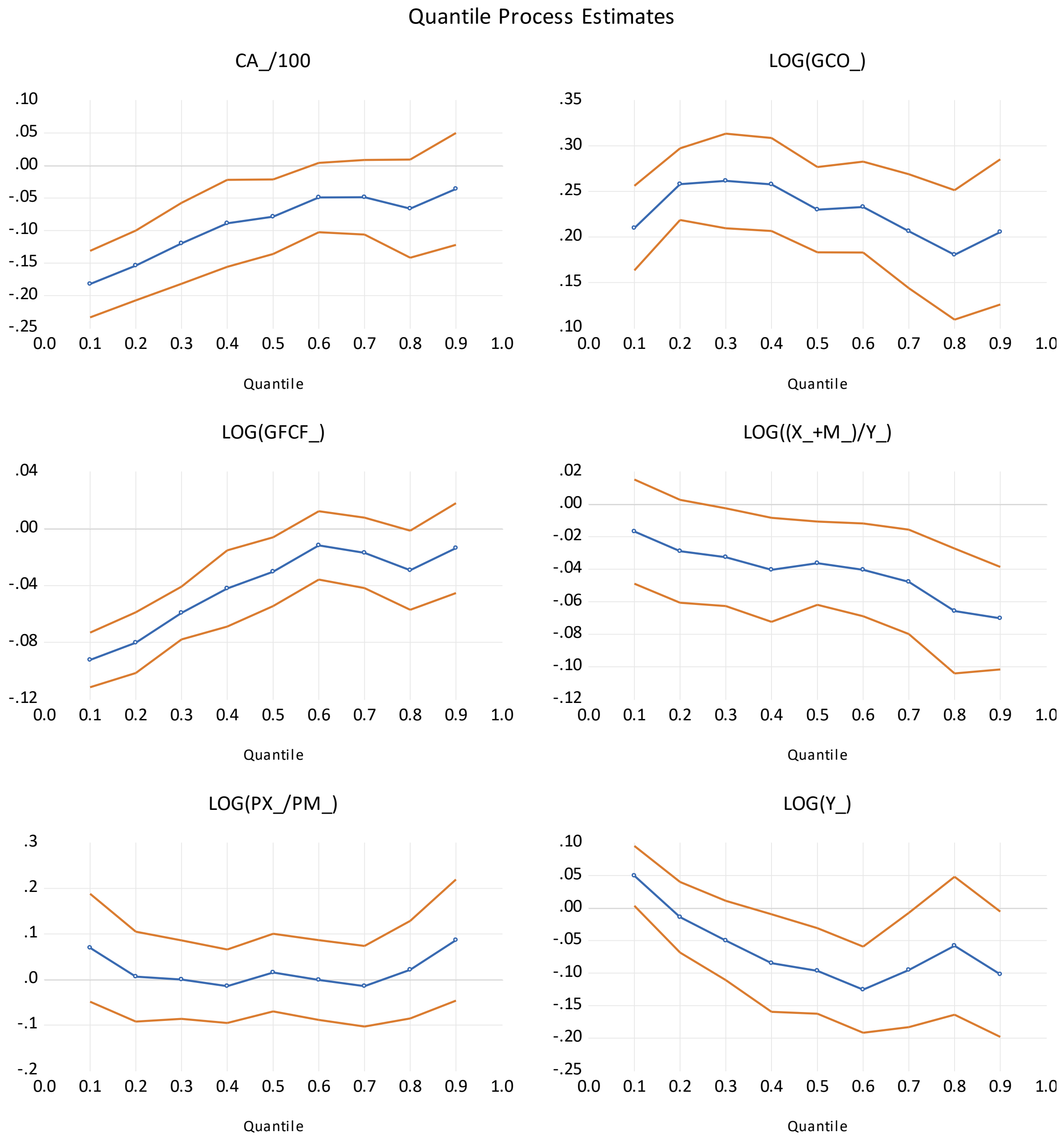
Note: The outer red lines represent 95% confidence intervals.

Figure 12: Quantile estimates CEECs



Note: The outer red lines represent 95% confidence intervals.

Figure 13: Quantile estimates EU15+2



Note: The outer red lines represent 95% confidence intervals.