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Igor Velickovski, Aleksandar Stojkov,
Ivana Rajkovic

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Igor Velickovski, PhD
National Bank of the Republic of Macedonia, Republic of Macedonia
e-mail: velickovskii@nbrm.mk

Aleksandar Stojkov, PhD
Iustinianus Primus Faculty of Law at Ss. Cyril and Methodius University, Republic of Macedonia
e-mail: a.stojkov@staffs.ac.uk

Ivana Rajkovic, MSc.
National Bank of Serbia, Republic of Serbia
e-mail: ivana.rajkovic@nbs.rs

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Abstract

This paper investigates the drivers of shock synchronization using quarterly data for 27 European countries over the period 1999–2013 and by taking into account the difference between core (the euro area core locomotive) and peripheral euro area and European transition countries (the peripheral wagons). The results from panel error-correction models suggest that the euro area core has not been a strong magnetizer of the shock convergence of peripheral and transition countries since the inception of the euro as a result of the offsetting effects of various factors that affected the shock convergence process. In particular, the demand shock convergence was supported by intra-industry trade developments and, to some extent, by the intensity of trade, at least for the peripheral countries, but their effects were offset by divergent fiscal policies, production structure changes and financial flows. On the other hand, supply shocks registered a divergent tendency that was mainly driven by trade intensity flows and uncoordinated fiscal policies. These findings challenge the endogeneity hypothesis and support the specialization paradigm — a concerning evidence for the future stability of the euro area.

Keywords Shock synchronization • Trade • Dynamic panel models

JEL ClassificationE32 • F10 • C33

Introduction

The prolonged European debt crisis — exacerbated by economic stagnation and diverse policy responses — has raised questions about the very existence of the Economic and Monetary Union (EMU) and the single currency. The concerns about the sustainability of the single currency area call for careful re-examination of adherence to the criteria for joining a monetary union. The crisis situation has demonstrated that the political support for the euro area almost ignored the risks and economic costs associated with its enlargement. In particular, the costs stemming from exposure to asymmetric shocks — an important consideration for joining a monetary union — were put aside by overstating the assumed political and economic benefits of a single currency. Thus despite the substantial increase in cross-country contagion and spillovers since the introduction of the euro (Enders et al. 2013), the negative impact of the crisis is more pronounced in the European peripheral countries (Greece, Ireland, Italy, Portugal and Spain) which have experienced severe losses in productivity, employment and welfare compared with the euro area core (Austria, Belgium, France, Germany, Luxembourg and the Netherlands). Such divergent economic performances compel us to consider the differences between the periphery and the euro area core, particularly in the context of similarity in business cycles. Although the present academic and policymaking attention is on the peripheral euro area countries, it is also important to assess whether the European Union (EU) candidate countries are making progress in satisfying the preconditions for the single currency area. Will the enlargement of the EU lead to the creation of more peripheral wagons that are disconnected from the euro area core locomotive? Are we observing desynchronization of the shocks and business cycles, regardless of the declarative aspirations for political integration?

Our paper provides new evidence to address these questions by investigating the factors that determine the desynchronization of demand-side and supply-side shocks in the euro area core (the euro area locomotive) vis-à-vis the non-core EU member states and EU candidate countries (the peripheral wagons). The central objectives of the paper are: (i) to investigate whether the euro area core is a driving force behind the shock convergence process in the rest of the EU and the EU candidate countries, with special focus on the different behaviours of peripheral versus transition countries, (ii) to identify the relative importance of various factors driving shock synchronization, and (iii) to propose policy-relevant recommendations. Additionally, we investigate the effects of the recent economic turmoil on the shock convergence process of the non-core EU members and EU candidate countries. Using quarterly data over the period 1999–2013 for 27 European countries, we employ the panel error-correction methodology and find that the euro area core has not been a strong magnetizer of shock convergence of peripheral and candidate countries since the euro's inception. However, this corollary ignores an important sideshow as a result of the offsetting effects of several factors driving the shock convergence process. The empirical results suggest that demand shock convergence was supported by the intensity of trade — at least in the peripheral countries — and intra-industry trade (hereinafter IIT), but their effects were offset by the fiscal policy, financial flows and structural developments on the production side. In the case of supply-side shocks, the centripetal effects of IIT and financial integration were not strong enough to counteract the

centrifugal forces of the trade intensity and uncoordinated fiscal policies.

The contribution of the paper to the literature on business cycle synchronization (BCS) is threefold: (i) it examines whether the euro area core can be a long-term driving force of the shock convergence process of the euro area peripheral as well as EU candidate countries, (ii) it quantifies the effects of the recent economic turmoil on the shock convergence process, and iii) it extends the previous research by applying more sophisticated econometric techniques to a larger data set covering 27 European countries and a more recent time span.

The remainder of the paper is organized as follows: Section 2 critically reviews the relevant theoretical and empirical literature on BCS. Section 3 elaborates the methodology by explaining the difficult trade-offs and decisions. Section 4 presents the data and the variables used in the empirical analysis of BCS. Section 5 discusses our empirical findings. Robustness checks are presented in Section 6. The concluding remarks and policy implications are presented in Section 7.

Literature Review

After a relatively long period of neglect, the beginning of the 1990s marked a revival of academic interest in the theory of optimum currency areas (OCAs), primarily due to the European monetary integration. The main debate in this period of the re-emergence of interest in OCAs focuses on the relationship between the degree of economic integration and the occurrence of asymmetric shocks; that is, whether the progress towards economic integration leads to economic convergence. De Grauwe (2015) classifies the two competing views as "the European Commission view" and "the Krugman view." The former — also known as the endogeneity hypothesis of Frankel and Rose (1998) — conjectures that differential shocks in demand will occur less frequently in the monetary union as the removal of barriers with the completion of a single market will reinforce trade between the European nations. Therefore, closer integration is expected to lead to less frequent asymmetric shocks (European Community Commission 1990). In contrast, the latter view — also known as the "specialization" paradigm — holds that trade integration leads to regional concentration of industrial activities (agglomeration effects) induced by economies of scale. Hence, closer integration implies greater specialization and, thus, a higher risk of idiosyncratic shocks (Krugman 1993).

These competing views inspired a rapidly growing body of empirical literature aimed at explaining the potential drivers of BCS. For expositional convenience, we categorize the main literature findings into the following conditioning factors: trade integration, financial integration, the recent global economic crisis and fiscal policy. Since the research is carried out in the European context, we are particularly interested in studies examining the similarities in business

cycles and shocks between the core and periphery of Europe.[1]

Trade Integration. Although the impact of trade integration on BCS has been thoroughly studied, there is a lack of academic consensus as to whether an increase in trade integration results in convergence or divergence in business cycles. Most studies empirically demonstrate that a strong and positive relationship exists between the degree of trade intensity and cross-country correlation of business cycles (Boone 1997; Imbs 1999; Clark and van Wincoop 2001; Imbs 2004; Baxter and Kouparitsas 2005; Abbott et al. 2008; Inklaar et al. 2008). Some earlier studies too, such as the one by Frankel and Rose (1998), find a strongly positive and statistically significant effect of the greater intensity of international trade on the cross-country correlation of economic activity. The endogenous nature of the relationship between trade intensity and BCS implies that although some countries may appear to be poor candidates for a monetary union, they are more likely to satisfy the entry criteria for a currency union ex post. Their emphasis is on IIT as a key component of the endogenous nature of the economic cycle correlations. In later work, IIT is estimated to contribute to a higher correlation of output fluctuations (Fidrmuc 2004; Shin and Wang 2005). Calderon et al. (2007) extend Frankel and Rose's (1998) analysis by examining the impact of trade integration on business cycle correlation not only in industrial but also among developing countries. Their results imply that the impact of trade intensity on cycle correlation is greater for country pairs with a higher share of IIT. The differences in the reaction of cycle synchronization to trade integration between industrial and developing countries are explained by the differences in the patterns of specialization and bilateral trade. On the other hand, Fiess (2007) — based on the results for Central America and the United States — shows that the gain in BCS through trade expansion is quite small, since the degree of BCS seems to be only weakly related to trade intensity and trade structure (IIT). Another way to investigate the impact of trade integration on BCS is to distinguish between the increase in existing trade flows and the creation of new trade flows, as demonstrated by Pentecote et al. (2015). They find that trade intensity has a positive direct effect on BCS, while synchronization is weakened when new firms are allowed to export in response to gains in productivity.

Financial Integration. The impact of increased financial flows on BCS is also ambiguous. Financial integration enables international risk sharing, which neutralizes the negative effects of an adverse shock. Countries that have more intensive FDI relations also have more synchronized business cycles (Jansen and Stokman 2004). Inklaar et al. (2008) state that financial openness only indirectly affects output correlations by increasing trade integration. However, Kalemli-Ozcan et al. (2001) and Imbs (2004) note that easier access to foreign financial markets in the monetary union allows more specialized production and, consequently, less synchronized business cycles. Morgan et al. (2004) investigate the impact of interstate banking integration on economic volatility within the United States and find that as the banks in any two given states become better linked, the business cycles in those particular states tend to converge. As a result of interstate banking integration, business cycles tend to be smaller and more similar. On the other hand, Kalemli-Ozcan et al. (2013) show that increases in cross-border banking activities are followed

1. Although greater empirical attention is being devoted to trade and financial integration and policy coordination, several studies find support for additional determinants of BCS, such as output similarity (Imbs 1999; Clark and van Wincoop 2001; Kalemli-Ozcan et al. 2001; Calderon et al. 2007; Dees and Zorell 2012).

by less synchronized output fluctuations among country-pairs. These authors estimate the impact of financial integration on BCS while focusing on changes over time within more than 150 pairs of advanced economies over the period 1978–2006 and report a strong and negative effect of banking integration on the degree of output synchronization. Jones and Witte (2011) find evidence that greater financial integration leads to less BCS, which may be explained by greater dissimilarity in consumption as opposed to investment.

Recent Global Economic Crisis. Not surprisingly, the most recent empirical studies are concerned with the impact of the recent global economic crisis on BCS. Asteriou and Moudatsou (2015) analyse BCS in the EU for the period 1998–2011 and find that the bilateral trade balance positively affects BCS in these countries. Regarding the strength of this relationship, the authors find that the role of the synchronicity of trade has become more prominent since 2000, but it has been hindered by the recent economic crisis. Ehrmann and Fratzscher (2015) document that the European sovereign debt crisis triggered a massive repatriation of capital to the home countries of investors, resulting in substantial financial fragmentation in the euro area compared with the period before the crisis.

Fiscal Policy. Besides trade and financial integration, some studies argue that more coordinated fiscal policies provide additional synchronization (Antonakakis and Tondl 2014). The importance of fiscal policies as a determinant of BCS is also stressed by Crespo-Cuaresma et al. (2011). According to them, fiscal deficits appear to be an important source of idiosyncratic macroeconomic fluctuations whenever a certain threshold of trade integration is reached by countries involved in the integration of Europe. While the importance of fiscal deficits in this context is undisputed, the evidence of fiscal policies' impact lacks clarity. Fiscal policies, according to Darvas et al. (2007) are an important source of business cycle divergence; Artis et al. (2008) support the results of these findings.

European Core vis-à-vis Periphery. In an earlier work in this area, Artis and Zhang (2001) apply the technique of cluster analysis to a set of variables as advised by the theory of OCA and suggest that the euro area may be divided into core (Germany, France, Austria, Belgium and Netherlands) and two peripheries (a northern and a southern group). The recent European economic and financial crisis intensified the interest in the OCA theory from this perspective, that is, the European core vis-à-vis the European periphery. The debt crisis shed light on the growing imbalances among member states with regard to their current accounts, private capital flows and level of competitiveness. Antonakakis et al. (2015) investigate the business cycle spillovers in the EU15 over the period 1977–2012 by employing the spillover index approach and find that the widening of the European debt crisis can be explained by business cycle shocks in the entire euro area periphery. They identify intertemporal changes in the direction of the spillovers between the euro area core and the periphery, and also find that non-EMU countries have been net receivers of business cycle shocks from either core or peripheral countries. According to Sinn et al. (2011), the introduction of the euro has widened the imbalances between the core and the periphery of the euro area. Lehwald (2013) analyses the evolution of the euro area core and peripheral BCS before and after the introduction of the euro. The results suggest that there was already a strong co-movement in output, consumption and investment growth for most euro area countries in the pre-euro period. After its introduction, the co-movement further increased for the core

euro area group but decreased for most of the peripheral countries. Gouveia and Correia (2013) estimate that the increase in trade intensified the synchronization between the euro area members from the start of the run-up to the EMU, but the inception of the euro did not have a significant impact. In their analysis, Greece and Portugal stand out distinctly from this common pattern. However, Caporale et al. (2015) find evidence of diverging patterns between the core and the peripheral euro area countries over the period 1988–2011. Their study suggests that trade intensity supports the specialization paradigm rather than the endogeneity hypothesis. Yet, in a comparative context, Europe outperforms North America: in the former the core-periphery divide is milder, and peripheral status seems generally less protracted (Ferreira-Lopes and Pina 2011).

Despite the abundance of literature related to OCAs, most of the empirical work in this area investigates business cycles, encompassing both shocks and policy responses. However, previous studies on transition countries — with the exception of Babetskii (2005) and Velickovski and Stojkov (2014) — do not isolate the effects of shock incidence from the effects of responses on the synchronization of economic variables, which is the main pillar of the OCA theory. Another important advantage of the shock approach over the BCS approach is the ability of the former to distinguish between supply-side and demand-side shocks. This distinction can be essential if the relevant driving forces affect the demand and supply shock convergence differently. Moreover, it is crucial for understanding and defining appropriate policies regarding the factors affecting the shock convergence. This study enriches the scarce empirical evidence on the determinants of shock convergence of the non-core EU members and EU candidate countries towards the euro area core.

Methodology

Estimation of Structural Shocks

To investigate the main driving forces of the synchronization of shocks between the euro area core on one hand and the non-core EU members and the EU candidate countries on the other, we follow the procedure applied by Babetskii (2005) and Stojkov and Velickovski (2014). Firstly, supply and demand shocks are estimated using the structural VAR methodology. Second, to account for the time variability of shock convergence, we apply the Kalman filter technique to estimate a time-varying measure of the similarity of shocks between countries of interest and the euro area core. Thirdly, we adopt a dynamic panel methodology to determine the driving forces of shock similarity between these countries and the process of convergence towards the long-run equilibrium.

The supply and demand shocks are estimated using the real output and GDP deflator as inputs to the structural VAR methodology launched by Bayoumi and Eichengreen (1997), which in turn relies on the canonical model of Blanchard and Quah (1989). The fundamental assumption of the model for the identification of supply and demand shocks is that supply shocks affect the output and prices permanently, whereas the latter change the prices permanently and the output temporarily. The response of the prices and output to supply and demand shocks, as modelled by the structural VAR, is the same as one would expect from standard textbook models. Regarding the sign of the effects, the two shocks affect the output in the same direction, but the effect on prices has the opposite direction.

The estimated supply-side and demand-side shocks for each EU member and EU

candidate country are then related to those in the euro area core to measure the degree of synchronization. For the purpose of this investigation, the "euro area core locomotive" encompasses Austria, Belgium, France, Germany, Luxembourg and the Netherlands, in line with the findings of Artis and Zhang (2001). In the robustness checks, we use an alternative definition of the euro area core that excludes France, since an issue was raised during the crisis concerning whether France belongs to the core group. We adhere to the view that shock similarity evolves over time, in line with the market integration in Europe (Babetskii 2005), thereby preferring a dynamic over a static measure of shock synchronization. To capture the evolving shock synchronization, we estimate time-varying coefficients of shock symmetry for supply and demand shocks using the Kalman filter methodology represented by the following system of equations:

Measurement (observation) equation

$$X_t^j - X_t^i = a_{it} + b_{it}(X_t^j - X_t^k) + u_{it} \qquad (1)$$

Transition (state) equations

$$a_{it} = a_{it-1} + v_{it}^a \qquad (2)$$

$$b_{it} = b_{it-1} + v_{it}^b \qquad (3)$$

where X are the supply or demand shocks; i denotes the converging country; j stands for the reference country or group of countries (the euro area core); k denotes the control country (the United States as a proxy for the rest of the world), which helps to distinguish the convergence of one country to the reference country or group of countries from the convergence in the rest of the world; $a_{i,t}$ and $b_{i,t}$ are time-varying coefficients defined in the transition equations as autoregressive processes; and $u_{i,t;}$ $v_{i,t}^{\ a}$ and $v_{i,t}^{\ b}$ are error terms.

The main variable of interest is $b_{i,t}$, which is a measure of the relative convergence of a particular country towards the reference group of countries, taking into account the evolution of the spread of shocks between the reference group and the control country. If $b_{i,t}$ tends towards zero, then the movements of the spread of supply or demand shocks between the converging and the reference country or group of countries are explained briefly over time by fluctuations in the spread of the same shocks between the reference country or group of countries and the control country. In other words, the reference country has a stronger role than the control country or group of countries in explaining the movements of shocks in the converging country, which means that a process of convergence is at work. On the other hand, if $b_{i,t}$ tends towards one, then the fluctuations in the spread of supply (demand) shocks between the converging and the reference country or group of countries are explained in greater detail over time by fluctuations in the spread of the same shocks between the reference and the control country or group of countries, which implies that there is no convergence with the reference country or group of countries.

Determinants of Structural Shock Convergence

The determinants that may influence the evolution of shock similarity in the non-core EU members and EU candidate countries (the peripheral wagons) to the euro area core (the euro area locomotive) are investigated by employing a dynamic panel framework. The starting point is the model used by Babetskii (2005) and Velickovski and Stojkov (2014), which is augmented by including additional variables related to the production structures and export sophistication.

The main empirical specification has the following form:

$$B_{i,t}^{s(d)} = c_{1i} + c_2 TI_{i,t} + c_3 IIT_{i,t} + c_4 FI_{i,t} + c_5 FPS_{i,t} + PS_t + ES_{i,t} + DEA\varepsilon_{i,t} \quad (4)$$

where $B_t^{s(d)}$ is the time-varying coefficient of supply (B^s) or demand (B^d) shocks estimated by the Kalman filter technique; TI is the log of the index of bilateral trade intensity; and IIT denotes the log of the index of IIT of a particular country with the euro area core. Our model differentiates between horizontal and vertical IIT and includes a variable for vertical IIT as a dominant component of two-way trade. FI denotes financial integration; FPS denotes fiscal policy synchronization between the country and the euro area core; PS denotes production structure similarity; ES denotes a measure of a country's export sophistication; DEA is a dummy for the euro area membership [2]; $i = 1,...N$ denotes the countries included in the analysis; t refers to time (quarter); and $\varepsilon_{i,t}$ indicates the disturbance term.

The baseline specification is further extended by adding interaction dummies for peripheral countries to control for potential heterogeneity among the different groups of countries. Besides, interaction dummies for the crisis are also included to investigate whether it introduced a structural break to the shock convergence process.

All the variables are explained in greater detail in Section 4.

Estimation Strategy

In this paper we deal with macroeconomic variables, which typically exhibit dynamic behaviour. Ignoring the dynamic in the model —when it actually exists — may lead to model misspecification (Greene 2008).[3] Thus, we employ the mean group (hereinafter MG) models proposed by Pesaran and Smith (1995). These models are designed for panels with a larger T dimension. The authors emphasize that if the true parameters in a model vary across countries, then those parameters cannot be estimated consistently using a model that imposes cross-country parameter homogeneity. The assumption of slope homogeneity in the traditional procedures for the estimation of dynamic panel models (such as fixed-effects or random-effects estimators) seems to be unrealistic, since most of the evidence from larger T panels suggests that slope heterogeneity is pervasive (Pesaran et al. 1996).

To obtain consistent estimators of the means of the slope coefficients, Pesaran and Smith (1995) propose the MG estimator based on the idea of averaging the estimates of the parameters obtained from N separate time-series regressions. While it might be reasonable to assume that the parameters vary across countries in the short run, it is less likely that there are no common features in the long-run relationships. This insight is exploited by the pooled mean group (hereinafter PMG) estimator proposed by Pesaran et al. (1999) as an intermediate estimator. It imposes homogeneity of the slope coefficients entering the long-run relationship (similar to a fixed-effects estimator), but allows for heterogeneity of the coefficients characterizing the short-run dynamics, similar to the MG estimator. This advantage fits well with our research as there

2. Alternatively, we use a variable for exchange rate volatility (based on the standard deviation), which is to some extent similar to the dummy variable, given that the volatility of the exchange rate is zero after joining the euro area.

3. From an econometric point of view, Greene (2008, 469) offers forcible arguments for the importance of modelling dynamics: "adding dynamics to a model [. . .] creates a major change in the interpretation of the equation. With the lagged variable, we now have in the equation the entire history of the right-hand-side variables, so that any measured influence is conditional on this history; in this case, any impact of the independent variables represents the effect of new information."

might be country-specific forces that cause heterogeneity of the short-run coefficients. It is also very likely that there are common features among the sample countries shaped by the European market integration process in the long run.

This approach is essentially a panel equivalent to the time-series error-correction reparameterization of an autoregressive distributed lag (hereinafter ARDL) model, which appears to be a useful platform for addressing a number of methodological issues. The error-correction model has the advantage of accounting for both the short-run fluctuations and the long-run equilibrium relationship between the variables, even if they appear to be non-stationary. This is very likely for relatively long macroeconomic data series, as in our case. Another major advantage of this estimator is that there is no requirement for the order of integration to be the same for all the variables since it yields consistent and asymptotically normal estimates of the parameters defining a long-run relationship between both stationary and integrated variables. Furthermore, Pesaran and Shin (1998) and Pesaran et al. (1999) point out that augmenting the ARDL specification with an adequate number of lags makes the estimation of the long-run coefficients more immune to endogeneity problems, irrespective of whether the regressors are stationary or not. This advantage is very important for our research since our empirical specification may face endogeneity problems, bearing in mind that many countries in the sample peg their exchange rates to the euro or are a euro-area member, which may result in increased shock convergence.

Our baseline sample (the wagons) comprises 21 countries (non-core euro area and EU candidate countries) that exhibit a different trade intensity and production structure, institutional development and development of financial sectors from the six advanced European countries (the euro area locomotive). Therefore, in the last stage, we test whether the estimated long-run relationship is homogeneous for all countries or it is country-specific. We estimate models using the PMG and MG methodology. Then, using the Hausman test, we determine whether the long-run coefficients are homogeneous or heterogeneous.

Estimation of Variables and Data Description

As outlined, our dataset consists of quarterly observations — from q1:1999 to q4:2013[4] — spanning six core euro area countries (Austria, Belgium, France, Germany, Luxembourg and the Netherlands) and 21 EU members and candidate countries, out of which five are peripheral countries (Greece, Ireland, Italy, Portugal and Spain) and 16 transition countries (Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Malta, Poland, Romania, Serbia, Slovakia, Slovenia and Turkey). A dataset with broader time and cross-sectional dimensions was hindered by the non-availability of reliable data for the earlier period and a discontinued time series for some transition countries (such as Albania, Bosnia and Herzegovina, and Montenegro). The dataset also includes the United States as a control county when the Kalman filter is used to estimate the convergence of demand-side and supply-side shocks.

Regarding the estimation of structural shocks, the dataset consists of seasonally adjusted output (real GDP) and prices (GDP deflator, or CPI if the GDP deflator is not available). Bearing in mind that the VAR representation applied to estimate structural supply and demand shocks requires both variables to be stationary, we applied the augmented Dickey–Fuller (hereinafter ADF) tests to test for the stationarity of the real GDP and the GDP deflator/CPI. Next, the stationary GDP growth and inflation (the year-on-year difference of the real GDP and GDP deflator/CPI) for all the countries are included in the analysis. The ADF tests applied to the real GDP growth and inflation give mixed results, thereby failing to provide sufficient evidence to reject the null of a unit root in some cases.[5] Following Suppel (2003), the data in our case are adjusted by applying the Hodrick–Prescott (H-P) trend to transform the real GDP growth and inflation into stationary variables. Thus, H-P-filtered fluctuations (smoothing parameter: 1600) in the real GDP growth and inflation are entered into the SVAR framework. The lag length is chosen based on several tests — the likelihood ratio, Schwarz information criterion (IC), Akaike IC and Hannan–Quinn IC — as well as by taking into account the criterion to obtain white noise residuals.[6] The results of the stability tests reveal that the VAR satisfies the stability condition for all the countries.

The convergence of demand-side and supply-side shocks of countries in the sample vis-à-vis the euro area core is then estimated using the Kalman filter, as explained in the previous section. Before estimating the equations, the initial state of the model is defined following the approach of Zhang and Sato (2005).[7] The average values of the estimated time-varying coefficient b for the sample (and separately for transition and peripheral countries) are presented in Figure 1. With the United States as an alternative attractor, the time-varying coefficient b for demand-side shocks follows different trends during the analysed period. After the introduction of the euro in 1999, when the sample starts, the time-varying coefficient of demand shocks for transition countries was relatively stable

4. Although our initial dataset was longer (q1:1997 to q4:2013), we lost eight observations for differencing and lag specification in VAR framework for shock estimation. The data sample starts in q1:2000 for Romania.

5. The results obtained from the ADF tests are not presented here due to the space limitation but are available from the authors on request.

6. This approach was also followed by Dibooglu and Horvath (1997).

7. The measurement equation (1) is estimated by ordinary least squares and the estimated constant coefficients are used as starting values of the unobserved variables. At the same time, the estimated variance–covariance matrix obtained by ordinary least squares is used for the specification of the starting values of the variance–covariance matrix of the unobserved variables.

until the beginning of the global financial crisis. On the other hand, the convergence process of demand-side shocks in peripheral countries was pronounced during this same period. During the crisis, abrupt changes occurred when the demand shocks converged substantially towards those of the euro area core in a short period of time, driven by a fall in the European aggregate demand. Then the process reverted, leading to substantial demand shock divergence, which was more pronounced in peripheral countries. The time-varying coefficient b of supply shocks was relatively stable until 2006, when it registered mild convergence to the euro area core. However, this process changed direction during the great recession, producing significant divergence.

As discussed in the previous section, the main variables expected to explain the convergence dynamics of the shocks are: measures of trade intensity; measures of IIT; proxies for fiscal policy synchronization and international financial integration; production structure similarity and export sophistication.

Trade intensity, calculated by following the methodology of Frankel and Rose (1998), represents the natural logarithm of the average bilateral trade intensity between country i and the euro area core j over the time period t. We employ two measures depending on whether the trade intensity is normalized by the total trade or the nominal GDP:

$$TI^{T}_{i,j,t} = (EX_{i,j,t} + IM_{i,j,t}) / (EX_{it} + EX_{jt} + IM_{it} + IM_{jt}) \quad (5)$$

$$TI^{Y}_{i,j,t} = (EX_{i,j,t} + IM_{i,j,t}) / (Y_{it} + Y_{jt}) \quad (6)$$

where TI denotes the index of trade intensity of the country with the euro area core, EX denotes exports, IM is imports and Y stands for the nominal GDP.

The indices presented in Figure 2 show that the trade intensity of the transition countries in relation to the euro area core (normalized either on the total trade or on the GDP) experienced an increase during the analysed period, although the crisis caused a decline in the trade with the euro area core. On the other hand, the trade intensity of the peripheral countries vis-à-vis the euro area core registered a reduction during this period.

IIT is expected to be another important factor behind the shock dynamics. Grubel and Lloyd's (1975) index (hereinafter GLI) is used to measure the degree of IIT between two trading partners. The GLI measures IIT as a percentage of a country's total trade that overlaps that of the trading partner. If all bilateral trade overlaps, the index will equal 100, which means that the trade consists of only IIT. On the other hand, if all trade is unmatched, then the index will be 0, indicating only inter-industry trade. Hence, the more the value of the index, the higher the degree of IIT. The index is calculated using the following formula:

$$AGLI = \left\{ \frac{\sum_{i=1}^{n}(X_{it} + M_{it}) - \sum_{i=1}^{n}|X_{it} - M_{it}|}{\sum_{i=1}^{n}(X_{it} + M_{it}) - \left|\sum_{i=1}^{n} X_{it} - M_{it}\right|} \right\} * 100 \quad (7)$$

where $AGLI$ denotes the Grubel–Lloyd index for IIT adjusted for trade imbalances; X denotes exports; M denotes imports; n represents the number of commodity groups; t indicates the period; and i denotes the commodity group.

This index does not allow the differentiation of IIT in line with Falvey's (1981) argument that commodities in the same industry can

also be differentiated by quality. Thus, IIT can be further divided into horizontal and vertical IIT,[8] a differentiation that is important in the context of our investigation since the synchronization of shocks may be affected differently by these two types of trade. While horizontal IIT should contribute to greater symmetry of shocks in accordance with the European Community Commission's (1990) view, vertical IIT does not guarantee the symmetry of shocks. The rationale is that it implies the intensification of the specialization of countries along the quality spectrum within industries. This quality spectrum includes major differences in research and development expenses, factor endowments and qualification of the labour force (Fontagné and Freudenberg 1997; Fontagné et al. 2005).

Fontagné and Freudenberg (1997) offer two indices for overcoming the disadvantages of GLI. The first considers trade at the product level as being either inter-industry (one-way) trade or IIT (two-way trade). Trade in a particular product is considered as IIT if the value of the minority flow (for example imports) is a significant percentage of the majority flow (for example exports). If the minority flow is below a particular defined minimum threshold, then the trade is considered as inter-industry trade. The authors recommend the following formula:

$$\frac{Min(X_{it}, M_{it})}{Max(X_{it}, M_{it})} \rangle \beta \qquad (8)$$

here β denotes the defined minimum threshold and the other symbols are the same as in the previous equations.

The second index allows the IIT calculated by applying equation (8) to be broken down into horizontal and vertical components. The main assumption here is that differences in prices reflect differences in quality. IIT is considered to be horizontal if the ratio between export and import unit values.[9] of a certain product differs by less than a particular defined threshold. If this condition is not satisfied, the IIT is considered to be vertical. The authors define the following formula:

$$\frac{1}{(1+\alpha)} \leq \frac{UV_{it}^{X}}{UV_{it}^{M}} \leq (1+\alpha) \qquad (9)$$

where UV denotes unit values as a common proxy for quality, α denotes the defined threshold, and the other symbols are the same as in the previous equations.

In our analysis the threshold for trade overlap defined in equation (8) is 10 percent, while that for product similarity defined in equation (9) is 15 percent — figures suggested by Fontagné and Freudenberg (1997).[10] All the reported estimates use quarterly data at the 5-digit level, producing 3,530 commodity groups. Although in many empirical studies the decomposition of trade is performed at the 3-digit level, we use a higher level of disaggregation. The intention is to estimate horizontal and vertical IIT more precisely, which depends on calculating the export and import unit values.

8. On theoretical grounds, horizontal IIT is assumed to be more consistent with the modern theories of trade and relevant to trade among developed countries, whereas vertical IIT is expected to be more closely related to traditional theories of comparative advantage and to dominate the trade among countries with different income levels (the so-called north–south trade models (e.g., Jean Louis and Simons 2014)). As Greenaway et al. (1995) demonstrate, failure to separate the two components can seriously undermine the interpretation of the empirical results. Not only are horizontal and vertical IIT driven by different factors, but adjustment implications of a given trade expansion also differ between the two.

9. The unit values for exports and imports are obtained by dividing the values of exports and imports by their quantity.

10. Fontagné and Freudenberg (1997) estimate the share of intra-EU trade flows according to the degree of overlap (the minority flow as a percentage of the majority flow) and find that the highest value is for a threshold of 10 percent (almost one-third of all intra-EU trade). As for the share of intra-EU trade flows according to the unit value ratios of bilateral trade flows (measured by dividing the larger unit value by the smaller one), the highest value is for the threshold of 15 percent (more than a quarter of the total intra-EU trade).

The calculated indices suggest that the share of IIT of the transition countries with the euro area core increased during the analysed period by around 10–15 percentage points, reaching 40 percent of the total trade (Figure 3). Given that the IIT of the peripheral countries was higher than that of the transition countries, it rose at a slower pace and increased cumulatively by around 5 percentage points during the analysed period. Nevertheless, the largest part of IIT is vertical IIT; the share of horizontal IIT is small and on an average amounted to less than one-fifth of the total IIT or around 10 percent of the total trade of the transition and peripheral countries with the euro area core during the analysed period.

Fiscal policy synchronization is defined in a way similar to Darvas et al.'s (2005) definition. It represents the difference in the cyclically adjusted government budget balance — surplus or deficit, measured as a percentage of the country's GDP — between the peripheral countries and the euro area core. The cyclically adjusted government budget balance is calculated by applying the H-P filter to the general government budget balance series. The average values of the variables related to fiscal policy synchronization for the countries do not seem to support a clear trend of movement during the analysed period, although the global economic crisis is reflected in increased fiscal policy divergence (Figure 4).

Since there are no available data for financial flows among the countries included in the analysis and the euro area core on a quarterly basis, we use — as a proxy for financial integration — index from the euro area core average (CPI-based, 2005=100), [11] to measure the log deviation of the country's real effective exchange rate (hereinafter REER). Our control variable is likely to capture the effects of, for example, higher foreign direct investments originating from the euro area core on shock convergence in the countries, which are reflected in appreciation of their REER. Indeed, Figure 5 presents a clear trend of REER appreciation before the crisis in the entire sample, which was then interrupted and turned in the opposite direction in some periods.

The production structures variable is introduced in the model to capture the effects of output similarity on shock convergence, given that it was estimated as a significant determinant in earlier researches (see footnote 1). The variable is constructed according to the definition of Krugman's specialization index and takes the value of zero if a country has an industrial structure identical to the euro area core, indicating that the country in question is not specialized. It takes a maximum value of two if it has no sectors in common with the euro area core, reflecting strong sectoral specialization.[12] The indicator can be seen as the relative specialization compared with a benchmark, which here is the euro area core. Sectoral specialization affects shock synchronization in such a way that more similar production structures between countries become prone to a higher level of synchronization. Transition countries have mostly higher index values than peripheral countries, reflecting a higher level of specialization as against the euro area core. Their level of specialization increased during the crisis period, as shown in Figure 6.

We also investigate the role of a country's export sophistication in shock convergence, given that export of more sophisticated

11. In a robustness check, we employ an alternative proxy for financial integration, relying on annual data of the FDI flows interpolated on a quarterly frequency by using quarterly data of the REER scaled to the per capita level.

12. The indicator is constructed using quarterly national accounts data compiled in accordance with the European System of Accounts 2010 (ESA 2010). It uses gross value-added data based on the statistical classification of economic activities in the European Community (NACE Rev. 2) and a detailed breakdown into 10 aggregates (agriculture, forestry and fishing; industry and manufacturing; construction; wholesale and retail trade, transport, accommodation and food service activities; information and communication; financial and insurance activities; real estate activities; professional, scientific and technical activities, administrative and support service activities; public administration; and other sectors).

products is expected to support the shock convergence process. Our study uses an outcome-based measure of sophistication. If a product is mostly produced and exported by rich countries, then it is revealed to be a sophisticated product. The export sophistication is calculated as a weighted average of the per capita GDP of the countries producing that product, with weights derived from the revealed comparative advantage. Figure 7 suggests that there is no clear trend of the movement of export sophistication, despite its volatility increasing during the crisis.

The dataset gives, in total, 1,260 observations (N=21 countries and T=60 quarters).[13] The panel is unbalanced because there are missing observations for some of the variables. The variables related to trade intensity, trade structure and a proxy for financial integration are expressed in natural logarithms for more convenient interpretation. The descriptive statistics for the variables of interest are provided in Table 1. We run several tests for non-stationarity to inspect the data more systematically. First, the Im–Pesaran–Shin (hereinafter IPS) test is appropriate for dynamic heterogeneous panels and is based on the average of the ADF statistics calculated for each cross-section in the panel. The IPS test checks the null of a unit root in the entire panel against the alternative that some panels are stationary. Second, the Fisher ADF and Fisher PP tests similarly check the non-stationarity for each individual panel and obtain the test statistic by combining the p-values from the separate tests. Both tests examine the null of a unit root in all panels against the alternative that at least one panel is stationary. The results suggest that the null of a unit root is strongly rejected for all the variables, except for the time-varying coefficients of supply shocks, which are non-stationary at the 1 percent or 5 percent significance level according to at least two tests (Table 2). The stationarity of this variable is obtained by first differencing, which suggests (tentatively) that the data are integrated of order 1 (that is, I(1)). In further analysis we do not transform the non-stationary variable because the estimator developed by Pesaran et al. (1999) does not require the order of integration to be the same for all the variables since it is consistent in estimating the long-run relationship between the stationary and the integrated variables.

13. The sources of the data employed in the analysis include Eurostat (data for prices, output and budget balances), the Eurostat Comext database (data for IIT), the IMF's international financial statistics (data for the REER), the IMF's direction of trade statistics (data for trade intensity), the World Bank (data for export sophistication) and the statistics of agencies and central banks of the respective countries for data that were not available from the previous sources.

Results

We present, firstly, the results of the baseline model described in equation (4). Given the heterogeneous movements of the variables, we then enlarge the model with interaction dummies with the aim to capture the heterogeneity between transition and peripheral countries as well as the effects of the crisis on shock convergence. Due to the limited number of observations, it is nearly impossible to estimate a model that includes numerous (at least 12) interaction dummies that simultaneously control for heterogeneity and crisis. Therefore, we develop two versions of this model. The first (Panel A) investigates whether the convergence process differs between transition and peripheral countries, and includes interaction dummies of peripheral countries with each variable in equation (4). This differentiation is important given that the peripheral countries joined the EU and the euro area much before the transition countries that may require different trade intensity and production structures as well as financial sector developments. The second version of the model (Panel B) investigates the effects of the crisis on the convergence process and includes interaction dummies of the crisis with each variable in equation (4).[14]

Before we discuss the results, we focus briefly on the lag structure and consistency of the estimator. Regarding the lag structure of the model, which is important for tackling the possible endogeneity, we determine the lag order suggested by the information criteria (the Schwarz IC, the Akaike IC and the R2-adjusted). We estimate a baseline regression for each country, allowing for up to four lags of each explanatory variable. We then choose the optimal number of lags for each country and finally identify the most common option. The results suggest the inclusion of one lag of the dependent variable and no lags of the independent variables in the model. As regards the consistency of the estimator (here we recall the discussion in sub-section 3.3), the Hausman test enables us to test the difference between the PMG and the MG estimator under the null that the estimates are the same; if the null cannot be rejected, the PMG is preferred, since it is both consistent and efficient in that case. The results of the Hausman test suggest that the PMG estimates are preferred since we do not reject the null of equality between the PMG and the MG at the 1 percent level of significance.[15]

Results of the Baseline Model

The results presented in Table 3 reveal that the coefficient of the error-correction term, both for the supply-side and demand-side shocks, is statistically significant at the 1 percent level. It suggests that the selected variables in the model demonstrate a return to a long-run equilibrium. The error-correction speed of the adjustment parameter from the demand shock equation is estimated as 0.111, implying that the demand shock convergence or divergence is likely to occur relatively slowly. If it is above its long-run equilibrium level, the deviation will be offset such that 11 percent of the remaining disequilibrium is accomplished in each successive quarter, which means a period of five years for around 90 percent of the total adjustment required. The error-correction speed of the adjustment parameter for the supply-side shocks is of a slightly higher magnitude (0.123), suggesting

14. The start of the crisis in q1:2008 was identified from the graphical presentation of demand and supply shocks in Figure 1.

15. Regarding equation (4) for demand shocks as a dependent variable, the p-value of the Hausman test is 0.399, while for supply shocks it is 0.754

that the supply shock convergence or divergence is likely to occur faster, yet it will need around 4.5 years to eliminate 90 percent of the remaining disequilibrium.

Regarding the explanatory variables, the coefficients for trade intensity (normalized on the total trade flows) suggest that the increase in the volume of trade with the euro area core causes supply shock divergence. When the trade intensity index increases by 1 unit, the supply shocks, on an average, diverge from those of the euro area core by 0.135 units, ceteris paribus. On the other hand, the increase in the volume of trade supports the demand shock convergence with the euro area core, although the coefficient is statistically significant at the borderline 10 percent level.

As for IIT, the estimated negative sign of the coefficients suggests that the increased similarity in the trade patterns is likely to contribute to convergence of both the demand and the supply shocks. More precisely, an increase in the IIT index by 1 unit is expected to lead to convergence of the demand shocks to those of the euro area core, on an average by 0.025 units, ceteris paribus. The supply shock convergence due to the increase in the similarity of the trade structure is even higher, given that the coefficient value is 0.061.

As for the fiscal policy synchronization — proxied by the difference between the country's cyclically adjusted general government budget balance and that of the euro area core — the model recognizes divergent fiscal policies as a source of idiosyncratic shocks. The coefficient is significant and positive in both the demand and supply shock equation. It suggests that an increase in the difference between the government budget balance (normalized by the GDP) of the transition/peripheral countries and the euro area core by 1 percentage point is expected to lead to demand and supply shock divergence of 0.001 and 0.003 units respectively.

The model identifies significant but opposing impacts of financial integration on the shock convergence process of the transition/peripheral countries towards the euro area core. The positive value of the coefficient indicates that when the REER in the transition/peripheral countries appreciates over and above the REER of the euro area core by 1 unit, the demand shocks, on an average, diverge from those of the euro area core by 0.092, holding other factors constant. The opposite is true for the supply shocks, since the coefficient has a negative value (-0.190), suggesting that financial integration contributes to similar and permanent effects on output (supply shock convergence).

The production structure variable is estimated to be statistically significant only in the demand shock equation. The positive value of the coefficient (0.172) suggests that the developments in the production structure induced demand shock divergence from the euro area core. The last two variables related to export sophistication and the euro area membership do not appear to be statistically significant.[16]

In general, the findings that higher IIT supports both supply and demand shock convergence processes are in line with previous empirical work (Fidrmuc 2004; Shin and Wang 2005; Velickovski and Stojkov 2014). Likewise, the estimated shock-diverging effects caused by lower fiscal policy synchronization and production structure similarities confirm the findings of the earlier studies (Imbs 1999; Kalemli-Ozcan et al.

16. The results from the alternative specification, which includes a variable for exchange rate volatility instead of a dummy for euro area membership, suggest that the coefficient of exchange rate volatility is statistically insignificant in both the supply and the demand equation

2001; Darvas et al. 2007; Artis et al. 2008). However, our study reveals that higher trade intensity and financial integration may have different effects on the convergence process depending on the type of shock. While a higher level of trade intensity to some extent contributes to demand shock convergence, it simultaneously leads to supply shock divergence. Furthermore, while increased financial integration on the one hand leads to demand shock divergence, on the other hand it leads to greater supply shock convergence. From a longer-term perspective, the dynamics of supply-side shocks appear to be more important, because supply disturbances have an effect on output that cumulates over time to reach a plateau after five years. The opposing effects, conditional on the type of shock, might be due to the heterogeneity among the countries and the great recession — investigated more thoroughly in the following sections.

Transition versus Peripheral Countries

The results in Table 4, Panel A present the heterogeneity of the shock convergence process between the transition and peripheral countries. With regard to the demand shock equation, the results suggest that the selected variables did not affect the shock convergence in the transition countries given that all the coefficients are statistically insignificant. On the other hand, trade intensity is estimated to be supportive of shock convergence in peripheral countries since its coefficient has a negative and statistically significant value (-0.064). However, its converging efforts were not supported by the rest of the variables, in particular by the financial integration and production structure, which created diverging tendencies of the demand shocks in relation to the euro area core.

As for the supply shock equation, the coefficient for trade intensity (normalized on total trade flows) suggests that the increase in the volume of trade with the euro area core causes supply shock divergence in transition countries. When the trade intensity index increases by 1 unit, the supply shocks in the transition countries diverge from those of the euro area core by 0.168 units on an average, holding other factors constant. The extent of divergence is substantially smaller in peripheral than in transition countries, given that the interaction dummy has a negative value of -0.161.

With regard to IIT, the estimated negative sign of the coefficient suggests that the increased similarity in the trade patterns is likely to contribute to convergence of the supply shocks in transition countries. More precisely, an increase in the IIT index by 1 unit is expected to lead to convergence of the supply shocks in the transition countries to those of the euro area core by 0.060 units on an average, ceteris paribus. The interaction coefficients for peripheral countries suggest that in the equation for supply shocks there are statistically significant differences from the transition countries, and its positive value (0.157) suggests divergence effects.

There are no statistically significant differences between the transition and peripheral countries with regard to the estimated effects of financial integration on the supply shock convergence process. The negative value of the coefficient (-0.264) indicates that the financial integration contributed to supply shock convergence of both transition and peripheral countries towards the euro area core. On the other hand, the estimated significant interaction dummy for production structures reveals the differences between the two groups of countries and suggests that the

developments in the production structure in peripheral countries induced supply shock divergence from the euro area core.

Transition and peripheral economies, therefore, have substantial differences in the shock convergence process that can be related to the results from earlier studies. In particular, the findings for the transition countries showing that trade intensity is not supportive of shock convergence are in line with the results of Caporale et al. (2015), estimating an increasing trade-driven business cycle divergence. However, it is clear that our results — suggesting that trade intensity supports demand shock convergence in peripheral countries — are not in line with their findings. This might, to some extent, be explained by the findings of Antonakakis et al. (2015), which suggest that there was a structural break and intertemporal alternation in the direction of shock spillovers between the core and periphery of the euro area. In particular, during the recent European debt crisis, it appears that the peripheral countries are mostly the dominant transmitters of business cycle shocks among the euro area members.

Crisis Effects

The results presented in Table 4, Panel B reveal the crisis effects on the shock convergence process in transition/peripheral countries vis-à-vis the euro area core. Regarding the demand shocks, IIT supported faster shock convergence during the crisis period by 0.028 units compared with the pre-crisis period. Controlling for the crisis yields a statistically significant effect of export sophistication on demand shock convergence, which was estimated to be insignificant in the baseline specification, although both the intra-industry trade interaction dummy and the export sophistication coefficient are statistically significant at the 10 percent level. On the other hand, the crisis implied divergent effects of the production structure on shock dynamics as the interaction dummies are statistically significant and positive in both the demand and the supply equation (0.241 and 0.102, statistically significant at 1 percent and 5 percent respectively). In addition, financial integration is estimated to lead to divergent tendencies of the supply shock developments during the crisis period since its interaction coefficient is positive and statistically significant at the 10 percent level. This divergent behaviour may be explained by the fact that in the post-crisis period, compared with the pre-crisis period, the financial flows to peripheral/transition countries were substantially reduced, imposing significant productivity shocks on these countries. This finding is in line with Ehrmann and Fratzscher (2015), who documented substantial financial fragmentation in the euro area compared with the period before the crisis.

Size Effects

Our evidence, discussed above, indicates that the analysed variables did not drive the evolution of the shocks in a systematic direction. In other words, some of the variables contributed to shock convergence of the transition and peripheral countries to the euro area core, while others supported divergence. To gain a deeper understanding of the individual and net effects, we estimate the relative size of the effects of some normal change in the explanatory variables on the dependent variable (Table 5). We define the normal change as a change from the 25^{th} percentile to the 75^{th} percentile of the explanatory variable of interest (presented in Table 1), which is multiplied by its estimated coefficient. The obtained results suggest that trade intensity and IIT contribute the most to the demand shock convergence process and the effect of its normal change on demand shock convergence is 0.05 and 0.02

units respectively. However, the rest of the variables caused demand shock divergent movements in a range of 0.01–0.05 units, which intensified during the crisis and — particularly for peripheral countries — were driven primarily by production structure and financial integration developments. As for the supply shocks, IIT was supportive of the shock convergence process and its normal change had an estimated effect of 0.04 units, albeit lower in peripheral than in transition countries. In addition, a normal change in financial integration contributed to supply shock convergence by 0.02 units, which was reduced during the crisis by 0.01 units. Trade intensity is the main driver of supply shock divergence, in particular for transition countries, since its estimated effect of normal change is 0.35 units. The fiscal policy also contributed to divergent movements of supply shocks by 0.02 units. The production structure changes are a relevant shock-diverging force in peripheral countries, with estimated effects of normal change of 0.07 units, which increased during the crisis by 0.02 units.

In a nutshell, demand shock convergence was supported by trade intensity, at least in peripheral countries and intra-industry trade, but their effects were largely neutralized by the unsynchronized fiscal policies, financial flows and production structure developments. On a net basis, demand shocks did not register a clear and strong convergence trend. At the same time, trade intensity, in tandem with fiscal policy, strongly contributed to the divergent movements of supply shocks and annulled the convergence-supporting effects of IIT and financial integration. This evidence of the prevailing supply shock divergent effect of trade intensity is also in line with the recent work by Caporale et al. (2015), which finds that trade flows within the euro area are leading to decreased business cycle correlation between member states. These findings, in combination with the reversal in financial flows during the crisis, challenge the endogeneity hypothesis of Frankel and Rose (1998) and rather support the specialization paradigm of Krugman (1993), which is concerning evidence for the future stability of the euro area.

Robustness

To assess the robustness of the findings, we modify the specifications in both Panel A and Panel B by: (1) employing an alternative measure of trade intensity and intra-industry trade, (2) using a different measure of financial integration, (3) controlling for the membership of the EU, (4) excluding France from the euro area core, and (5) excluding Italy from the periphery.

In the first set of robustness checks we employ an alternative measure of trade intensity normalized by the GDP and vertical IIT index instead of the adjusted weighted Grubel–Lloyd index, which were previously explained in detail in section 4. The results obtained for trade intensity and vertical IIT are consistent with the baseline model estimations based on employing the trade intensity measure normalized by the total trade and adjusted weighted Grubel–Lloyd index in terms of sign, although some of the coefficients lose statistical significance (Table 5).

In the second step we use an alternative proxy for financial integration, relying on annual data of the FDI flows interpolated with a quarterly frequency by using quarterly data of the REER. The coefficients of the alternative variable lose statistical significance in the pre-crisis period and for the transition countries, but the findings that financial integration was a shock-diverging force in peripheral countries and during the crisis times are confirmed.

In the third step the baseline specification is further extended by adding dummy variables to control for the influence of the EU membership on the shock convergence process. The dummies are insignificant, but the general conclusions arising from the baseline model estimate are largely supported.

In the next two steps we exclude France from the euro area core and Italy from the periphery since an issue was raised during the crisis concerning whether they both belong to the reference groups. For example, Italy was often not considered as part of the so-called GIPS periphery (Greece, Ireland, Portugal and Spain). On the other hand, the funding of peripheral banks shifted from private to public sources during the crisis, increasing the TARGET2 imbalances (Cecchetti et al. 2012). Unlike other core countries that registered net claims from the rest of the members of the euro area, France was a borderline net debtor. Given that both France and Italy are big countries and thus may influence our results, we exclude them from the reference group to check the stability of our findings from the baseline specification. The results obtained are consistent with those discussed in Section 5.

Conclusion

The current crisis questioned the feasibility of the euro area as a monetary union, underlining the differences between the core and the periphery. In this context, the research examines whether the euro area core can be a driving force of the shock convergence process of the wider periphery (encompassing the non-core EU member states and the EU candidate countries). In particular, the paper investigates whether the developments of trade intensity, structure of trade, financial integration, fiscal policy, production structure and export sophistication support either the convergence or divergence process in Europe. The analysis covers the period from the introduction of the euro in 1999 until 2013 in a panel framework for six euro area core countries, five peripheral countries, 13 new members of the EU and three EU candidate countries.

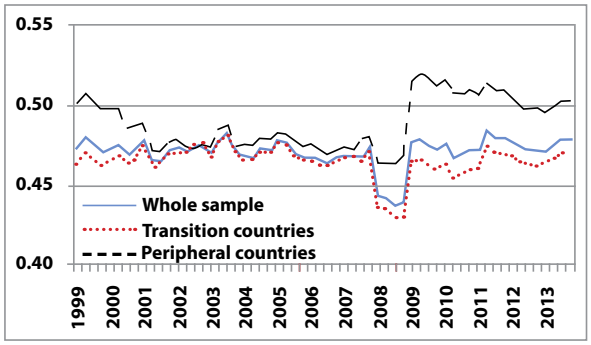
We argue that the shock-centred approach is methodologically sounder than the BCS approach for at least two reasons: (i) it isolates the shock incidence from policy responses, a distinction that lies at the heart of OCA, and (ii) it differentiates between supply-side and demand-side shocks.

Our findings suggest that the euro area core has not been a strong magnetizer of the shock convergence of peripheral and transition countries from the time of euro's inception until the end of 2013. This is due to the offsetting effects of the different variables that affected the shock convergence process. In particular, the demand shock convergence was supported by the IIT developments and to some extent by the trade intensity, at least for the peripheral countries, but their effects were offset by the divergent fiscal policies, production structure changes and financial flows. On the other hand, supply shocks registered a divergent tendency, which was mainly driven by trade intensity flows and uncoordinated fiscal policies. The centripetal (or convergence-supporting) effects of IIT and financial integration were not strong enough to counteract the diverging forces.

Taken together, it appears that trade flows are the prevailing force in shock divergence, in particular for supply-side shocks in transition countries vis-à-vis the euro area core. The estimated divergent shock effects of trade flows support the specialization hypothesis of Krugman (1993), and in combination with the reversal of financial flows during the crisis and the increasing production structure dissimilarities, especially in the peripheral countries, they raise the issue of setting an appropriate monetary policy, fiscal policy and financial stability mix to overcome the weaknesses of the eurozone's institutional underpinnings and maintain the future stability of the euro area. At the same time, despite the fact that many transition countries have already joined the euro area, these findings advise a more vigilant approach in assessing the costs and benefits of relinquishing an independent monetary policy by the rest of the transition countries that have not adopted the euro yet. In this light, the problems that some of the peripheral countries experienced during the crisis due to their inability to depreciate their currency constitute very relevant evidence of the size of costs that a country may face when abandoning its monetary independence. In this context, the appropriate structural reforms are necessary in the peripheral and transition countries — current and potential future members of the euro area — that will result in longer-lasting financial inflows. Inter alia, they are expected to narrow the differences in production structures and IIT patterns and thus ease the governance in the fiscal area. Otherwise, reconnecting the peripheral wagons to the euro area core locomotive could easily turn into an impossible mission, with vast political, economic, social and cultural consequences for Europe.

Graphs and Tables

a) Demand shocks



b) Supply shocks

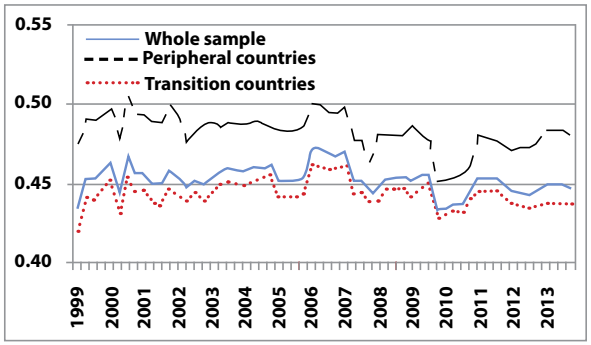
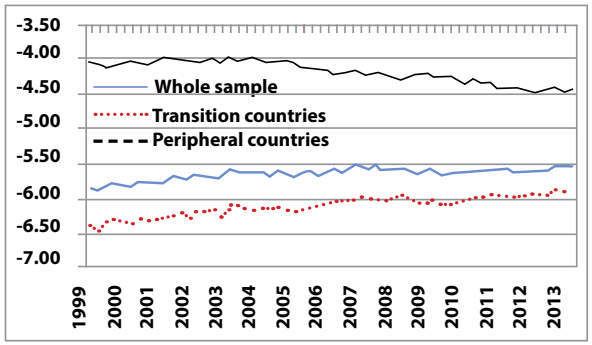


Fig.1 Time-varying coefficient b for transition and peripheral countries (average values) Calculated in EViews7
Source: Authors' calculations.

a) Normalized on total trade



b) Normalized on GDP

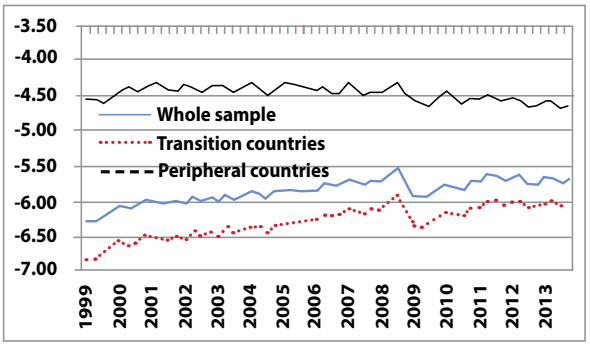
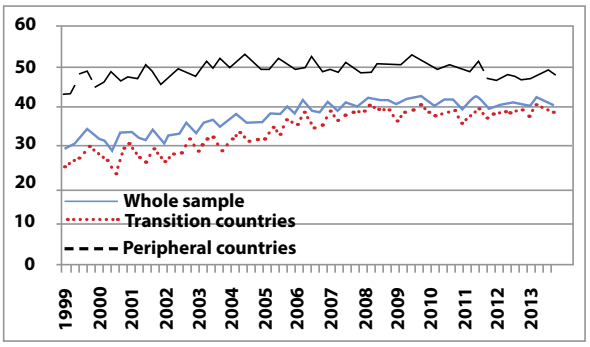


Fig.2 Trade intensity of the transition and peripheral countries with the euro area core (average logarithmic value)
Source: Authors' calculations.

a) Adjusted Grubel–Lloyd index



b) vertical IIT

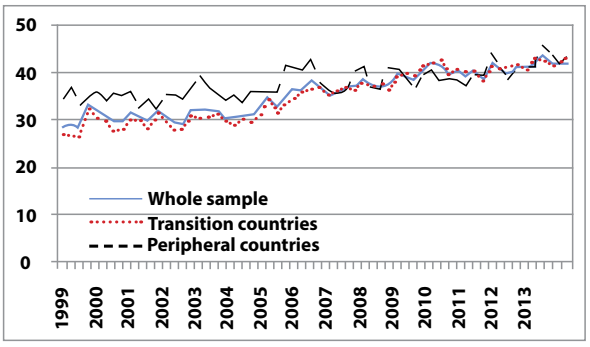


Fig. 3 IIT of the transition and peripheral countries with the euro area core (average values in %)
Source: Authors' calculations.

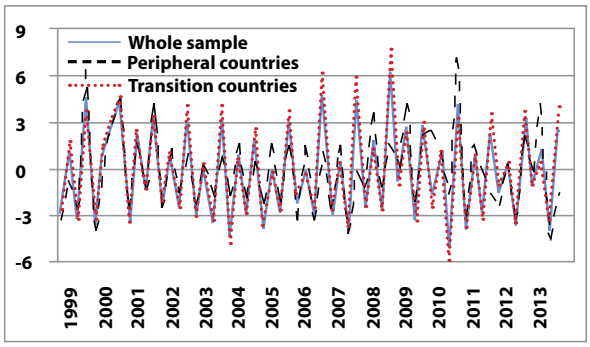


Fig.4 Fiscal policy synchronization (average values)

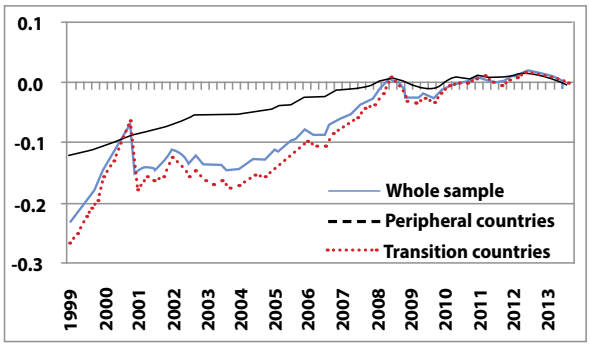


Fig. 5 Financial integration (average values)

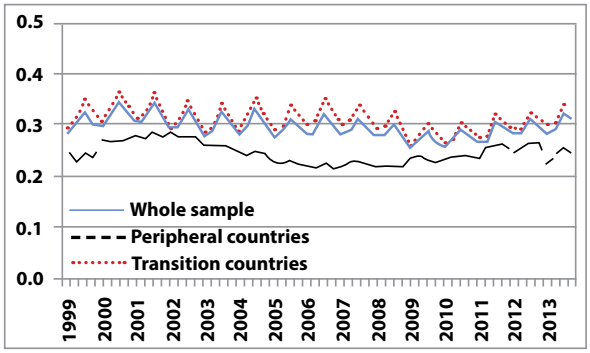


Fig. 6 Production structure (average values)

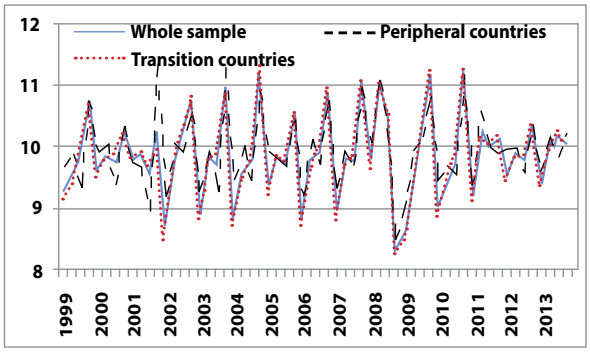


Fig.7 Export sophistication (average values)

Table 1. Descriptive statistics for the variables of interest.

	Min.	Max.	Mean	25th	75th	NC	SD
Time-varying coefficients for demand shocks	0.24	0.66	0.46	0.36	0.55	0.19	0.11
Time-varying coefficients for supply shocks	0.18	0.76	0.45	0.37	0.50	0.13	0.13
Trade intensity (normalized by total trade)	-8.53	-2.78	-5.65	-7.05	-4.43	2.61	1.50
Trade intensity (normalized by GDP)	-9.09	-3.23	-6.00	-7.34	-4.79	2.55	1.49
Adjusted weighted GLI	1.11	4.54	3.49	3.25	3.90	0.65	0.62
Vertical IIT	1.03	4.25	3.42	3.14	3.93	0.79	0.62
Fiscal policy synchronization	-41.77	29.16	0.01	-2.92	2.66	5.58	4.61
Financial integration (based on REER)	-0.74	1.07	-0.07	-0.12	0.00	0.12	0.13
Financial integration (based on FDI flows)	-11.68	29.66	0.47	0.02	0.24	0.22	2.35
Production structure	0.05	0.64	0.29	0.20	0.39	0.18	0.11
Export sophistication	4.09	15.65	9.88	9.42	10.35	0.93	0.87

Note: NC – normal change in the variable measured as a change from the 25th to the 75th percentile; SD – standard deviation.

Source: Authors' calculations.

Table 2. Summary of panel unit root tests (p-values).

Original data			First difference of the data			
	IPS	**Fisher**	**Fisher**	**IPS**	**Fisher**	**Fisher**
Variables		**ADF**	**PP**		**ADF**	**PP**
Time-varying coefficients for demand shocks	0.000	0.001	0.001	0.000	0.000	0.000
Time-varying coefficients for supply shocks	0.525	0.634	0.040	0.000	0.000	0.000
Trade intensity (normalized by total trade)	0.015	0.000	0.000	0.000	0.000	0.000
Trade intensity (normalized by GDP)	0.000	0.000	0.000	0.000	0.000	0.000
Adjusted weighted GLI	0.000	0.000	0.000	0.000	0.000	0.000
Vertical IIT	0.000	0.000	0.000	0.000	0.000	0.000
Fiscal policy synchronization	0.000	0.000	0.000	0.000	0.000	0.000
Financial integration (based on REER)	0.000	0.001	0.000	0.000	0.000	0.000
Financial integration (based on FDI flows)	0.000	0.000	0.000	0.000	0.000	0.000
Production structure	0.000	0.000	0.000	0.000	0.000	0.000
Export sophistication	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' calculations.

Table 3. PMG estimation of the long-run coefficients of the determinants of supply and demand shock convergence (q1:1999–q4:2013).

Independent variable	Demand shocks	Supply shock
Trade intensity *(normalized on total trade flows)*	***-0.019**** *0.011*	***0.135**** *0.015*
Intra Industries trade *(adjusted Grubel-Lloyed index)*	***-0.025**** *0.006*	***-0.061**** *0.015*
Fiscal policy synchronization *(based on budget balance)*	***0.001**** *0.001*	***0.003**** *0.001*
Financial integration	***0.092**** *0.027*	***-0.190**** *0.034*
Production structures	***0.172**** *0.033*	*0.017* *0.062*
Export sophistication	*-0.002* *0.002*	*-0.005* *0.004*
EA membership	*-0.001* *0.001*	*-0.001* *0.001*
Error-correction term	***-0.111**** *0.023*	***-0.123**** *0.026*
Constant	***0.047**** *0.011*	***0.173**** *0.037*
Number of observations	927	927

Note: Numbers in italic are robust standard errors; asterisks indicate statistical significance at the ***1, **5 and *10% level. Calculated in Stata 12.

Source: Authors' calculations.

Table 4. PMG estimation of the long-run coefficients of the determinants of supply and demand shock convergence – interaction dummies (q1:1999–q4:2013).

	Panel A Transition Vs Peripheral Countries		Panel B Crisis effects	
Independent variable	**Demand shocks**	**Supply shocks**	**Demand shocks**	**Supply shocks**
Trade intensity *(normalized on total trade flows)*	*0.011* *0.014*	***0.168**** *0.019*	***-0.082**** *0.029*	***0.075**** *0.019*
Intra Industries trade *(adjusted Grubel-Lloyd index)*	*-0.009* *0.009*	***-0.060**** *0.020*	***-0.056**** *0.027*	***-0.030** *0.016*
Fiscal policy synchronization *(based on budget balance)*	*0.001* *0.001*	*0.001* *0.001*	***0.002*** *0.001*	***0.003**** *0.001*
Financial integration	*-0.040* *0.025*	***-0.264**** *0.035*	***-0.010*** *0.058*	***-0.263**** *0.051*
Production structures	***-0.024**** *0.040*	*0.096* *0.072*	***-0.412**** *0.102*	*0.016* *0.067*
Export sophistication	*0.002* *0.003*	*-0.008* *0.005*	***-0.013*** *0.007*	*-0.002* *0.004*
Trade intensity *Interaction dummy*	***-0.064**** *0.025*	***-0.161**** *0.035*	*-0.006* *0.004*	*0.002* *0.002*
Intra Industries trade *Interaction dummy*	*0.037* *0.038*	***0.157**** *0.041*	***-0.028*** *0.015*	*0.007* *0.009*
Fiscal policy synchronization *Interaction dummy*	*0.001* *0.001*	*0.001* *0.002*	*0.000* *0.001*	*0.000* *0.001*
Financial Integration *Interaction dummy*	***0.128**** *0.063*	*-0.150* *0.159*	*-0.055* *0.135*	***0.180*** *0.098*
Production structures *Interaction dummy*	***0.148**** *0.068*	***0.448**** *0.124*	***0.241**** *0.091*	***0.102**** *0.047*
Export sophistication *Interaction dummy*	*0.012* *0.008*	*0.007* *0.008*	*0.003* *0.006*	*-0.004* *0.004*
Error- correction term	***-0.122**** *0.022*	***-0.137**** *0.031*	***-0.057**** *0.018*	***-0.133**** *0.027*
Constant	***0.059**** *0.012*	***0.131**** *0.039*	*0.008* *0.006*	***0.128**** *0.027*
Number of observations	927	927	927	927

Note: Numbers in italic are robust standard errors; asterisks indicate statistical significance at the ***1, **5 and *10% level.
Calculated in Stata 12.

Source: Authors' calculations.

Table 5. Relative effects of the determinants of supply and demand shock convergence.

	Baseline Specification		Panel A Transition Vs Peripheral Countries		Panel B Crisis effects	
Independent variable	Demand shocks	Supply shocks	Demand shocks	Supply shocks	Demand shocks	Supply shocks
Trade intensity	-0.05	0.35		0.42	-0.22	0.20
Intra-industry trade	-0.02	-0.04		-0.05	-0.05	-0.02
Fiscal policy synchronization	0.01	0.02			0.01	0.02
Financial integration	0.01	-0.02		-0.04	0.00	-0.04
Production structures	0.03				-0.07	
Export sophistication					-0.01	
Interaction dummies						
Trade intensity			-0.12	-0.29		
Intra-industry trade				0.03	-0.01	
Fiscal policy synchronization						
Financial integration			0.01			0.01
Production structures			0.02	0.07	0.05	0.02
Export sophistication						

Source: Authors' calculations.

Table 6. Robustness checks.

	1)Alternative measure for trade intensity and intra-industry trade				2)Alternative measure for financial integration				3)Controlling for EU membership				4)Excluding France from the core				5)Excluding Italy from the periphery			
	Panel A TRANSITION VS PERIPHERAL COUNTRIES		**Panel B** CRISIS EFFECTS		**Panel A** TRANSITION VS PERIPHERAL COUNTRIES		**Panel B** CRISIS EFFECTS		**Panel A** TRANSITION VS PERIPHERAL COUNTRIES		**Panel B** CRISIS EFFECTS		**Panel A** TRANSITION VS PERIPHERAL COUNTRIES		**Panel B** CRISIS EFFECTS		**Panel A** TRANSITION VS PERIPHERAL COUNTRIES		**Panel B** CRISIS EFFECTS	
Independent variable	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks	Supply Shocks
Trade intensity	-0.003	**0.115*** **	**-0.032** **	**0.020***	**-0.044***	0.034	**-0.054*** **	**0.087*** **	0.006	**0.166*** **	-0.011	**0.075*** **	0.023	**0.070*** **	**0.035** **	**0.085*** **	0.011	**0.168*** **	-0.005	**0.087*** **
	0.010	0.017	0.012	0.012	0.025	0.022	0.028	0.014	0.015	0.020	0.014	0.016	0.030	0.014	0.016	0.016	0.014	0.019	0.011	0.019
Intra-industry trade	-0.002	**-0.099*** **	-0.001	-0.004	0.005	**-0.184*** **	0.005	**-0.042*** **	-0.003	**-0.068*** **	-0.013	0.001	**-0.116*** **	**-0.087*** **	**-0.072*** **	**-0.053*** **	-0.009	**-0.058*** **	**-0.018** **	-0.019
	0.011	0.023	0.011	0.013	0.019	0.018	0.024	0.014	0.011	0.022	0.009	0.011	0.003	0.015	0.014	0.015	0.009	0.019	0.007	0.016
Fiscal policy synchronization	0.001	**0.003*** **	-0.001	**0.003*** **	-0.001	**0.003*** **	0.001	0.001	0.000	0.001	0.000	**0.003*** **	0.000	**0.002*** **	-0.000	**0.003*** **	0.001	0.001	0.000	**0.002***
	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Financial integration	**-0.060***	**-0.311*** **	-0.022	**-0.273*** **	**0.030***	0.004	0.028	0.002	-0.030	**-0.213*** **	0.007	**-0.235*** **	**-0.195*** **	**-0.109*** **	-0.019	**-0.263*** **	-0.040	**-0.263*** **	0.016	**-0.276*** **
	0.033	0.049	0.038	0.059	0.016	0.003	0.017	0.001	0.032	0.037	0.038	0.040	0.056	0.028	0.032	0.038	0.025	0.034	0.035	0.045
Production structures	**-0.128*** **	-0.062	**0.130*** **	-0.012	**-0.343*** **	**0.535*** **	**-0.365*** **	-0.034	-0.009	-0.096	**0.140*** **	**-0.275*** **	**-0.277*** **	**0.095***	0.062	**-0.141** **	-0.024	-0.112	**0.131*** **	**-0.113***
	0.045	0.089	0.038	0.060	0.101	0.082	0.096	0.032	0.039	0.070	0.038	0.058	0.100	0.050	0.045	0.057	0.040	0.071	0.037	0.065
Export sophistication	**-0.005***	-0.001	**-0.015*** **	-0.004	**-0.015** **	**-0.010*** **	**-0.018** **	0.002	**-0.003***	-0.009	**-0.009** **	-0.003	-0.004	-0.005	**-0.005***	-0.004	0.002	**-0.007***	**-0.009*** **	-0.005
	0.003	0.004	0.005	0.004	0.008	0.003	0.008	0.003	0.002	0.005	0.004	0.004	0.005	0.003	0.003	0.003	0.003	0.004	0.004	0.004
Trade intensity Interaction dummy	**-0.099*** **	**-0.127*** **	0.001	**0.007*** **	0.010	**0.057***	**-0.008***	**0.006** **	**-0.064** **	**-0.158*** **	**0.008*** **	**0.008*** **	-0.022	**-0.158** **	0.003	**0.012*** **	**-0.068*** **	**-0.289*** **	**0.010*** **	**0.012*** **
	0.027	0.037	0.003	0.003	0.008	0.030	0.004	0.002	0.031	0.035	0.003	0.002	0.035	0.063	0.003	0.003	0.025	0.039	0.002	0.003
Intra-industry Trade Interaction dummy	0.003	**0.183*** **	**-0.029*** **	-0.012	**-0.324***	**0.200*** **	-0.015	**0.017** **	0.044	**0.165*** **	**-0.013** **	-0.006	**0.081***	**-0.109***	**-0.012** **	0.005	0.040	**0.105*** **	**-0.013** **	0.014
	0.023	0.043	0.009	0.008	0.170	0.040	0.016	0.009	0.046	0.042	0.006	0.008	0.046	0.057	0.006	0.009	0.038	0.041	0.006	0.010
Fiscal policy synchronization Interaction dummy	0.000	-0.000	**0.001***	-0.000	**0.017***	0.000	0.001	0.001	0.001	0.002	0.000	0.001	0.001	**0.003***	0.000	0.001	0.001	0.001	0.000	0.000
	0.001	0.002	0.001	0.001	0.009	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001
Financial integration Interaction dummy	**0.167** **	-0.079	**0.575*** **	0.163	-0.126	**0.023***	-0.015	**0.015*** **	0.091	-0.200	**0.432*** **	0.066	**0.315*** **	-0.298	**0.247** **	0.104	**0.122***	-0.218	**0.426*** **	**0.174** **
	0.071	0.129	2930	0.117	0.100	0.014	0.020	0.006	0.080	0.160	0.114	0.097	0.074	0.220	0.108	0.081	0.064	0.135	0.114	0.088
Production structures Interaction dummy	**0.261*** **	0.144	**0.076** **	**0.149*** **	-0.92	-0.155	**0.239*** **	**0.067** **	0.113	**0.449*** **	0.047	**0.304*** **	**0.492*** **	-0.050	**0.087*** **	**0.374*** **	**0.145** **	-0.060	0.059	0.086
	0.072	0.135	0.035	0.041	0.753	0.151	0.089	0.028	0.079	0.122	0.042	0.041	0.113	0.139	0.028	0.057	0.070	0.107	0.037	0.055
Export sophistication Interaction dummy	0.008	-0.005	**0.008** **	0.004	0.032	**0.014** **	0.003	**-0.007***	0.004	0.007	**0.007** **	0.001	-0.011	0.008	0.002	-0.001	-0.011	0.003	**0.008** **	0.000
	0.011	0.009	0.004	0.004	0.025	0.006	0.007	0.004	0.006	0.007	0.003	0.004	0.011	0.008	0.013	0.004	0.008	0.006	0.003	0.005
EU membership									-0.000	0.000	-0.000	-0.001								
									0.000	0.001	0.000	0.001								
Error-correction term	**-0.110*** **	**-0.113*** **	**-0.100*** **	**-0.147*** **	**-0.045*** **	**-0.110*** **	**-0.060*** **	**-0.142*** **	**-0.119*** **	**-0.143*** **	**-0.114*** **	**-0.148*** **	**-0.055*** **	**-0.112*** **	**-0.106*** **	**-0.134*** **	**-0.125*** **	**-0.123*** **	**-0.108*** **	**-0.123*** **
	0.020	0.026	0.021	0.029	0.015	0.033	0.016	0.034	0.021	0.034	0.021	0.034	0.019	0.033	0.028	0.026	0.023	0.034	0.022	0.023
Constant	**0.030** **	**0.102*** **	**0.038*** **	**0.090*** **	**0.028** **	**0.111*** **	**0.029*** **	**0.149*** **	**0.045*** **	**0.134*** **	**0.055*** **	**0.136*** **	**0.052*** **	**0.127*** **	**0.099*** **	**0.151*** **	**0.060*** **	**0.117*** **	**0.060*** **	**0.130*** **
	0.012	0.030	0.008	0.018	0.012	0.039	0.009	0.037	0.011	0.045	0.011	0.031	0.019	0.037	0.024	0.032	0.013	0.042	0.013	0.026
Number of observations	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	882	882	882	882

Source: Authors' calculations.

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Notes

Notes

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NEW DELHI
HEAD OFFICE
Global Development Network
2nd Floor, West Wing, ISID Complex
4, Vasant Kunj Institutional Area
New Delhi-110070, INDIA
T: +91 11 4323 9494 / 2613 9494
F: +91 11 2613 6893