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Trade integration and synchronization of shocks*

Implications for EU enlargement

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Abstract

According to the European Commission (1990), closer integration leads to less frequent asymmetric shocks and to more synchronized business cycles between countries. However, for Krugman (1993) closer integration implies higher specialization and, thus, higher risks of idiosyncratic shocks. Drawing on the evidence from a group of transition countries, this paper tries to determine whose argument is supported by the data. This is done by confronting estimated time-varying coefficients of supply and demand shock asymmetry with indicators of trade intensity and exchange rates. We find that (i) an increase in trade intensity leads to higher symmetry of demand shocks: the effect of integration on supply shock asymmetry varies from country to country; and (ii) a decrease in exchange rate volatility has a positive effect on demand shock convergence. The results confirm 'The European Commission view' and also the argument by Kenen (2001) according to which the impact of trade integration on shock asymmetry depends on the type of shock.

JEL classifications: E32, F30, F42.
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Over the long run everything is
endogenous and we are all dead
Flandreau and Maurel (2001), p. 19

1. Introduction

In accordance with European Union (EU) decisions at the summits in Brussels and Copenhagen,[1] EU enlargement took place on 1 May 2004. Ten countries – Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia – entered the European Union.[2] The question of sharing a common monetary policy there by arises. Would it be beneficial for the entering countries to join the European Monetary Union (EMU) immediately upon entering the EU, or to postpone adoption of the euro for a number of years? A comprehensive assessment of this challenging issue is beyond the scope of our study. In this paper we concentrate on some cost aspects of joining the eurozone, namely on the degree of shock asymmetry between the EU and the entering countries, with the objective of identifying the effects of economic integration on the synchronization of shocks.

The issue of shock asymmetry has received particular attention due to the development of the optimal currency area (OCA) theory, which originates in the work of Mundell (1961), McKinnon (1963) and Kenen (1969). According to the classical OCA criteria, two countries or regions would benefit from forming a monetary union if they are characterized by high similarity of business cycles, have strong trade links, and if they possess an efficient adjustment mechanism[3] that can mitigate the adverse effects of asymmetric shocks.[4] The first criterion is often considered the key one. Indeed, if the business cycles of two countries are highly synchronized, or in other words if countries are exposed to symmetric shocks and exhibit similar responses to these shocks, a common monetary policy response does not introduce imbalances between them. In other words, higher symmetry of shocks between countries, *inter alia*, implies a lower cost of sharing a common monetary policy. Much interest, therefore, has been focused on estimating the degree of shock asymmetry between countries or regions. As far as the EU candidate countries are concerned, empirical studies have only recently begun to appear as longer time series become available. The still scarce evidence suggests that

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[1] On 18 November and 12–13 December 2002, respectively.
[2] The accession of Bulgaria and Romania has been set for 2007.
[3] For example, labour mobility, flexibility of factor prices, and a system of fiscal transfers.
[4] There is a tendency in the literature to use the terms 'shocks' and 'business cycles' as synonyms. However, the term 'business cycle' has a broader meaning than 'shock': business cycles usually refer to the de-trended components of macroeconomic aggregates such as GDP, industrial production, employment, etc. Hence, the business cycle represents a mixture of shocks (e.g., export, wage, oil, climatic, etc.) and the responses to them.

selected Central and Eastern European countries (CEECs) have achieved some synchronization of their business cycles with the EU, at least on the demand side.[5] It is commonly stressed, however, that the period of transition is too short to draw robust conclusions. For this reason, we re-estimate our previous results (Babetskii *et al.* 2002, 2004) focusing on sensitivity analysis with respect to the choice of countries, time span, and identification approach.

Along with the measurement issue, another question concerns the link between economic integration and shock asymmetry. It is here that the endogeneity issue arises. The endogeneity of the OCA criteria is formulated in the sense of the Lucas critique: currency union affects the underlying OCA criteria in such a way that they are more likely to be satisfied *ex post,* as both monetary and trade integration deepen.[6] Putting it in practical terms, the endogeneity argument means that a policy change (e.g., steps towards forming a monetary union) influences shock asymmetry. There are two opposite views on this subject, classified by De Grauwe (1997) as 'The European Commission View' and the 'Krugman View'. According to the European Commission (1990), closer integration leads to less frequent asymmetric shocks and to more synchronized business cycles between countries. On the other hand, for Krugman (1993) closer integration implies higher specialization and, thus, higher risks of idiosyncratic shocks. Drawing on the evidence from a group of ten transition countries which have experienced an impressive increase in trade openness and economic integration with the European Union during the past decade, this paper tries to find out whose argument is supported by the data. Since the trade of the CEECs with the EU has significantly increased over the transition period, and since several accession countries have pegged their currencies to the Deutschmark, subsequently replaced by the euro, we face a sort of natural experiment for testing the endogeneity argument.

Methodologically, we apply a bi-variate vector autoregressive procedure proposed by Blanchard and Quah (1989), theoretically anchored in the sticky price paradigm for open economies, in order to identify supply and demand shocks for the candidate countries, with Germany and the aggregate EU-15 as alternative benchmarks. Then, using the Kalman filtering technique in a way advocated by Boone (1997), we construct the time-varying correlation of shocks between the candidate countries and the aggregate EU-15 and Germany as alternative benchmarks. The new results are in line with our previous estimates (Babetskii *et al.* 2002, 2004) and show more clear-cut patterns. In particular, the results demonstrate that the demand shocks have converged (to levels comparable to present EU member countries such as Ireland, Portugal and Spain), while asymmetries of the supply

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[5] See Boone and Maurel (1998, 1999a, 1999b), Horvath and Rátfai (2004), and Babetskii, Boone and Maurel (2002, 2004).

[6] The term 'endogeneity of the OCA criteria' was introduced by Frankel and Rose (1997, 1998). See also Bayoumi and Eichengreen (1997) and Rose (2000) for a discussion.

shocks prevail. Next, we confront the time-varying estimates of supply and demand shock convergence with indicators of trade and exchange rates. We find that (i) an increase in trade intensity leads to higher symmetry of demand shocks: the result for supply shocks is ambiguous; and (ii) a decrease in exchange rate volatility has a positive effect on demand shock convergence and no significant impact on supply shocks. The results for demand shocks can be interpreted in favour of 'The European Commission View', also referred to as the endogeneity argument by Frankel and Rose (1998) in the OCA criteria discussion, according to which trade links and monetary integration reduce asymmetries between countries. Overall, our results support Kenen's (2001) argument that the impact of trade integration on shock asymmetry depends on the type of shock.

The paper is structured as follows. After this brief introduction, the second section presents a literature review on the subject of shocks and trade integration and illustrates some stylized facts from the CEECs. The third section describes the data and empirical methodology. The fourth section starts with an illustration of the methodology for the Czech Republic case and then presents a comparative analysis for a group of ten transition countries. The last section states the conclusions and draws policy implications.

2. Shock asymmetry and integration: What do we expect?

2.1 Measuring shock asymmetry

A number of studies focus on measuring the degree of shock asymmetry across countries. In earlier research, the judgment about shocks was based on cross-country correlation of real output, industrial production, or real exchange rate cycles.[7] Such an approach, however, does not allow one to distinguish between the shocks themselves and the reactions to them. Since both components are present in the actual series, similar results in terms of correlation coefficients might be observed in the presence of various combinations of shocks and responses to shocks, for example, in the case of a symmetric reaction to asymmetric shocks or an asymmetric reaction to symmetric shocks.

Blanchard and Quah (1989) propose a bi-variate vector autoregressive (VAR) procedure in order to separate shocks from responses. Moreover, this method makes it possible to identify the origins of shocks, for example, supply and demand. Blanchard and Quah (1989) define shocks as linear combinations of the residuals from a bi-variate VAR representation of real output growth and inflation. By construction, one type of shock (labeled as 'demand') has only a transitory

[7] See, for example, Cohen and Wyplosz (1989), Weber (1991), De Grauwe and Vanhaverbeke (1993), and Artis and Zhang (1995).

impact on the level of output, while another type of shock (labeled as 'supply') might have a long-term impact on the level of output.

More precisely, if real output and prices are used as inputs to the VAR model, then 'demand' shocks are defined so that they do not have a long-term impact on either output or prices, while 'supply' shocks might have a long-term effect on output. VAR decomposition has become an especially popular tool in identifying shocks since it was applied by Bayoumi and Eichengreen (1993, 1996) to assess the similarities of economic cycles in the case of European monetary integration. One should, however, be aware of the limitations of the VAR technique. In particular, the methodology does not distinguish whether the corresponding supply and demand disturbances are due to domestic or foreign shocks. VAR decomposition is performed on a country-by-country basis; hence, a country's fluctuations in output and prices may be affected by domestic as well as foreign shocks. Of course, it is not likely that, say, Czech shocks affect fluctuations in macroeconomic fundamentals in Germany or the European Union. However, it seems plausible that German or EU shocks may affect the CEECs. As will be illustrated in Section 2.3, Germany and the EU are important, if not the major, trade partners for the accession countries. The results, therefore, should be interpreted with care. The same level of shock symmetry between two countries may correspond to various combinations of foreign and domestic shocks and responses.

Later, co-movements of shocks across countries and regions were used for the assessment of the OCA criteria. For example, a high correlation between two countries' series of shocks indicates that the economic structures of the countries under consideration are quite similar. This methodology allows Bayoumi and Eichengreen (1996) to identify the 'core' European countries, for which the cost of a common monetary policy could thus be low.

Note that the shock-series correlation coefficient is a static measure. Therefore, it is difficult to judge whether shocks become more symmetric or not. However, since the degree of economic integration changes over time, there are few reasons to believe that shock asymmetry remains constant. The dynamics can be partially assessed by splitting up the whole period and calculating the correlation coefficient by sub-periods, provided that the sub-intervals are long enough. There is, however, a more fundamental critique of this approach. Fontagne and Freudenberg (1999) argue that 'the central critique to be addressed to studies based on VAR estimates of asymmetric shocks refers to the assumption of structural asymmetries. The only way to relax this assumption is to use the Kalman filter in order to tackle the issue of a dynamic convergence of shocks.'[8]

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[8] In the context of Fontagne and Freudenberg (1999), the term 'structural asymmetries' sounds like a synonym for 'parameter stability'. It is unclear why the Kalman filter is the 'only' tool available to deal with dynamic convergence. We would prefer to replace 'the only' with 'a useful' tool.

Boone (1997) applies the Kalman filter technique in order to obtain time-varying estimates of shock symmetry. Her results for Western European countries are consistent with those reported by Bayoumi and Eichengreen (1996) and, notably, give rich information about the dynamics of evolving symmetries. The results are generally interpreted in favour of the endogeneity argument: the observable increase in supply and demand shock correlation goes along with deepening European integration.

An increasing number of studies focus on the analysis of symmetries between current European Union members and accession countries. Frenkel, Nickel and Schmidt (1999), Fidrmuc and Korhonen (2003), Horvath and Rátfai (2004), Frenkel and Nickel (2002), and Babetskii, Boone and Maurel (2002, 2004) follow the structural VAR identification methodology developed by Blanchard and Quah (1989) and Bayoumi and Eichengreen (1996). Supply and demand shocks are extracted from quarterly series of real output and prices. Short time series (less then ten years of quarterly observations) complicate the econometric analysis.

Frenkel, Nickel and Schmidt (1999) and Horvath and Rátfai (2004) conclude that supply and demand shocks hitting the CEECs, on the one hand, and the EU on the other hand, are quite different. Fidrmuc and Korhonen (2003) find that the cross-country correlation of supply shocks varies substantially from country to country. Correlation of demand shocks between the EU and the CEECs is substantial for Hungary and Estonia, while other accession countries show modest results. Compared to the earlier studies for Western European countries, current results indicate an increase in synchronization between the EU 'core' and Italy and Portugal, previously considered 'peripheral' countries. Frenkel and Nickel (2002) point out that there is high heterogeneity among CEECs and EU countries in terms of correlation of supply and demand shocks, and that in addition the adjustment dynamics of output and prices are far from being similar. However, 'the more advanced CEECs are hardly different in the correlation of their shocks *vis-à-vis* the euro area and the bigger EMU countries than the smaller countries of the EU that have already adopted the euro as their currency'. By the same token, some accession countries show evidence of similarity of impulse responses with either Germany, France, Italy, or the EU as a whole.

Babetskii, Boone and Maurel (2002, 2004) extend the analysis of supply and demand shocks by measuring time-varying correlation in a way advocated by Boone (1997). Their results stress an on-going process of demand shock convergence between the EU and the accession countries. Supply shocks tend to diverge, which is interpreted as a due restructuring process at work and the Balassa–Samuelson effect. Overall, there seems be a problem with the low robustness of the estimated correlation of supply and demand shocks in different studies, despite the fact that they use the same (Blanchard and Quah, 1989) methodology. The diversity of the results might be due to the sensitivity of the correlation coefficient to the VAR specification, data sources, and sample lengths. For example, Frenkel, Nickel and Schmidt (1999) and Babetskii, Boone and Maurel (2002, 2004) use data on the

CEECs from the early 1990s and thus include the 'transformational recession' in the sample. Fidrmuc and Korhonen (2003) and Frenkel and Nickel (2002) use later data, so the results are believed to be less affected by structural changes. The first objective of the present paper, therefore, is to assess the robustness of the time-varying correlation of shocks.

The debate has been centred so far on the measurement issue, namely, how to identify shocks and how to measure cross-country correlation of disturbances. One serious issue has been omitted. A natural question concerns the determinants and sources of the observable increases or decreases in shock symmetry. To some extent, all the studies mentioned above try to discuss factors that drive the cycles' symmetries or asymmetries. Integration in the various interpretations of this broad concept is often said to be the key factor that affects the understanding of business cycle co-movements. Yet such a potentially important explanatory variable is missing from the analysis. This is the subject to which we now turn.

2.2 Shock asymmetry and integration: Discussing endogeneity

Frankel and Rose (1998) open a large debate on the endogeneity of OCA criteria fulfillment. In the spirit of the European Commission (1990), Frankel and Rose (1998) put forward an argument that closer trade links could lead to business cycle synchronization or, equivalently, increase the symmetry of shocks. According to the alternative viewpoint, e.g., Krugman (1993), the opposite effect should prevail: international trade increases specialization, making shocks more asymmetric. The overall impact of trade integration on shock symmetry could thus be ambiguous, at least theoretically. Modern formal models of optimum currency areas do not seem to offer a unique answer either.[9] Frankel and Rose (1998) stress the necessity of further analysis of the role of international trade by distinguishing between inter-industry and intra-industry trade. Inter-industry trade (trade which involves exports and imports of different goods, for example, when one country exports cotton and imports wines) reflects specialization, thus potentially causing asymmetries. On the other hand, intra-industry trade (when a country simultaneously exports and imports products of the same category, e.g., cars) should lead to business cycle co-movements. There is on-going theoretical work in this direction.[10]

The concept of integration can be considered in a broader sense, including monetary integration as well. Ricci (1997a) builds a two-country model of optimum currency areas which incorporates monetary and real variables. One of the model's key implications is that 'the adoption of fixed exchange rates endogenously (i.e., within the model) increases the desirability of this currency area by reducing the

[9] See Ricci (1997b); see also Horváth (2002), pp. 21–23, for a recent review of OCA models.
[10] See, among others, Kose and Yi (2001).
[11] 'Endogenously' means 'within the model'.

shock asymmetry.'[11] Note that in Ricci's model exchange rates affect shock asymmetry indirectly, through trade: flexible exchange rates favour specialization compared with fixed rates. Specialization, in turn, leads to higher asymmetry of shocks. Hence, it follows that exchange rate arrangements may matter for business cycle correlation, at least to the extent that specialization leads to asymmetric responses. Naturally, other determinants beside bilateral trade, its specialization patterns, and exchange rate regimes may influence shock transmission between countries. One might think about tariffs and non-tariff barriers, institutional agreements, border effects, and so on.

As for empirical evidence, Frankel and Rose (1998) in their influential work argue that 'countries with closer trade links tend to have more tightly correlated business cycles'. Econometrically, Frankel and Rose assess the following relationship between trade intensity and correlation of business cycles:

$$\overline{Corr(Q_i, Q_j)_t} = c_1 + c_2 \overline{\log(TI_{ij})_t} + \varepsilon_{ij_t}$$

where the bars denote period-averaged values of trade intensity $\log(TI_{ijt})$ and of the correlation of business cycles $Corr(Q_{it}, Q_{jt})$.[12] The business cycle Q_{it} in country i at time t is defined as the detrended component of real economic activity (e.g., GDP, index of industrial production, total employment or unemployment). The trade intensity between countries i and j is calculated from exports, imports or total bilateral trade according to the following expressions (natural logarithms of):

$$\begin{aligned} TI_{ijt}^{EX} &= EX_{ijt}/(EX_{it} + EX_{jt}) \\ TI_{ijt}^{IM} &= IM_{ijt}/(IM_{it} + IM_{jt}) \\ TI_{ijt}^{T} &= (EX_{ijt} + IM_{ijt})/(EX_{it} + EX_{jt} + IM_{it} + IM_{jt}) \end{aligned}$$

where EX_{ijt} are exports from country i to country j, EX_{it} are total exports from country i, and IM denotes imports. The estimates are performed on a large cross-section of OECD countries over thirty years, and the results seems be very robust as to the choice of indicators of bilateral trade and business cycles. Total trade is further confronted with intra-industry trade. Although not directly tested, it is the latter that is said to be particularly relevant for business cycle convergence. Additional inclusion of the exchange rate regime dummy does not qualitatively change the results. At least one important question remains, however, after reading this article: are underlying shocks becoming more symmetric as well? All the constructed indicators of business cycles belong to the same class. Namely, they represent detrended indicators of economic activity. Hence, shocks and responses to shocks enter the analysis together. Kenen (2001, p. 15) argues that the results of Frankel and Rose (1998) are biased, since trade, a real variable, is not exogenous to fluctuations of another real variable such as economic activity. Kenen (2001)

[12] The time dimension is four, since the sample, which covers 1959–93, is divided into four sub-periods.

sketches a simple Keynesian framework where the correlation of output changes between two countries is positively related to bilateral trade intensity, not necessarily due to higher symmetry of shocks. Generally, the impact of trade integration on shock asymmetry depends on the type of shock.

Fidrmuc (2004) re-estimates the specification of Frankel and Rose (1998), focusing on a cross-section of OECD countries over the last ten years and working with different frequencies (quarterly data). Aware of Kenen's (2001) criticism, Fidrmuc (2004) reconfirms the interpretation by Frankel and Rose (1998) and bypasses Kenen's criticism. This is done by direct inclusion of intra-industry trade in the regression. Thus, according to the main point of Fidrmuc (2004), it is the particular structure of trade that matters for business cycle transmission.

Using disaggregated trade data, Fontagne and Freudenberg (1999) find evidence that exchange rate variability depresses intra-industry trade, and consequently, as they argue, should lead to a higher symmetry of shocks. Based on historical data, Flandreau and Maurel (2001) argue that there is a positive impact of both monetary arrangements and trade on business cycle correlation.

This analysis of the literature is far from being complete.[13] However, looking at these and other studies not discussed here, one can note a surprising segmentation in research interests. Two entirely separate classes of studies seem to co-exist: those focusing on measuring correlation of shocks, and others concentrating on assessing the link between business cycle fluctuations and trade, the exchange rate and other explanatory variables. More specifically, studies of the first group illustrate static or dynamic patterns of shock correlation, stressing the importance of distinguishing between shocks and responses to shocks. Studies of the second group identify the effects of trade and other variables on various business cycle indicators containing both shocks and responses to shocks. To our knowledge, there are no direct estimates of the effects of integration on shock asymmetry.

In our work we will try to build a bridge between these two groups of studies by confronting time-varying estimates of shock asymmetry with trade and exchange rate variables. Bringing the two classes of studies together gives us a tool for assessing the long-running debate between the proponents of 'The European Commission View' and those of 'The Krugman View'. Before proceeding with the estimates, the following sub-section will briefly clarify our choice of countries.

2.3 Some stylized facts from the candidate countries

In this study we focus on the candidate countries, since they represent a kind of 'natural experiment' for testing the endogeneity argument of the OCA theory.

[13] There are studies on estimations of the 'OCA indices' which infer the readiness of countries to join a monetary union by predicting exchange rate variability. See Bayoumi and Eichengreen (1997) and Horváth and Komárek (2002).

Table 1. Size and degree of openness of the CEECs

Country	[Exports+Imports]/ GDP (%)		GDP per capita (USD)		Population (millions)	
	1993	2001	1993	2001	1993	2001
Bulgaria	84	119	1,190	1,603	8.5	7.9
Czech Republic	109	145	3,391	5,551	10.3	10.3
Estonia	144	188	985	3,830	1.5	1.4
Hungary	61	123	3,790	5,215	10.3	9.9
Latvia	130	103	813	3,275	2.6	2.4
Lithuania	173	106	719	3,245	3.7	3.5
Poland	45	63	2,229	4,561	38.5	38.6
Romania	51	75	1,157	1,768	22.8	22.4
Slovak Republic	122	157	2,489	3,794	5.3	5.4
Slovenia	116	121	6,368	10,605	2.0	2.0
CEECs average	103	120	2,313	4,345	10.5	10.4
Germany	45	68	24,120	22,530	81.2	82.4
United States	21	24	25,742	35,367	258.1	284.8

Sources: Trade and population: *IMF International Financial Statistics*, author's computations; GDP per capita: *IMF World Economic Outlook Database*.

Indeed, the past decade has been characterized by an increase in the trade openness of the CEECs and their trade and monetary integration with EU member countries. These three factors together, briefly illustrated below, may affect the degree of business cycle co-movement.

In 2001, the ratios of total bilateral trade to GDP represented more than one hundred percent of GDP for eight of the CEECs from our sample. In the remaining two 'big' candidate countries, Poland (population 39 million) and Romania (22 million), trade accounted for 63 percent and 75 percent of GDP, respectively (see Table 1). Compared to 1993, there has been a significant increase in trade openness for the majority of the candidate countries. The two exceptions are Latvia and Lithuania, but these countries had already achieved high shares of trade in GDP during the earlier transition period.

Table 2 illustrates the shares of trade with the EU and Germany in the total trade of the CEECs. In 2001, the bilateral trade of the CEECs with the European Union varied from roughly 50 percent of total trade for Lithuania to 70 percent of total trade for the Czech Republic. For comparison, this is on average higher than the share of the trade of Germany with other EU member countries (54 percent). Germany itself is an important trade partner for the majority of the CEECs,

Table 2. Shares of trade with the EU and Germany in total trade of the CEECs (ordered by decreasing shares of trade with the EU in 2001)

Country	European Union		Germany	
	1993	2001	1993	2001
Czech Republic	0.52	0.69	0.27	0.38
Poland	0.67	0.68	0.32	0.31
Hungary	0.56	0.66	0.23	0.31
Slovenia	0.62	0.65	0.26	0.23
Romania	0.44	0.64	0.15	0.18
Latvia	0.30	0.55	0.08	0.16
Estonia	0.55	0.55	0.09	0.07
Slovak Republic	0.29	0.54	0.13	0.27
Bulgaria	0.44	0.52	0.13	0.13
Lithuania	0.31[1)]	0.49	0.13[1)]	0.16
CEECs average	0.47	0.60	0.18	0.22
Germany	0.56	0.54		

Note: [1)] 1994 values.
Source: *IMF Direction of Trade Statistics*, author's computations.

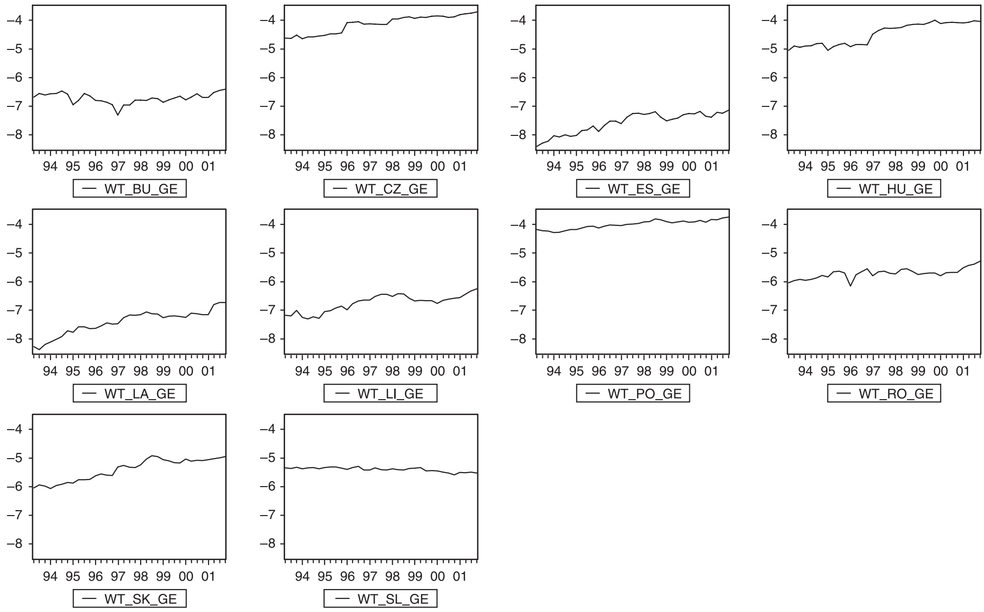
accounting in 2001 for 20−40 percent of total bilateral trade for half of the accession countries. Overall, we observe an important increase in trade with the European Union and Germany.

Bilateral trade intensity is another indicator which serves to characterize the extent of trade between countries. Figure 1 shows the total bilateral trade intensity between ten transition countries and EU/Germany over 1993–2001, quarterly. Except for Bulgaria and Slovenia, bilateral trade intensity exhibits upward trend patterns with respect to either Germany or the EU. In the case of Slovenia, bilateral trade intensity has been relatively high since the early 1990s and this indicator has remained practically unchanged over the past decade. For Bulgaria, trade intensity has had a rising tendency since 1997.

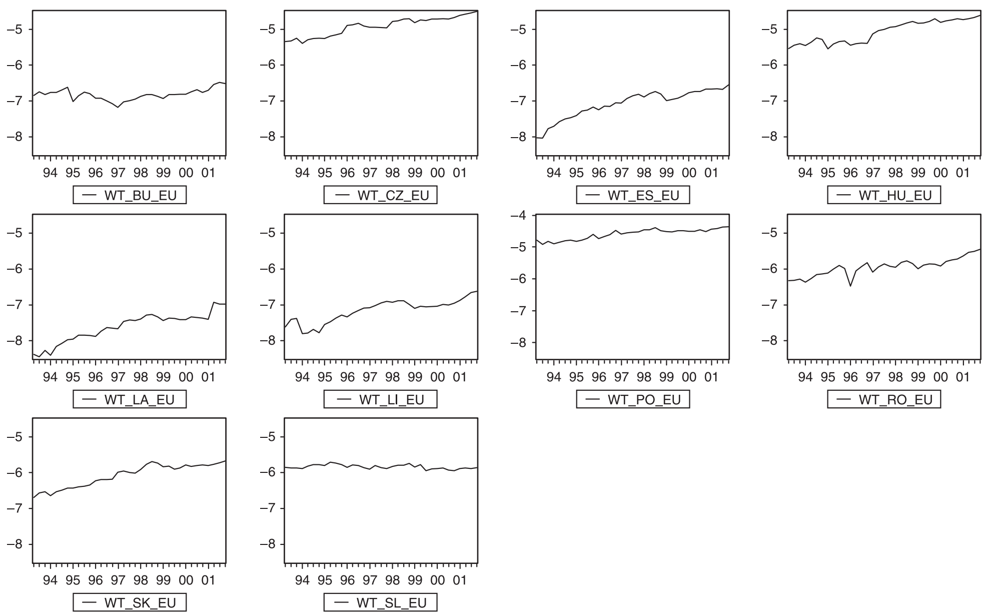
Along with trade openness and trade integration, substantial convergence of exchange rates with the euro has been visible. As illustrated in Table 3, in many cases the candidate countries peg their currencies to the DEM (replaced by the euro at the beginning of 1999). Other monetary authorities (e.g., in the Czech Republic and Slovakia, and recently also in Hungary and Poland), who formally follow a free float policy, use the euro as the reference currency in formulating their preferred exchange rate developments. Thus, the actual exchange rate regimes in these countries can be characterized as a managed float with euro-based intervention

Figure 1. Total bilateral trade intensity, 1993–2001

a) Between the CEECs and Germany



b) Between the CEECs and the European Union



Total bilateral trade intensity is defined according to the following formula (natural logarithm of):

$$TI^{T}_{ijt} = (EX_{ijt} + IM_{ijt})/(EX_{it} + EX_{jt} + IM_{it} + IM_{jt})$$

where i = CEECs, j = Germany/EU, EX_{ijt} = exports from country i to country j, EX_{it} = total exports from country i, and IM denotes imports.

Source: *IMF Direction of Trade Statistics*, author's computations.

Table 3. Exchange rate regimes in the CEECs over the last decade

Country	Date	Exchange rate regime	Currency basket/ target currency	Fluctuation band
Bulgaria	February 1991	Managed Float		
	1 July 1997	Currency Board	DEM	0%
	1 January 1999	Currency Board	euro	0%
Czech Republic	3 May 1993	Peg	DEM(65%), USD(35%)	±0.5%
	28 February 1996	Peg	DEM(65%), USD(35%)	±7.5%
	26 May 1997	Managed Float	Reference currency DEM replaced in 1999 by euro	
Estonia	June 1992	Currency Board	DEM	0%
	1 January 1999	Currency Board	euro	0%
Hungary	22 December 1994	Crawling Band	ECU(70%), USD(30%)	±2.25%
	1 January 1997	Crawling Band	DEM(70%), USD(30%)	±2.25%
	1 January 1999	Crawling Band	euro(70%), USD(30%)	±2.25%
	1 January 2000	Crawling Band	euro	±2.25%
	4 May 2001	Crawling Band	euro	±15%
Latvia	February 1994	Peg	SDR	±1%
Lithuania	October 1992	Independent Float		
	April 1994	Currency Board	USD	0%
	1 February 2002	Currency Board	euro	0%
Poland	16 May 1995	Crawling Band	USD(45%), DEM(35%), BP(10%), FF(5%), SwF(5%)	±7%
	26 February 1998	Crawling Peg	USD(45%), DEM(35%), BP(10%), FF(5%), SwF(5%)	±10%
	28 October 1998	Crawling Peg	USD(45%), DEM(35%), BP(10%), FF(5%), SwF(5%)	±12.5%
	1 January 1999	Crawling Peg	euro(55%), USD(45%)	±12.5%
	25 March 1999	Crawling Peg	euro(55%), USD(45%)	±15%
	12 April 2000	Independent Float		
Romania	August 1992	Managed Float		
Slovak Republic	14 July 1994	Peg	DEM(60%), USD(40%)	±7%
	1 January 1996	Peg	DEM(60%), USD(40%)	±3%
	31 July 1996	Peg	DEM(60%), USD(40%)	±5%
	1 January 1997	Peg	DEM(60%), USD(40%)	±7%
	2 October 1998	Managed Float	Reference currency euro since 1999	
Slovenia	January 1992	Managed Float		

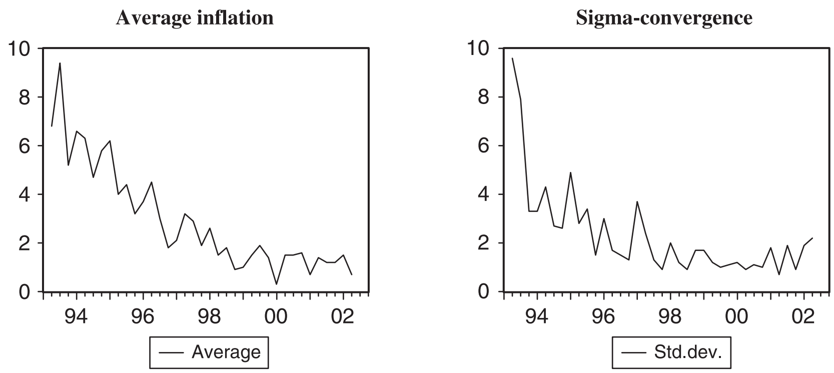
Sources: Valachy and Kočenda (2003), Schoors (2001), Halpern and Wyplosz (2001) and *Central Europe Weekly* (2001, January 18).

Table 4. Volatility of nominal exchange rates[1] (%)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bulgaria	n.a.	24.5	5.5	39.7	20.1	77.0	85.6	15.2	0.4	0.0	0.0
Czech Rep.	n.a.	n.a.	n.a.	1.4	1.2	1.0	4.4	4.3	2.9	2.6	2.8
Hungary	8.0	6.2	4.4	9.6	16.0	10.3	5.8	7.9	4.3	1.8	2.3
Poland	6.9	17.3	12.6	14.5	9.5	4.9	5.7	4.7	5.4	3.7	5.6
Romania	94.7	77.5	48.5	41.7	19.2	22.1	36.9	14.8	26.7	13.2	14.8
Slovakia	n.a.	n.a.	n.a.	3.9	1.6	0.9	1.5	3.9	6.7	2.8	1.6
Slovenia	n.a.	n.a.	14.4	8.4	2.1	5.6	3.2	2.0	2.4	3.5	3.4
Estonia	n.a.	n.a.	2.1	0.8	1.6	1.3	1.8	0.5	0.5	0.1	1.0
Latvia	n.a.	n.a.	17.1	13.8	2.5	1.3	3.4	2.0	3.8	6.4	2.6
Lithuania	n.a.	n.a.	n.a.	10.5	6.4	2.4	6.1	3.4	4.4	8.6	4.6
CEECs average	36.5	31.4	14.9	14.4	8.0	12.7	15.4	5.9	5.8	4.3	3.9
USA	5.8	5.8	6.5	3.7	5.9	2.4	6.1	3.4	4.4	8.6	4.6

Note: [1] Standard deviations in percent from average nominal exchange rates against ECU/euro over preceding two years.
Source: Author's computations based on the IMF *International Financial Statistics*, monthly averages.

Figure 2. Inflation[1] convergence across the CEECs, 1993–2002



CEECs average quarterly inflation rates (excluding Bulgaria and Romania)

Variability of quarterly inflation rates across CEECs (excl. Bulgaria and Romania)

Note: [1]GDP-deflator based.
Source: Author's calculations.

Table 5. Inflation[1] convergence across the CEECs

	1994–98	1999–2002
CEECs average	6.3	2.0
CEECs: sigma-convergence	7.7	2.6
CEECs average. (excl. Bulgaria and Romania)	3.6	1.2
CEECs (excl. Bulgaria and Romania): sigma-convergence	2.4	1.3
Germany average	0.3	0.2
EU-15 average	0.5	0.5
Euro-area average	0.5	0.4

Note: [1]GDP-deflator based.
Source: Author's computations.

levels. The actual volatility of exchange rates under this kind of policy has been decreasing over time (Table 4).

Figure 2 and Table 5 show convergence of GDP-deflator-based inflation rates. Not only have inflation levels decreased, but so has the variability of inflation rates across the CEECs.

3. Data and methodology

This section starts with a description of the dataset, followed by the empirical methodology, which contains three main procedures: (i) identifying supply and demand disturbances; (ii) constructing time-varying correlation of shocks; and (iii) confronting shock asymmetry with indicators of trade and exchange rate volatility. The last part of the section describes econometric specifications for illustrating the endogeneity argument of the OCA theory.

The sample covers ten accession countries (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia), plus Germany, the EU-15 aggregate, the United States, Ireland, Portugal, and Spain.

The series of real output (GDP at 1995 prices, in billions of national currency), prices (GDP deflator, rebated to 100 for 1995), and exports and imports (in millions of current US dollars) are quarterly, ranging from 1990:Q1 to 2002:Q2.

The following sources are used: OECD Analytical Database, IMF International Financial Statistics, EIU Country Data, IMF Direction of Trade Statistics, and National Statistical Committees. The OECD is the main source for the series of real output and prices. These data are available in seasonally adjusted form. The remaining output and price series were deseasonalized by applying the US Census Bureau's X11 procedure, the same method as used by the OECD.[14] Data for some accession countries are unavailable prior to 1994. The trade data cover the period up to 2001:Q4.

3.1 Step 1: Identification of shocks

In the first step, we decompose the fluctuations in the macroeconomic aggregates into shocks and responses to shocks. There is no unique identification strategy. We choose a bi-variate structural VAR method proposed by Blanchard and Quah (1989) in their influential *American Economic Review* paper, in the way that Bayoumi and Eichengreen (1993) apply this decomposition to extract supply and demand shocks from quarterly series of real output and prices. As discussed in Section 2.2, such an approach is quite popular in studies of business cycle convergence for developed countries, and there is recent evidence for accession countries as well.

The identification strategy is based on a stylized representation of the economy described by aggregate supply and demand curves. The aggregate demand (AD) curve is negatively sloped in both the short run and the long run, meaning that lower prices increase demand output. The aggregate supply curve is upward-sloping in the short run and vertical in the long run. A positively sloped short-run aggregate supply (SRAS) reflects the existence of nominal rigidities, therefore a nominal variable (prices) has a temporary effect on the real variable (output). Finally, a vertical long-run aggregate supply (LRAS) curve implies full-capacity use of the production factors.

Shocks in this simple model correspond to shifts in the aggregate supply and demand curves away from equilibrium. Supply shocks, which are associated with a shift in the aggregate supply curve, have both short-term and long-term impacts on both output and prices. Demand shocks also have short-term effects on both variables. However, since the long-term supply curve is vertical, demand shocks do not have a long-term effect on the level of output. A structural bi-variate VAR decomposition makes it possible to identify supply and demand shocks from the observable movements of output and prices.

Formally, consider stationary variables y_t and p_t, for example, the first differences of logarithmic GDP and logarithmic prices: $y_t = \log GDP_t - \log GDP_{t-1}$ and $p_t = \log P_t - \log P_{t-1}$.

Then the following VAR representation can be estimated:

$$y_t = b_{01} + \sum_{k=1}^{K} b_{11k} y_{t-k} + \sum_{k=1}^{K} b_{12k} p_{t-k} + e_t^y \tag{1}$$

$$p_t = b_{02} + \sum_{k=1}^{K} b_{21k} y_{t-k} + \sum_{k=1}^{K} b_{22k} p_{t-k} + e_t^p \tag{2}$$

[14] X11 is a sort of moving-average filtering procedure with time-evolving seasonal factors.

where e_t^y and e_t^p are white-noise disturbances, b_{ijk} are coefficients, and K is the lag length chosen so that e_t^y and e_t^p are serially uncorrelated.[15] Disturbances e_t^y and e_t^p are not structural, they simply represent unexplained components in output growth and inflation movements. In order to recover structural disturbances, i.e., those having an economic interpretation of supply and demand shocks, the following two relationships are proposed:

$$e_t^y = c_{11}\varepsilon_t^D + c_{12}\varepsilon_t^S \tag{3}$$

$$e_t^p = c_{21}\varepsilon_t^D + c_{22}\varepsilon_t^S \tag{4}$$

where ε_t^D and ε_t^S are demand and supply disturbances, respectively. These equations state that the unexplainable components in the movements of output growth and inflation are linear combinations of supply and demand shocks. In matrix form, $e_t = C\varepsilon_t$. The vector of the structural disturbances ε_t can be obtained by inverting matrix C: $\varepsilon_t = C^{-1}e_t$.

In order to recover the four coefficients of matrix C, four restrictions have to be imposed. Knowledge of the variance-covariance matrix of the estimated disturbances ε_t^D and ε_t^S is sufficient to specify three restrictions:

$$c_{11}^2 + c_{12}^2 = Var(e^y) \tag{5}$$

$$c_{21}^2 + c_{22}^2 = Var(e^p) \tag{6}$$

$$c_{11}c_{21} + c_{12}c_{22} = Cov(e^y, e^p) \tag{7}$$

These restrictions on the coefficients of matrix C are directly derived from Equation (3) and Equation (4) using normalization conditions:

(i) the variance of demand and supply shocks is unity: $Var(\varepsilon^D) = Var(\varepsilon^S) = 1$;

(ii) demand and supply shocks are orthogonal: $Cov(\varepsilon^D, \varepsilon^S) = 0$.

The fourth restriction on coefficients c_{ij} is that demand shocks ε_t^D have no long-term impact on the level of output. To put this restriction into a mathematical form, one should substitute Equations (3) and (4) into the VAR system given by Equation (1) and Equation (2), and then express variables y_t and p_t as the sum of the contemporaneous and past realizations of structural disturbances ε_t^D and ε_t^S:

[15] We select K in two ways. First, following Blanchard and Quah (1989) and Babetskii, Boone and Maurel (2002, 2004) we use eight lags, which is equivalent to two years, and perform estimates starting from 1990. Alternatively, we focus on the period since 1993 in order to minimize the impact of 'transformational recession' and apply the Akaike and Schwarz information criteria, which suggest two, three or four lags. We set uniformly two and four lags. Finally, we perform diagnostic checking of the residuals for higher-order serial correlation (Ljung–Box test) and normality (Jarque–Bera test). Comparison between the estimates allows us to assess robustness with respect to sample and lag lengths.

$$y_t = c_{01} + \sum_{k=0}^{\infty} c_{11k}\, \varepsilon^D_{t-k} + \sum_{k=0}^{\infty} c_{12k}\, \varepsilon^S_{t-k} \tag{8}$$

$$p_t = c_{02} + \sum_{k=0}^{\infty} c_{21k}\, \varepsilon^D_{t-k} + \sum_{k=0}^{\infty} c_{22k}\, \varepsilon^S_{t-k}. \tag{9}$$

System (8)–(9) is an infinite moving-average representation of the VAR form (1)–(2). Coefficients c_{ijk} – called impulse response functions – characterize the effect of structural disturbances on the left-hand-side variables after k periods (c_{ijk} can be expressed in terms of the four coefficients of interest c_{ij} and the estimated coefficients b_{ij}, but the algebra is messy). The restriction that the cumulative effect of demand disturbances on output growth is zero, for all possible realizations of demand disturbances, means that $\sum_{k=0}^{\infty} c_{11k} = 0$. This restriction also implies that demand disturbances have no long-term impact on the level of output itself. Indeed, c_{11k} represents the effect of the demand disturbance ε^D_{t-k} on $y_t = \log GDP_t - \log GDP_{t-1}$, output growth after k periods. Therefore, the sequence $c_{110}, c_{111}, c_{112}, \ldots, c_{11k-1}, c_{11k}$ represents the effect of ε^D_{t-k} on $(\log GDP_t - \log GDP_{t-1})$, $(\log GDP_{t+1} - \log GDP_t)$, $(\log GDP_{t+2} - \log GDP_{t+1}), \ldots, (\log GDP_{t+k-1} - \log GDP_{t+k-1})$, $(\log GDP_{t+k} - \log GDP_{t+k-1})$. Hence, the cumulative restriction $\sum_{k=0}^{N} c_{11k} = 0$ states that the effect of $\varepsilon_{D,t}$ on $(\log GDP_{t-1} - \log GDP_{t+N})$ equals zero, i.e., that the level of output does not change in the long run: $\log GDP_{t-1} = \log GDP_{t+N}$. It can furthermore be shown that the restriction $\sum_{k=0}^{\infty} c_{11k} = 0$ translates into the parameters of interest c_{ij} and the coefficients $b_{ij}(k)$ of the unrestricted VAR system (1)–(2) as:

$$c_{11}\left(1 - \sum_{k=0}^{K} b_{22}(k)\right) + c_{21}\left(\sum_{k=0}^{K} b_{12}(k)\right) = 0 \tag{10}$$

Restrictions (5), (6), (7), (10) serve to identify four coefficients c_{ij} which, in turn, are used to recover the supply and demand disturbances from the VAR residuals by inverting matrix C: $\varepsilon_t = C^{-1}e_t$.

3.2 Step 2: Calculating 'time-varying correlation' of supply and demand disturbances

Following Boone (1997) we use the Kalman filter to compute the 'time-varying correlation coefficient' between countries i and j given by b_t:

$$(X^j_t - X^i_t) = a^{ijk}_t + b^{ijk}_t (X^j_t - X^k_t) + \mu_t \tag{11}$$

$$a^{ijk}_t = a^{ijk}_{t-1} + v^a_t \tag{12a}$$

$$b_t^{ijk} = b_{t-1}^{ijk} + v_t^b \tag{12b}$$

where X are the supply or demand shocks, error terms μ and v are white noise disturbances, index i denotes an accession country, j stands for Germany or the EU, and k is the United States. Equation (11) is called the *measurement* or *observation equation*. Coefficients a_t^{ijk} and b_t^{ijk} (denoted as a_t and b_t henceforth in order to facilitate reading) are allowed to vary in time according to (12a) and (12b), which are called *transition* or *state equations*.

The intuition behind this specification is simple. For example, in the presence of perfect correlation of shocks between countries i and j, coefficients a_t and b_t both go to zero. The right-hand side of (11) being equal to zero implies that X_t^i – shocks for an accession country i – are thus explained by X_t^j – shocks for a reference country j (Germany or the European Union). If b_t diverge from zero, then the United States has a stronger effect on country i shocks than the reference country j. The United States is used as a benchmark since it is the major trade partner for the EU and an important trade partner for the CEECs. For a convergence process to be at work, we expect a_t to be close to zero and b_t to decrease over time.

Technically, the Kalman filter represents a recursive algorithm for computing the optimal estimator of unknown parameters a_t and b_t. This is done by maximizing a likelihood function given the information available at time t. The estimator is optimal in the sense that it minimizes the mean square error (MSE). Furthermore, if all disturbances are normal, the Kalman filter provides the maximum likelihood estimator (MLE) of a_t and b_t. Details on the Kalman filter estimations of the representation (11)–(12) are available in Annex A in Boone (1997). For more information, see Harvey (1992).

The main advantage of the method in hand is that it gives optimal estimations of the time-varying coefficients in the presence of structural changes, which is the case with the accession countries. As a drawback, the Kalman filter does not explain why the coefficients change over time; the filter simply draws the time path of the model's parameters. It is the objective of the next sub-section to confront the dynamics of coefficient b_t – an indicator of shock asymmetry – with such potentially important variables as indicators of bilateral trade intensity.

3.3 Step 3: Shock asymmetry and integration – 'The European Commission View' versus 'The Krugman View'

The endogeneity argument implies that trade integration affects shock asymmetry. The sign of this effect is either positive or negative depending on which view – that of the European Commission (1990) or that of Krugman (1993) – is believed to be true. Basically, we need to determine whether there is a link between the indicators of shock asymmetry and integration. Thanks to the use of the Kalman filter, we are able to determine the degree of shock asymmetry at quarterly frequency. Indicators of trade intensity are available on a quarterly basis as well. Hence, as a starting point, we look at the correlation between the time-varying coefficients of shock asymmetry $\hat{b}(i, j)_t$, estimated from (11), and the actual trade intensity $TI(i, j)_t$:

$$\rho(i, j) = Corr(\hat{b}(i, j)_t, TI(i, j)_t) \quad (13)$$

where i denotes accession country and j stands for Germany or the EU. To perform sensitivity checking, the correlation coefficient $\rho(i, j)$ is calculated for two types of shocks (supply and demand) and three indicators of trade intensity (with respect to exports, imports, and total bilateral trade). A positive correlation coefficient $\rho(i, j)$ would be in accordance with 'The Krugman View' (higher trade intensity goes along with higher shock asymmetry), while a negative correlation would support 'The European Commission View'.

The correlation coefficient, however, does not indicate the direction of causality. Although the endogeneity argument states that trade integration affects shock asymmetry, in either a positive or negative way, the causality can go in the reverse direction, too. For example, a recession in one country (a negative real shock) usually decreases the demand for imported products, thus lowering the volume of imports. In our group of ten transition countries it seems possible to separate or at least to minimize the impact of shocks on trade given the explicit increase in trade integration over the past decade observable in all countries except Bulgaria and Slovenia (see Figure 1). This long-term increase in trade integration between the CEECs and the EU/Germany, driven by structural factors, is not likely to have been caused by shocks. (Yet in the short term, e.g., over the horizon up to several quarters, aggregate shocks might affect trade intensity.) Therefore, we assume that trade intensity is exogenous to shock asymmetry in terms of the long-run relationship. As an alternative to the simple correlation coefficient, we model the relationship between these two variables in a regression framework:

$$\hat{b}(i, j)_t = c_1 + c_2 TI(i, j)_t + \varepsilon(i, j)_t \quad (14)$$

For a given pair of countries i and j, the error term $\varepsilon(i, j)_t$ depends on time only. Here another difficulty arises. Note that shock asymmetry $\hat{b}(i, j)_t$ is not an observable variable such as trade intensity $TI(i, j)_t$ but a product of estimation. Strictly speaking, the distribution of $\hat{b}(i, j)_t$ is unknown and the inclusion of $\hat{b}(i, j)_t$ in further regression might be inappropriate; the residuals $\varepsilon(i, j)_t$ are, generally, heteroskedastic and autocorrelated. Therefore, at the very limit, one can stop at calculating the correlation between shock asymmetry and trade intensity. Another option is to treat shock asymmetry as a classical variable, in the spirit of Frankel and Rose (1998), who link fluctuations in real economic activity to trade intensity and other explanatory variables.

Additional insight into the link between trade intensity and shock asymmetry can be obtained from estimating (14) in a panel framework. For a given benchmark country j (the EU or Germany), and a group of candidate countries i (i = Bulgaria, Czech Republic, Estonia, etc), we estimate the following equation (fixed effects):

$$\hat{b}(j)_{it} = c_{1i} + c_2 \log[TI(j)_{it}] + c_{3i}D_i + \varepsilon(j)_{it} \tag{15}$$

where D_i are country dummies. Due to the unknown distribution of $\hat{b}$, the residual terms, again, are not expected to exhibit the conventional properties. The reason for estimating Equation (15) is, nevertheless, to check whether the relationship between trade intensity and shock asymmetry can be described by a common slope plus country-specific effects.

Further sensitivity analysis can be done by including the exchange rate variable in the right-hand side of (15). In fact, according to the theoretical model of Ricci (1997a), exchange rate pegs can transmit shocks from one country to another. We check, therefore, whether the coefficient of trade intensity is affected by augmenting Equation (15) with the exchange rate variable:

$$\hat{b}(j)_{it} = c_{1i} + c_2 \log[TI(j)_{it}] + c_3 ERV_{it} + c_{4i}D_i + \varepsilon(j)_{it} \tag{16}$$

where ERV_{it} is the exchange rate volatility, calculated as the standard deviation of the nominal exchange rate in candidate country i against the euro over the past 12 months. ERV_{it} is chosen as a proxy for exchange rate pegs to the euro.[16]

Equation (16) implies that exchange rate volatility is exogenous to shock asymmetry: lower volatility is expected to reduce shock asymmetry. The causality, however, may go in the opposite direction. For example, if two countries have similar production structures, which increases the probability of common shocks, then the cost of fixing the exchange rate may be lower compared to countries with very different economies. Shock asymmetry can, therefore, influence the choice of appropriate exchange rate regime. Hence, inclusion of the exchange rate variable as exogenous can potentially bias the results.

To justify the inclusion of exchange rate volatility in Equation (16), we perform Granger causality tests for exchange rate volatility and shock asymmetry to determine which variable, if any, is exogenous. There is no strong support for causality in any of the directions. On the other hand, we have good reasons to believe that using the DEM, and later the euro, as the reference currency in the EU candidate countries is driven by other (e.g., political) factors rather than the level of symmetry of shocks.

Besides, exchange rates can affect shock asymmetry indirectly, via trade: fixing an exchange rate tends to stimulate trade; trade links, in turn, can make shocks more symmetric. If the effect of exchange rates on trade is strong, then the inclusion of the exogenous exchange rate variable might cause a multicollinearity problem, altering the coefficient of trade intensity c_2 or making it insignificant. One more reason for including the exchange rate volatility variable is, therefore, to assess whether it has an effect on trade intensity.

[16] This measure artificially increases volatility when a country operates under a crawling peg: changes in the crawl are interpreted as volatility.

So, in order to assess the robustness of the endogeneity argument of the OCA theory we have at our disposal (i) two types of shocks, (ii) three indicators of trade intensity with respect to two benchmarks (the EU and Germany), and (iii) four empirical specifications (the correlation coefficient (13), time series (14), and panel frameworks (15) and (16)).

4. Results

This section begins with an illustration of the methodology in the Czech Republic case. Using demand shocks as an example, time-varying estimates of shock convergence are derived and then confronted with indicators of bilateral trade intensity. The second part covers supply and demand shocks and their determinants for a large group of EU candidate countries. Sensitivity analysis is performed by considering several estimates of shock asymmetry and indicators of trade intensity.[17]

4.1 The Czech Republic case, demand shocks

Figures 3a) and 3b) plot Czech demand shocks compared to German and EU demand shocks respectively.

One can see some similarities between the Czech and the EU/German patterns of demand shocks, at least over certain periods. For example, around the beginning of 1997 there is a noticeable negative demand shock observed in the Czech Republic, Germany and the EU. The next question is to quantify the degree of similarity of the shock series co-movements.

Kalman Filter estimates help to draw the 'time-varying correlation coefficient' of shock series between the Czech Republic on the one hand and Germany/the EU on the other hand. Estimates of a_t and b_t from (11) over 1994:Q1–2002:Q2 suggest that Czech demand shocks converge to the corresponding German and EU shocks: coefficients a_t decline towards zero, indicating that there is no 'autonomous' convergence, and coefficients b_t decrease, meaning that the dissimilarities between the Czech and German/EU shock series diminish over time.

Note that since Equation (11) is specified in differences, the values of b_t characterize the relative importance of EU/German shocks versus American ones in explaining the Czech shock series. In the case of convergence to Germany, for example, b_t close to zero indicates that Czech shocks are more similar to German than to US shocks.

[17] Due to space limitations, and to preserve clarity, we report results for the case of supply and demand shocks recovered from the eight-lag VAR system over 1990–2002. Besides, it is for this case that time-varying patterns of supply and demand shock asymmetries between the CEECs and the EU are illustrated in Babetskii *et al.* (2004). The results based on the estimates over 1993–2002, using two or four lags, do not differ qualitatively and are available upon request.

Figure 3a. German and Czech demand shocks, 1994–2002, quarterly

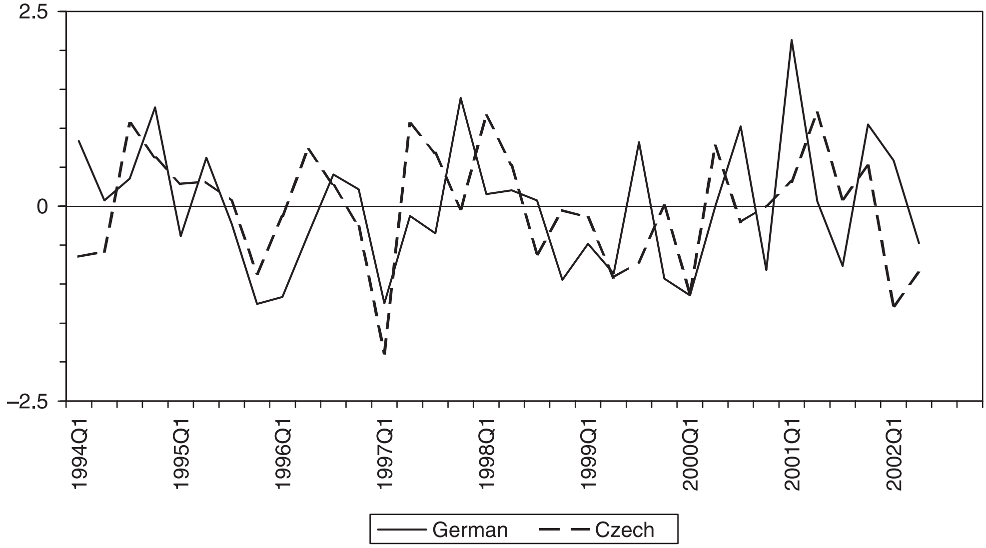
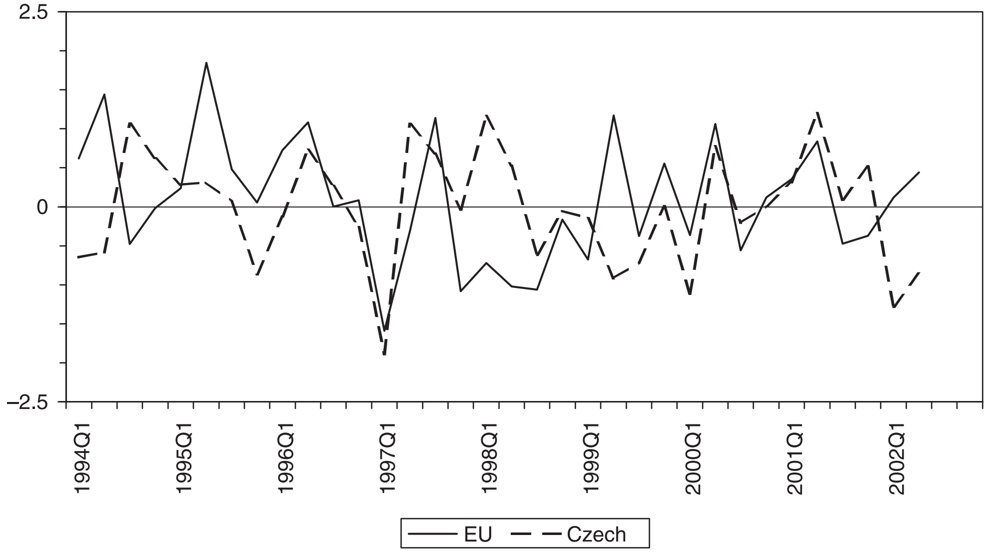
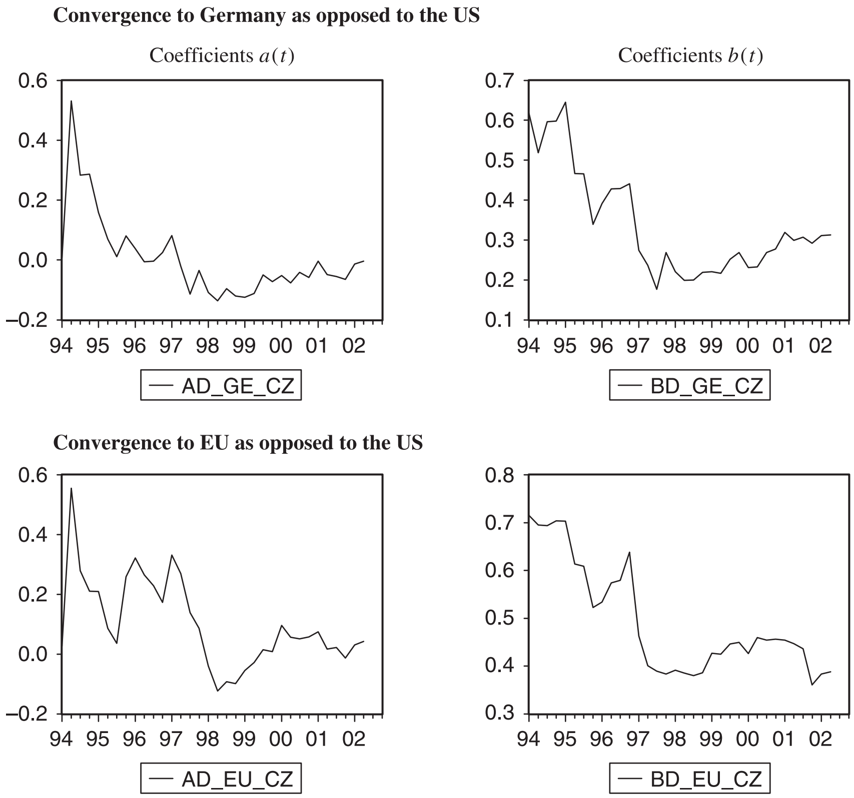


Figure 3b. EU and Czech demand shocks, 1994–2002, quarterly



Source: Author's computations.

Figure 4. Czech Republic, convergence of demand shocks



Source: Author's computations.

Intuitively, the average value of b_t over 1996–97 (0.3) approximately corresponds to the weights of the German and US currencies in the basket for the Czech crown (65 percent DEM and 35 percent USD) over the same period.

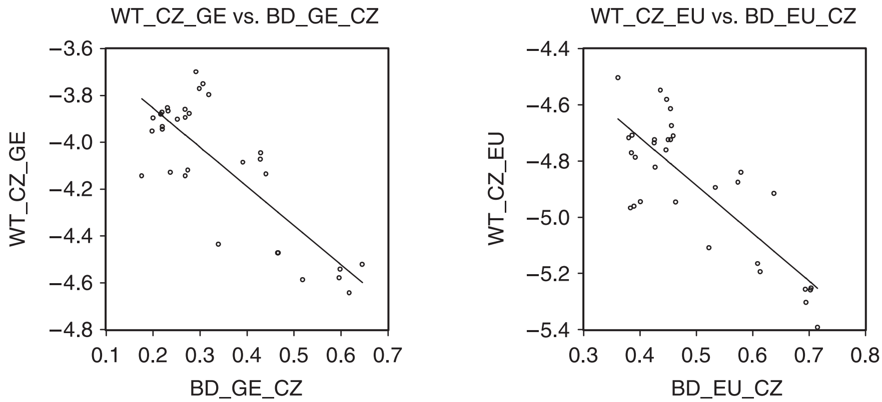
Next, we confront the indicators of shock asymmetry and trade intensity. Figure 5 illustrates a scatter plot of coefficients b_t (horizontal axis) versus total bilateral trade intensity (in logarithms; vertical axis).

There is a strong negative relationship between the asymmetry of demand shocks and trade intensity with Germany, captured by a high correlation coefficient (–0.81) or, alternatively, by a significant slope from an OLS regression (–0.46). Almost identical similar results hold for the Czech–EU case. These results can be interpreted in favour of the argument that trade intensity reduces demand shock asymmetry.

Figure 5. Czech Republic case, link between trade intensity and demand shock asymmetry, 1994–2001, quarterly

Czech Republic versus Germany	Czech Republic versus EU

Trade intensity (vertical axis) versus shock asymmetry (horizontal axis)



Correlation between shock asymmetry and trade intensity

$\rho_{Cz\_GE} = -0.81$		$\rho_{Cz\_EU} = -0.81$	
OLS regression of shock asymmetry on trade intensity (Standard errors in parentheses)			
$b_t^D = -1.56 - 0.46\ TI$		$b_t^D = -1.66 - 0.44\ TI$	
(0.23) (0.06)		(0.30) (0.06)	
Number of obs.	32	**Number of obs.**	32
Adjusted R-squared	0.64	**Adjusted R-squared**	0.66
S.E. of regression	0.08	**S.E. of regression**	0.07

Source: Author's computations.

4.2 Asymmetry of shocks, trade intensity, and exchange rate volatility

Table 6 reports average values of shock asymmetry over 1994–2002 and two sub-periods. The decreasing averages and variance of the time-varying coefficients b_t from Equation (11) mean that the asymmetry of the underlying shocks diminishes.[18] The results can be interpreted in favour of demand shock convergence, while the

[18] It is also verified that the constant term a_t converges to zero for both supply and demand shocks. Results are available upon request.

pattern of the supply shocks (Table 6b) is rather diverging. Note that the average values of the supply and demand shock asymmetries for the CEECs do not differ much from the corresponding levels for such EU member countries as Ireland, Portugal, and Spain.[19]

Estimates of shock asymmetry are unavailable for Bulgaria and Lithuania, due to their short GDP time series. On the other hand, we exclude the series of trade intensity for Slovenia due to a lack of variation. Hence, we are left with seven CEECs to analyse the effect of trade on shock asymmetry. Table 7 shows that there is strong negative correlation between trade intensity and shock asymmetry on the demand side: more trade intensity means lower asymmetry. On the supply side, the correlation is close to zero and insignificant (Germany) or positive (EU). A similar pattern follows from the country-by-country estimates of equation (14).[20]

The panel estimates of (15) do not qualitatively change the results. An increase in trade intensity is associated with higher symmetry of demand shocks; the link with supply shocks is ambiguous (Table 8). The results for demand shocks are robust with respect to the three indicators of trade, the two benchmarks (the EU aggregate and Germany), and the estimation method (country-specific correlation coefficients or a panel framework). Demand shock convergence can be interpreted as being due to trade and monetary integration. Since intra-industry trade accounts for a large share of trade for the candidate countries, the total effect of trade on demand shock symmetry is positive. The link between trade intensity and the correlation of demand shocks is similar to the link between trade intensity and output correlation found by Frankel and Rose (1998) and Fidrmuc (2004), among others.[21] This is not surprising, given that demand shocks, by construction, can have only short-term effects on output.

On the supply side, asymmetries of shocks characterize the process of catching-up at work: productivity gains in the candidate countries translate into increases in per capita incomes. Supply shocks can be also interpreted in terms of Schumpeterian 'innovations', which are perceived as an engine of technological progress (Schumpeter, 1943).[22] Higher trade intensity due to an increase in intra-industry trade may be associated with more intensive restructuring, whence might follow the observed positive impact of trade on supply shock asymmetry. On the other hand, higher trade intensity is accompanied by lower shock asymmetry in a number of cases;

[19] There is a question of whether these selected EU countries represent a good benchmark. On the one hand, they already share a common monetary policy. On the other hand, the chosen three countries due to their geographical location are said to belong to the EU 'periphery'. In the long term, the CEECs may be more correlated with Germany/the EU than the 'peripheral' countries.
[20] The results are not shown since in the case of two variables the correlation coefficient and OLS regression give almost the same information.
[21] A significant effect of total trade on synchronization of business cycles, controlling for multiple causalities among trade, finance, specialization and output co-movements, has also been documented by Imbs (2004).
[22] See Hénin (1997) and Hospers (2003) for a review.

Table 6. Shock asymmetry, 1994–2002[1] (Standard deviations in parentheses)

(a) Demand shocks

	Germany			European Union		
	1994–2002	**94–98**	**99–02**	**1994–2002**	**94–98**	**99–02**
Czech Republic	0.34 (0.13)	0.39 (0.16)	**0.27** (0.04)	0.49 (0.11)	0.54 (0.13)	**0.43** (0.03)
Estonia	0.41 (0.07)	0.39 (0.08)	0.43 (0.06)	0.36 (0.10)	0.41 (0.10)	**0.29** (0.02)
Hungary	0.50 (0.07)	0.52 (0.08)	**0.47** (0.04)	0.35 (0.04)	0.37 (0.04)	**0.32** (0.02)
Latvia	0.44 (0.11)	0.49 (0.12)	**0.37** (0.05)	0.35 (0.16)	0.45 (0.14)	**0.22** (0.07)
Poland	0.60 (0.09)	0.61 (0.11)	**0.60** (0.06)	0.50 (0.19)	0.63 (0.12)	**0.32** (0.08)
Romania	0.72 (0.35)	0.84 (0.39)	**0.54** (0.16)	0.89 (0.42)	0.93 (0.39)	**0.82** (0.47)
Slovakia	0.60 (0.14)	0.68 (0.17)	**0.52** (0.05)	0.59 (0.09)	0.64 (0.09)	**0.53** (0.02)
Slovenia	0.58 (0.08)	0.64 (0.08)	**0.53** (0.04)	0.78 (0.09)	0.83 (0.05)	**0.71** (0.08)
CEECs average	0.52	0.57	**0.47**	0.54	0.60	**0.46**
Ireland	0.50 (0.01)	0.50 (0.00)	0.50 (0.01)	0.45 (0.01)	0.44 (0.01)	0.45 (0.00)
Portugal	0.49 (0.00)	0.49 (0.00)	0.49 (0.00)	0.35 (0.00)	0.35 (0.00)	0.35 (0.00)
Spain	0.61 (0.00)	0.60 (0.00)	0.61 (0.00)	0.49 (0.00)	0.49 (0.00)	0.49 (0.00)

(b) Supply shocks

	Germany			European Union		
	1994–2002	**94–98**	**99–02**	**1994–2002**	**94–98**	**99–02**
Czech Republic	0.29 (0.30)	0.08 (0.26)	0.51 (0.15)	0.01 (0.28)	–0.22 (0.15)	0.26 (0.16)
Estonia	0.66 (0.12)	0.66 (0.15)	0.66 (0.07)	0.72 (0.20)	0.76 (0.26)	**0.68** (0.11)
Hungary	0.46 (0.09)	0.45 (0.11)	0.46 (0.07)	0.39 (0.14)	0.43 (0.14)	**0.30** (0.09)
Latvia	0.75 (0.17)	0.86 (0.19)	**0.66** (0.07)	0.34 (0.14)	0.26 (0.10)	0.48 (0.07)
Poland	0.09 (0.11)	0.07 (0.12)	0.13 (0.07)	–0.02 (0.26)	–0.20 (0.13)	0.23 (0.16)
Romania	0.25 (0.11)	0.25 (0.14)	**0.23** (0.05)	0.13 (0.13)	0.05 (0.07)	0.25 (0.10)
Slovakia	0.72 (0.43)	1.00 (0.48)	**0.47** (0.11)	0.30 (0.28)	0.10 (0.24)	0.52 (0.06)
Slovenia	0.58 (0.16)	0.70 (0.15)	**0.47** (0.07)	0.55 (0.37)	0.72 (0.45)	**0.37** (0.12)
CEECs average	0.48	0.51	**0.45**	0.30	0.24	0.39
Ireland	0.36 (0.00)	0.36 (0.00)	0.36 (0.00)	0.42 (0.01)	0.42 (0.00)	0.43 (0.00)
Portugal	0.43 (0.00)	0.43 (0.00)	0.43 (0.00)	0.45 (0.02)	0.43 (0.01)	0.46 (0.02)
Spain	0.46 (0.00)	0.46 (0.00)	0.46 (0.00)	0.50 (0.00)	0.50 (0.00)	0.50 (0.00)

Note: [1] Shock asymmetry between CEECs and Germany (EU) is measured by coefficient b_t from Equation (11). Lower coefficients mean higher symmetry. Values in boldface denote diminishing asymmetry of shocks.
Source: Author's computations.

Table 7. Correlation between shock asymmetry and trade integration, 1994–2001 $\rho_{ij} = Corr(b_{ijt}, \log(TI_{ijt}))$ where i = CEECs, j = Germany/EU, t = quarter for two types of shocks[1] and three indicators of trade intensity[2]

(a) Demand shocks

	Total Germany	Exports Germany	Imports Germany	Total EU	Exports EU	Imports EU
Czech Republic	–0.81	–0.84	–0.76	–0.81	–0.84	–0.74
Estonia	0.32	0.13	0.35	–0.92	–0.86	–0.85
Hungary	–0.73	–0.71	–0.72	–0.70	–0.72	–0.66
Latvia	–0.57	–0.58	–0.54	–0.90	–0.86	–0.88
Poland	–0.46	–0.31	–0.47	–0.76	–0.75	–0.72
Romania	–0.10	–0.14	–0.07	–0.09	–0.07	–0.10
Slovakia	–0.83	–0.76	–0.84	–0.82	–0.79	–0.81
CEECs average	–0.45	–0.46	–0.44	–0.71	–0.70	–0.68

(b) Supply shocks

	Total Germany	Exports Germany	Imports Germany	Total EU	Exports EU	Imports EU
Czech Republic	0.36	0.40	0.30	0.80	0.77	0.76
Estonia	0.56	0.29	0.58	–0.55	–0.44	–0.60
Hungary	0.01	0.02	0.00	–0.74	–0.75	–0.71
Latvia	–0.77	–0.80	–0.70	0.63	0.68	0.56
Poland	0.30	0.09	0.38	0.67	0.77	0.58
Romania	–0.29	–0.32	–0.24	0.58	0.60	0.52
Slovakia	–0.93	–0.86	–0.95	0.51	0.65	0.35
CEECs average	–0.11	–0.17	–0.09	0.27	0.33	0.21

[1] *Supply or demand shock asymmetry* between CEECs and Germany (EU) is measured by coefficient b_t from Equation (11).

[2] *Trade intensity* is defined with respect to *exports*, *imports*, and *total* bilateral trade according to the following expressions (natural logarithms of):

$$TI_{ijt}^{EX} = EX_{ijt}/(EX_{it} + EX_{jt})$$
$$TI_{ijt}^{IM} = IM_{ijt}/(IM_{it} + IM_{jt})$$
$$TI_{ijt}^{T} = (EX_{ijt} + IM_{ijt})/(EX_{it} + EX_{jt} + IM_{it} + IM_{jt})$$

where i = CEECs, j = Germany/EU, EX_{ijt} = exports from country i to country j, EX_{it} = total exports from country i, and IM denotes imports.

Source: Author's computations.

Table 8. Effect of trade intensity and exchange rate volatility on shock asymmetry[1]
(standard errors in parentheses)

a) Demand shocks

Germany	**Total**	**Exports**	**Imports**	**Total**	**Exports**	**Imports**
Trade intensity	–0.33 (0.05)	–0.34 (0.05)	–0.30 (0.06)	–0.31 (0.05)	–0.32 (0.05)	–0.29 (0.05)
Exch. rate volatility	–	–	–	4.84 (0.06)	4.55 (0.06)	4.94 (0.07)
Number of obs.	204	204	204	204	204	204
Adjusted R-sq.	0.47	0.47	0.43	0.59	0.59	0.57
S.E. of regression	0.15	0.15	0.16	0.14	0.15	0.14

EU	**Total**	**Exports**	**Imports**	**Total**	**Exports**	**Imports**
Trade intensity	–0.27 (0.06)	–0.27 (0.05)	–0.25 (0.07)	–0.28 (0.06)	–0.26 (0.06)	0.30 (0.07)
Exch. rate volatility	–	–	–	5.17 (0.06)	4.83 (0.05)	5.34 (0.06)
Number of obs.	204	204	204	204	204	204
Adjusted R-sq.	0.53	0.55	0.56	0.55	0.55	0.55
S.E. of regression	0.17	0.18	0.18	0.19	0.20	0.20

b) Supply shocks

Germany	**Total**	**Exports**	**Imports**	**Total**	**Exports**	**Imports**
Trade intensity	0.05 (0.06)	0.03 (0.06)	0.05 (0.05)	0.05 (0.06)	0.03 (0.06)	0.05 (0.05)
Exch. rate volatility	–	–	–	–1.58 (2.24)	–1.36 (2.04)	–1.61 (2.51)
Number of obs.	196	196	196	196	196	196
Adjusted R-sq.	0.67	0.66	0.66	0.65	0.65	0.65
S.E. of regression	0.16	0.16	0.16	0.17	0.17	0.17

EU	**Total**	**Exports**	**Imports**	**Total**	**Exports**	**Imports**
Trade intensity	0.18 (0.06)	0.14 (0.06)	0.19 (0.06)	0.15 (0.06)	0.11 (0.06)	0.16 (0.07)
Exch. rate volatility	–	–	–	1.48 (2.30)	1.71 (2.30)	1.58 (2.30)
Number of obs.	196	196	196	196	196	196
Adjusted R-sq.	0.58	0.57	0.58	0.55	0.56	0.56
S.E. of regression	0.22	0.22	0.22	0.24	0.24	0.25

Notes: [1]: Estimates of Equation (15) and (16) (OLS, fixed effects):

$$\hat{b}(j)_{it} = c_{1t} + c_2 \log[TI(j)_{it}] + c_{3i}D_i + \varepsilon(j)_{it}$$

$$\hat{b}(j)_{it} = c_{1t} + c_2 \log[TI(j)_{it}] + c_3 ERV_{it} + c_{4i}Di + \varepsilon(j)_{it}$$

Exchange rate volatility ERV_{it} for candidate country i at quarter t is defined as standard deviations in percent from average nominal exchange rates against ECU/euro over preceding 12 months

Source: Author's computations.

the estimates depend on the estimation method and on whether Germany or the EU is considered as the benchmark.

When exchange rate volatility is added, the coefficient of trade intensity does not change significantly. A decrease in exchange rate volatility is accompanied by demand shock convergence, while no notable effect on supply shocks is observed. The attempts by some candidate countries to fix their currencies to the euro contribute to the synchronization of demand shocks. To the extent that supply shocks have a long-term impact on output, there is no significant impact of nominal exchange rate volatility on supply shock symmetry.

5. Conclusion

This paper supports the view about demand shock convergence and divergence of supply shocks between the candidate countries, the EU-15, and Germany as alternative benchmarks. Estimated time-varying coefficients of shock asymmetry are then confronted with several indicators of bilateral trade intensity and exchange rate volatility. The results for demand shocks support Frankel and Rose's (1998) endogeneity argument, according to which international trade links synchronize business cycles. In terms of demand shocks, countries are more likely to satisfy criteria for monetary union membership *ex post*, as economic integration deepens. On the supply side, the link between shock asymmetry and trade integration is ambiguous. Higher trade intensity may be accompanied by both supply shock symmetry and asymmetry.[23] Nevertheless, there are a number of considerations which complicate the interpretation of the results.

First, there is no consensus in the literature on which shocks, i.e., supply or demand, are more relevant for assessing the costs of joining the EMU.[24] The optimum currency area theory says that the more symmetric are the shocks (implying both supply and demand disturbances) between countries, the less costly is forgoing an autonomous monetary policy.[25] The empirical studies do not make a clear point either. Often there is simply no discussion of the importance of various types of shocks. Two different points of view equally exist. For example, for Fidrmuc and Korhonen (2003, p. 325) '*supply shocks are especially relevant, if demand shocks originate mainly from domestic economic policies, since in a monetary union economic policies should converge to a large extent*.' On the other hand, according to Babetskii, Boone and

[23] For comparison, Tenreyro and Barro (2003) find that adopting a common currency (which is synonymous to taking steps towards a monetary union in the context of the endogeneity argument) increases bilateral trade and leads to higher correlation of price co-movements but lower synchronization of shocks to output.
[24] See Gros and Thygesen (1999, pp. 277–80) for a discussion of the effects of various shocks in the context of the OCA theory.
[25] Mundell (1961) and McKinnon (1963) use an example of export demand shocks to illustrate the basic OCA principles. Kenen (1969) makes a further distinction between demand and technology disturbances.

Maurel (2004, p. 227), the absence of supply shock convergence is not necessarily bad from the point of view of EMU memberships. CEEC countries, by fixing nominal exchange rates, have simply to let productivity gains translate into inflation differentials.

Second, the relationship between business cycle indicators (e.g., the correlation of de-trended economic activity) and supply and demand shocks is not straightforward. For example, Fidrmuc and Korhonen (2003) mention the puzzling behaviour of Slovenia, which has highly correlated business cycles with the euro area but poorly correlated both demand and supply shocks. Given that business cycles consist of a mixture of shocks and responses, the same level of business cycle synchronization can be observed in two opposite cases: similar shocks and similar responses, and asymmetric shocks and asymmetric responses. The Slovenian example illustrates the last case. Generally, it is also difficult to quantify the impact of policy-induced responses to exogenous shocks on the estimation results (see Kenen, 2001).

Due to the above problems, and given that there is a relatively low robustness of the results among different studies, the policy recommendations should be mentioned with caution. One interpretation of the results is that pegging national currencies to the euro or even entering the EMU would not be so costly for the candidate countries in terms of the costs associated with demand shock asymmetry. Indeed, the EU candidate countries are characterized by levels of supply and demand shock asymmetries comparable to those for present EU member countries such as Ireland, Portugal, and Spain. However, one should bear in mind that a closed economy approach does not allow us to distinguish between domestic and foreign shocks. Therefore, we may observe more convergence or more symmetry than in the case of 'pure domestic' shocks.

Furthermore, the importance of the OCA criteria to the analysis of membership in a monetary union should not be overemphasized. The degree of symmetry of contemporaneous shocks is only one aspect of the costs associated with monetary union membership. There might be other costs of EMU accession of at least the same importance as dissimilarity of shocks, for example, the incompatibility of the current Maastricht inflation criteria with the catching-up objective.[26] The still existing substantial asymmetries, in terms of shocks, among the present EMU countries suggest that this is probably not the most important criterion. Another way of looking at shock asymmetries is to recall the risk-sharing argument proposed by Mundell (1973) and recently discussed by McKinnon (2002, p. 344).[27] Asymmetric shocks are not necessarily bad: 'asset holding for international risk sharing is better served by a common currency spanning a wide area – within which countries or regions could be, and perhaps should best be, quite different.'

[26] See Buiter and Grafe (2002).
[27] See also Nuti (2002).

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