SYMMETRY OF SHOCKS AND TRADE INTEGRATION IN THE ENLARGED EUROPEAN UNION[a]

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ABSTRACT

This paper explores the relationship between trade flows and symmetry of aggregate supply and aggregate demand shocks across national economies using data from the EU-27 countries. Demand and supply shocks are identified from real-output-growth and GDP-deflator-growth data using the Blanchard-Quah structural VARs methodology. Overall trade intensity is found to have a positive impact on the correlation of both demand and supply shocks across the EU economies. Intra-industry trade is found to be positively linked to the correlation of supply-side shocks but negatively linked to the correlation of aggregate demand shocks. Our results thus provide support for the argument that aggregate demand spillovers and intra-industry trade, rather than specialization, dominate in the process through which trade flows affect the cross-country transmission of shocks in Europe.

I. Introduction

There is currently a debate in the literature as to whether intense trade between economies accompanies highly correlated business cycles. Krugman (1993) and Eichengreen (1992), stressing trade-induced specialization, pointed to a negative association between increased trade and cross-country synchrony of business cycles. Kalemli-Ozcan *et.al.* (2001) support this view, emphasizing that the increased opportunities for income diversification, which results from international integration, will induce higher specialization in production and thus less symmetric business cycles. Kose and Yi (2001) employing a standard business-cycle model also fail to establish a strong link between trade intensity and cross-country output correlations, while Imbs (2004) points out that the overall impact of trade on business-cycle synchronization is ambiguous as trade flows affect national economies through a variety of channels. Several other papers, however, have reached different conclusions. Frankel and Rose (1998), employing data from a large number of countries, have found a strong positive relationship between increased bilateral trade and cross-country synchronization of macroeconomic fluctuations. Coe and Helpman (1995), Fatàs (1997), Canova and Dellas (1993), Clark and Wincoop (2001), Bergman (2004), Inklaar *et. al.* (2005) and Calderon *et.al.* (2007) also provide evidence suggesting a favorable impact of trade integration on business-cycle synchrony.

Upon examining the impact of trade on business-cycle correlations, much of the literature pays no attention to the link between increased trade and demand and supply shocks focusing directly on the relationship between bilateral trade flows and output co-movements. A crucial issue, however, is how international trade relates to cross-country asymmetries of shocks since the existence of such asymmetries is one of the main reasons for the limited synchronization of national business cycles. Indeed, the mechanisms by which international trade affects business-cycle correlations may be better understood if its relationship with demand and supply innovations is separately and explicitly examined. In this respect, one argument, which follows from Krugman (1993), is that closer trade links, by inducing specialization in production according to comparative advantage, would result in greater cross-country asymmetries of supply-side shocks. An opposing argument, which follows from Coe and Helpman (2001) and Frankel and Rose (1997, 1998), is based on international spillovers and the new theory of international trade. Trade between economies increases the diffusion of knowledge and technology, resulting in more rapid transmission of productivity shocks. It is also a major channel through which country-specific spending shocks are spread internationally. Thus, as overall trade intensity increases, international spillovers increase leading in general to greater correlation of shocks across countries. At the same time, trade between a number of countries seems to be increasingly taking place within the same industries. In such cases, increased trade would also imply more intense intra-industry trade. This would lead to less export specialization and greater similarity of industrial branches across national economies and thus more comparable supply-side shocks.

The above considerations have testable implications. If international spillovers are dominant and the argument about intra-industry trade is correct, one would expect increased overall trade (and thus bilateral trade intensities) to be significantly and positively related to cross-country correlations of both demand and supply shocks: to demand shocks through spending spillovers; and to supply-side shocks through productivity spillovers and similarity of industrial structures. On the other hand, if specialization dominates, increased overall trade should be negatively linked to correlations of supply-side shocks, although it may be positively associated with demand-shock correlations through

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aggregate spending and income spillovers. At the same time increased intra-industry trade, while having a positive impact on the cross-country correlation of supply-side shocks, can be expected to be negatively associated with correlations of demand shocks to the extent that it would imply relatively large intra-industry spending transfers rather than large aggregate spending spillovers. We test these hypotheses using data from the EU-27 countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden, the UK, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria and Romania) for the period 1995Q1-2005Q4.

The rest of the paper is organized as follows: Section II focuses on the existing empirical literature on trade integration and synchrony of macroeconomic fluctuations and considers the evolution of trade flows in EU member states. Section III proceeds to identify demand and supply shocks in each of the EU-27 economies from real-output-growth and GDP-deflator-growth data employing a structural VARs methodology along the lines suggested by Blanchard and Quah (1988). Following that, correlation coefficients of shocks versus Germany, France and the euro zone are computed and the nature of the relationship between such correlations and trade flows is examined. Since similarity of economic policies may, in addition to trade, influence correlations of shocks across countries, policy convergence as a shock-transmission or shock-absorption mechanism is also considered. Section IV contains concluding comments.

Increased overall trade is found to be positively and significantly associated with greater symmetry of both supply and demand shocks. Intra-industry trade is found to be positively related to cross-country correlations of supply-side shocks but negatively linked to correlations of demand shocks. Our estimates thus provide support for the argument that international spillovers and intra-industry trade, rather than specialization, dominate in the process through which trade flows affect the cross-country transmission of shocks across Europe. They also implicitly provide evidence in favor of the Frankel-Rose (1997, 1998) optimum-currency-areas (OCA) 'endogeneity' argument, namely that the OCA criterion of similarity of shocks is more likely to be satisfied *ex post* rather than *ex ante*. In particular, to the extent that our results suggest that more intense overall trade would imply less asymmetric demand shocks as well as less asymmetric supply shocks, then, provided that intra-EU trade continues on an upward trend, the process of European integration should lead to more synchronized national business cycles. At the same time, our results suggest that monetary-policy convergence in Europe (the circulation of the euro), while having increased symmetry of supply-side shocks, has had no favorable impact on symmetry of demand shocks. By contrast, the process of fiscal-policy convergence is found to have resulted in more correlated demand shocks across the EU member states.

II. TRADE INTEGRATION AND BUSINESS CYCLES

II.1. Overview of the literature

Much of the literature on the link between trade integration and synchronization of business cycles focuses on the impact of increased trade on cross-country co-movements of some measure of real economic activity, such as output, industrial production, employment and unemployment. A seminal paper in this literature is that of Frankel and Rose (1998), who, using data from a large set of industrial countries covering the period 1959-1993, considered the extent to which cross-country correlations of quarterly real-GDP growth, industrial production growth, employment growth and unemployment could be explained by average bilateral trade flows normalized by total trade or nominal GDP. Determinants of international trade from gravity models that were uncorrelated with policy co-ordination (such as distance between countries, geographic adjacency and common language) were used as instruments for bilateral trade patterns in their regressions. Their results suggested a strong positive association between overall bilateral trade and the cross-country correlation of cyclical macroeconomic fluctuations. Employing a similar methodology Clark and Wincoop (2001) and Calderon, Chong and Stein (2007) confirmed the Frankel-Rose results.

Gruben, Koo and Millis (2002) refined and extended the Frankel-Rose specification. Pointing out that the instruments for trade intensity used by Frankel and Rose were rather inappropriate, due to their possible association with omitted variables, they included distance between countries, geographic adjacency and common language directly into their regressions. They also decomposed the total trade-intensity variable into inter- and intra-industry intensity. Their findings were consistent with the Frankel-Rose general argument of a positive association between close trade links and synchrony of business cycles but suggested that the Frankel-Rose estimated coefficients of trade intensity were biased upwards. At the same time, they found no evidence in support of the specialization hypothesis: no significantly negative effect of greater inter-industry trade on business-cycle correlations was detected. Inklaar, Jong-A-Pin and de Haan (2005) also argued against using instrumental variables and estimated a multivariate model that included as regressors specialization and policy integration, in addition to trade. Data from 21 OECD countries covering the period 1970-2003 were employed. They found that the Frankel-Rose trade-intensity coefficients were biased upwards, but overall their results were consistent with the Frankel-Rose proposition of a positive effect of trade on business-cycle synchrony.

Fidrmuc (2001, 2004) also extended the Frankel-Rose specification by incorporating bilateral levels of intra-industry trade as well as trade intensity into his regressions for the OECD countries. Cross-country correlations of industrial-production growth and real-GDP growth for the period 1990Q1-1999Q4 were used as measures of business-cycle synchrony and two-stages ordinary least squares were employed with instrumental variables being the same as in Frankel and Rose (1998). Fidrmuc found the trade intensity variable to be insignificant. The intra-industry-trade coefficient was positive and significant in almost all his specifications. These results were robust with respect to the inclusion of several other variables, such as institutional factors (EMU membership) and GDP differences among countries. Drawing on his results, Fidrmuc (2004) concluded that convergence of business cycles between the major CEECs (the Czech Republic, Hungary, Poland, Slovakia and Slovenia) and the rest of Europe would take place quickly due to the relatively large share of intra-industry trade in their total trade with EU.

Imbs (2000) introduced an index of similarity in countries' economic structure, a variable related to intra-industry trade, as a factor influencing cyclical output co-movements. His estimates suggested a positive association between this index and cyclical synchronization. Imbs (2004), using data from 18 countries covering the period 1983Q1-1998Q1, also examined the effect on output co-movements of differences in the degree of specialization between economies. His sample included both industrial and developing countries. Pointing out that trade flows affect correlations of real-GDP growth through several different channels, he proceeded to empirically assess the magnitude of these channels using simultaneous equation techniques. His results provided weak evidence for a trade-induced specialization effect on business-cycle synchrony. On the other hand, Traistaru (2004), in examining the synchronization of business cycles between the euro zone and several CEECs over the period 1990Q1-2003Q3, concluded that both bilateral trade intensity and similarity of sectoral structures were positively and significantly associated with increased synchrony of GDP fluctuations.

Shin and Wang (2005) attempted to examine the relative importance of four factors influencing cross-country synchrony of real-GDP-growth: overall trade, intra-industry trade, fiscal-policy coordination and monetary-policy coordination. Annual data from 13 EU countries plus Norway for three periods (1976-1983, 1984-1991 and 1992-1999) were used. Their results were similar to those of Fidrmuc (2004) in that the trade intensity variable was significant only when intra-industry trade was excluded from the regressions. As far as fiscal-policy coordination is concerned, it was found to have no significant effect on output co-movements. Also the impact of monetary-policy coordination was sensitive to the proxy used, with cross-country correlation of M2 growth rates having no effect on synchronization while correlation of short-term interest rates appear as an important determinant of synchrony of cyclical GDP fluctuations across countries.

The impact of fiscal- and monetary-policy convergence, in addition to trade, on business-cycle synchronization was also examined by Bergman (2005). Bergman employed industrial-production data from the EU-15 countries plus Canada, Japan, Norway, Switzerland and the US for the period 1961Q1-2001Q4 and a methodology similar to that of Frankel and Rose (1998). His results suggested that fiscal-policy similarity increases cyclical synchrony across national economies but common monetary policy decreases synchrony. At the same time, he found trade intensity to be always significant in explaining business-cycle synchronization, regardless of whether the fiscal- and monetary-policy-coordination variables were included in the regressions. Kose, Prasad and Terrons (2003) examined the relation between increased trade and synchronization of consumption growth as well as output growth. Annual data from 21 industrial and 55 developing countries for the period 1960-1999 were employed. Their results provided weak evidence for the argument that more intense overall trade leads to more correlated business cycles. On the other hand, Otto, Voss and Willard (2001), who estimated a reduced-form equation in which real-output correlations across 17 OECD countries, were explained by bilateral trade, financial integration, monetary coordination and an index of specialization, found evidence broadly in line with that in Frankel and Rose (1998).

Babetskii (2005) is, to our knowledge, the only existing paper which examines directly the link between trade flows and cross-country symmetry of shocks. Using a structural-VARs methodology and data from seven CEECs (the Czech Republic, Estonia, Hungary, Latvia, Poland and Slovakia and Romania) plus Ireland, Portugal and Spain for the period 1990Q1-2002Q4, he first identifies demand and supply shocks in these economies and then computes time-varying correlation coefficients of shocks between each one of them and Germany (or the EU-15). Following that, he examines the extent to which the estimated time-varying coefficients of shock similarity are affected by trade intensity. The results suggest a positive effect of increased overall trade on the symmetry of demand shocks. However, Babetskii is unable to establish the impact of more intense overall trade on the symmetry of supply-side shocks. Also, the role of intra-industry trade is not considered. As a result, the different channels through which increased international trade could affect symmetry of different shocks are not explored.

The purpose of this paper is to extend and bring together earlier analyses of the link between business-cycle synchronization and trade flows by focusing directly on correlations of demand and supply innovations across countries and, within this context, to examine the impact on shock symmetry of both overall trade and intra-industry trade. Indeed, as implied in Kenen (2000), the association between increased trade and symmetry of shocks is an important issue to examine when attempting to explain synchrony of output co-movements across countries.
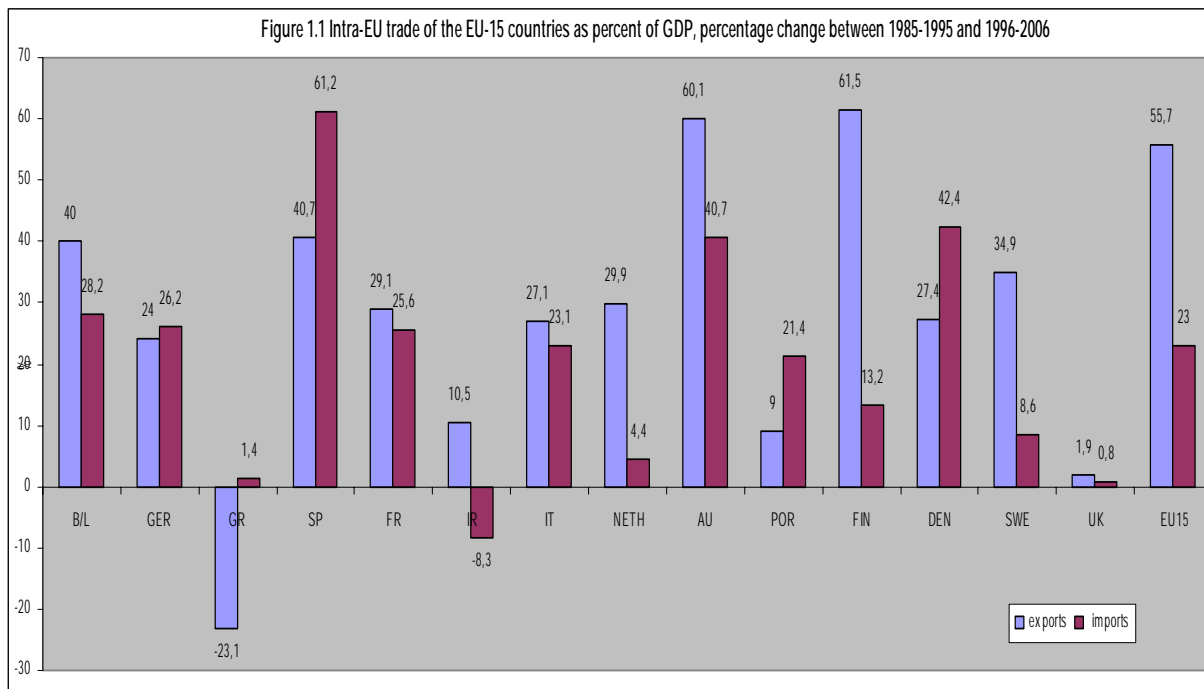
II.2. Evolution of trade flows in Europe

Intra-community trade increased as a percentage of GDP in almost all EU-15 member states following the implementation of the Single European Act and the decision to adopt a common currency. Between 1985-1995 and 1996-2006 intra-EU exports as percent of GDP increased on average for the EU-15 as a group by 6.4 percentage points (from 11.5 percent to 17.9 percent), and intra-EU imports rose by 3.2 percentage points (from 13.9 percent to 17.1 percent) (see Table 1.1 and Figure 1.1). The magnitude of the increase varied across the member states. Of the six original members, Belgium and Luxemburg (taken together) showed the biggest increase in intra-EU exports to GDP (40 %). France, Italy and Germany followed with increases between approximately 25% and 30% in both exports and imports, while in the Netherlands, where levels of intra-EU trade had already been high, the increase between 1985-1995 and 1996-2006 was almost 30% for exports and about 5% for imports. As regards the other EU-15 states, intra-EU exports to GDP increased by 60% in Austria and Finland, by between about 30% and 40% in Sweden, Denmark and Spain, by 9% in Portugal and by slightly less than 2% in the UK. The rise in intra-EU imports to GDP over the same period amounted to between 40% and 60% in Austria, Denmark and Spain, between about 9% and 20% in Sweden, Finland and Portugal and about 1% in Greece and the UK. Only Ireland experienced a drop in intra-EU imports as a percentage of GDP and Greece a drop in intra-EU exports. At the same time, the process of European integration was accompanied by external-trade creation: extra-EU imports and exports as a percentage of GDP showed an upward trend in all EU-15 countries except Portugal, with the increase in 1996-2006 relative to 1985-1995 for the group as a whole being equal to 1.7 percentage points for exports and 8.7 percentage points for imports. [2]

Table 1.1 Trade of the EU-15 countries as percent of GDP

	Intra-EU Exports		Intra-EU imports		Extra-EU exports		Extra-EU imports	
	1985-1995	1996-2006	1985-1995	1996-2006	1985-1995	1996-2006	1985-1995	1996-2006
B/L	41,7	58,4	40,4	51,8	13	17,9	13,4	20,4
GER	14,6	18,1	12,2	15,4	8,3	11,1	8,2	9
GR	6,5	5	14,7	14,9	3,5	3,9	8,2	9,8
SP	9,1	12,8	9,8	15,8	3,6	4,9	7	7,8
FR	11	14,2	12,1	15,2	6,3	7,8	5,7	7
IR	39,9	44,1	30,3	27,8	13,1	22,6	13,4	15,5
IT	9,6	12,2	9,1	11,2	6,6	8,5	6,6	7,9
NETH	35,4	46	27,3	28,5	7,6	11,4	13	23,7
AU	15,3	24,5	20,4	28,7	8	10,5	7,7	7,9
POR	15,5	16,9	20,6	25	4,5	3,9	9,4	7,3
FIN	12,2	19,7	12,9	14,6	9,9	13,6	7,8	8,5
DEN	16,8	21,4	13,9	19,8	7,9	9,4	7	7,8
SWE	14,9	20,1	15,2	16,5	11	14,2	7,7	8,5
UK	10,6	10,8	12,4	12,5	7,6	8	8,9	10,7
EU15	11,5	17,9	13,9	17,1	7,7	9,4	8,2	16,9

Source: Original data are from Eurostat, National Account

AU = Austria, B/L= Belgium/Luxemburg, DEN = Denmark, FIN = Finland, FR = France, GER =Germany, GR = Greece, IR = Ireland, IT = Italy, NETH = Netherlands, POR = Portugal, SP = Spain, SWE = Sweden, UK = United Kingdom

Figure 1.1 Intra-EU trade of the EU-15 countries as percent of GDP, percentage change between 1985-1995 and 1996-2006

Country	exports	imports
B/L	40	28,2
GER	24	26,2
GR	-23,1	1,4
SP	40,7	61,2
FR	29,1	25,6
IR	10,5	-8,3
IT	27,1	23,1
NETH	29,9	4,4
AU	60,1	40,7
POR	9	21,4
FIN	61,5	13,2
DEN	27,4	42,4
SWE	34,9	8,6
UK	1,9	0,8
EU15	55,7	23

As far as the newcomers are concerned, the 10 countries that became EU members in May 2004 (EU-10) are, with the exception of Poland, very open economies, showing ratios of total imports and exports to GDP higher than those of the EU-15 (see Table 1.2). In Slovakia, the Czech Republic, Estonia and Hungary intra-EU imports and exports amount to between approximately 60% and 50% of their GDP. Next comes Slovenia showing imports from (exports to) the European Union of 49% (39.9%) of GDP, followed by Lithuania and Latvia with ratios of 39.7% and 38.7% (33.2% and 23.3%) respectively. In Malta imports from EU correspond to 49.1% of GDP and exports amount to 21%, while in Poland intra-EU imports and exports correspond to about 25% of GDP. Cyprus's exports to EU represent no more than 6.5% of GDP but imports from EU correspond to about 28% of its GDP.

Table 1.2	New EU member states: Openness and EU trade as % of GDP, 2006		
	Openness: Total exports and imports as % of GDP	**Intra-EU exports as % of GDP**	**Intra-EU Imports as % of GDP**
SLOV	143	39,9	49
CZ	200	55,3	50,2
EST	117	48,9	56,3
CY	114	6,4	27,7
LAT	126	23,3	38,7
LITH	150	33,2	39,7
HU	209	49,9	47,2
MA	73	21	49,1
POL	167	24,2	26,3
SK	128	62,4	58
BU	85	46,1	56,1
ROM	74	49	59

Source: Original data are from Eurostat, National Accounts
BU = Bulgaria, CY = Cyprus, CZ = Czech Republic, EST = Estonia, HU = Hungary,
LAT = Latvia, LITH = Lithuania, MA = Malta, POL = Poland, ROM = Romania,
SLOV = Slovenia, SK = Slovakia

Moreover, in almost all EU-10 states, trade with the European Union has increased considerably after 1999 following the enlargement negotiations (see Table 1.3 and Figure 1.2). Between 1999-2002 and 2003-2006 imports from EU as a

percentage of GDP increased by between 20% and 30% in Poland, Lithuania, Latvia, Cyprus, Slovakia and the Czech Republic, by 16% in Slovenia, by 10.6% in Estonia, by 3.7% in Malta and by about 2% in Hungary. Intra-EU exports to GDP increased by 88% in the case of Cyprus, by 50.7% in Poland, by around 20% in the case of the Czech Republic, Latvia and Lithuania, by 12.1% in Slovenia and 15.8% in Slovakia and by about 3% in Estonia. In most EU-10 states exports to non-EU countries also showed a significant upward trend over the period 1999-2006 as the opening up of markets and the restructuring of their economies attracted a lot of foreign direct investment that was directed towards export industries. As a result, in some of them, the ratio of intra-EU exports to total exports showed a tendency to decline. On the other hand, in most EU-10, extra-EU imports dropped as a percentage of GDP from 1999 onwards as the elimination of customs barriers on imports from other member states induced a shift in the origin of their imports towards the European Union.
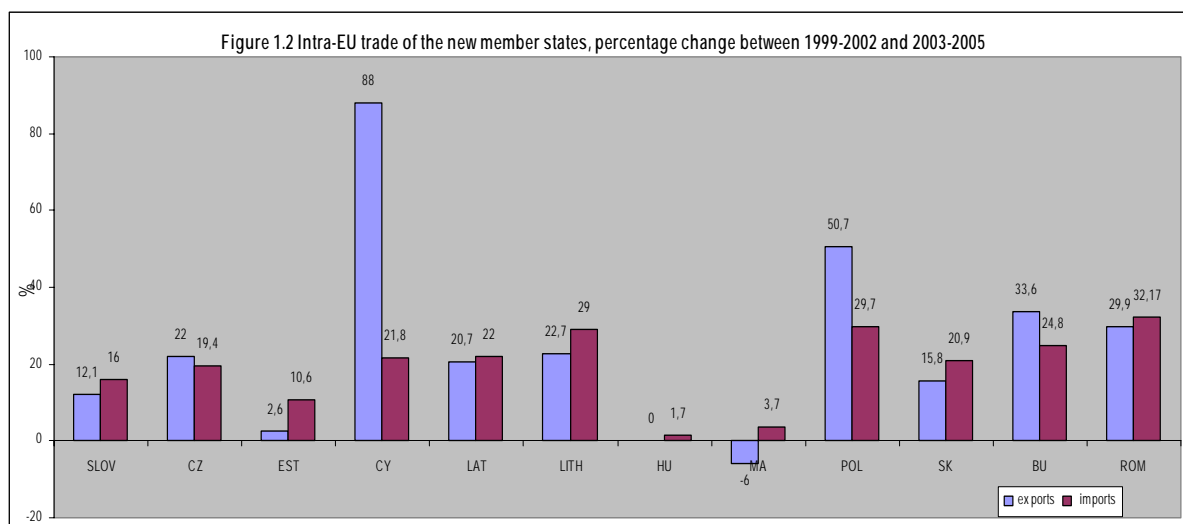
   Bulgaria and Romania, which formally became EU members in January 2007, have shown high real-export growth since 2000, and their trade with the European Union has increased considerably in the last 3-4 years. Exports to the European Union increased in Bulgaria and Romania from 28.3% and 35.4% of GDP respectively in 1999-2002 to 37.8% and 46% in 2003-2006. Imports from EU as percent of GDP have also been rising, from an average of 38.3% in Bulgaria and 40.1% Romania in 1999-2002 to 47.8% and 53% respectively in 2003-2006.

Table 1.3 Trade of the New EU member states as percent of GDP

	Intra-EU Exports		Intra-EU imports		Extra-EU exports		Extra-EU imports	
	1999-2002	2003-2006	1999-2002	2003-2006	1999-2002	2003-2006	1999-2002	2003-2006
SLOV	31,4	35,2	38,1	44,2	13,3	18	11,9	12,9
CZ	42,8	52,2	40,2	48	7,3	9,1	13,8	13,7
EST	41,9	43	47	52	7,8	10,5	20,6	21
CY	2,5	4,7	19,7	24	1,9	2,1	14,3	10,2
LAT	18,8	22,7	31,4	38,3	5,1	7,2	10,2	14,3
LITH	23,3	28,6	27	34,8	8,9	15,1	20,9	23,7
HU	44,5	44,5	40,1	40,8	10,1	12,4	20,7	19,4
MA	23,2	21,8	46	47,7	28,5	23,3	25,4	18,6
POL	15	22,6	19,2	24,9	3,6	6,2	8,3	9,3
SK	50,1	58	45,9	55,5	6,4	9,5	17,8	17,2
BU	28,3	37,8	38,3	47,8	7,9	8	17,9	18
ROM	35,4	46	40,1	53	1,4	22,7	11,4	12,7

Source: Original data are from Eurostat, National Accounts

BU = Bulgaria, CY = Cyprus, CZ = Czech Republic, EST = Estonia, HU = Hungary, LAT = Latvia, LITH = Lithuania, MA = Malta, POL = Poland, ROM = Romania, SLOV = Slovenia, SK = Slovakia

Figure 1.2 Intra-EU trade of the new member states, percentage change between 1999-2002 and 2003-2005

III. SYMMETRY OF SHOCKS AND EUROPEAN INTEGRATION

III.1. Identifying demand and supply innovations

Cyclical fluctuations in real output and prices can be assumed to result from both demand and supply innovations, with the former having a permanent effect only on prices while the latter having a permanent effect on both prices and output. Such demand and supply innovations can be recovered from a 2x2 vector auto-regression (VAR) for each country involving real-GDP growth and GDP-deflator growth by imposing long-run restrictions on the estimated coefficients.[3] In particular, in a world characterized by nominal rigidities, current real-output growth (inflation) can be assumed to be influenced by contemporaneous inflation (real output growth) and by past real-output growth rates and inflation rates:

$$\Theta_0 X_t = \Theta_1 X_{t-1} + \Theta_2 X_{t-2} + ... + \Theta_i X_{t-i} + \varepsilon_t \tag{1.1}$$

$$\text{with} \quad X_t = \begin{bmatrix} \Delta y_t - \Delta \widehat{y} \\ \Delta p_t - \Delta \widehat{p} \end{bmatrix}, \quad \varepsilon_t = \begin{bmatrix} \varepsilon_{dt} \\ \varepsilon_{st} \end{bmatrix}$$

where Θ_i are 2x2 coefficient matrices, ε_d and ε_s are structural demand and supply shocks respectively, $\Delta(.)$ is the difference operator, y_t (p_t) is (the log of) the current real GDP (GDP deflator), and $\widehat{y}$ and $\widehat{p}$ represent initial steady-state values. ε_d and ε_s are assumed to be contemporaneously uncorrelated.

Solving for X_t, (1.1) becomes

$$X_t = A_1 X_{t-i} + A_2 X_{t-2} + ... + A_i X_{t-i} + A_o \varepsilon_t \tag{1.2}$$

where $A_o = \Theta_o^{-1}$ and $A_i = \Theta_o^{-1} \Theta_i$ for $i = 1,2,....$. From (1.2), through appropriate substitutions, the behavior of real-GDP growth and GDP-deflator growth can be explained by the contemporaneous and the lagged effects of the structural demand and supply shocks:

$$X_t = B_0 \varepsilon_t + B_1 \varepsilon_{t-1} + B_2 \varepsilon_{t-2} + B_3 \varepsilon_{t-3} + ... = B_0 \varepsilon_t + \sum_{i=1}^{\infty} B_i L^i \varepsilon_t \tag{1.3}$$

where L^i is the lag operator (with $L^i \varepsilon_t = \varepsilon_{t-i}$), $B_o = A_o = \Theta_o^{-1}$ and the B_i's (for $i = 1, 2...$) are 2x2 coefficient matrices representing the lagged effects of demand and supply innovations on Δy and Δp. Along the lines suggested by Blanchard and Quah (1989), the restriction that in the long run an aggregate demand shock has no impact on real-output growth implies that

$$\beta_{11,o} + \sum_{i=1}^{\infty} \beta_{11,i} = 0 \tag{1.4}$$

where $\beta_{11,o}$ and $\beta_{11,i}$ are elements (1, 1) of matrices B_o and B_i respective

Using ordinary least squares, (1.2) can be estimated as a VAR with the original demand and supply innovations being identified from the estimated residuals. Such a VAR is estimated for each of the EU-27 countries using quarterly data drawn from Eurostat (KRONOS) covering the period 1995Q1-2005Q5.[4] The estimated VAR can be expressed as:

$$X_t = e_t + C_1 e_{t-1} + C_2 e_{t-2} + C_3 e_{t-3} + ... = e_t + \sum_{i=1}^{\infty} C_i L^i e_t \tag{2}$$

where e_t is the vector of the residuals and the C_i's (for $i = 1,2 ..$) are 2x2 matrices of estimated coefficients. Given (1.3) and (2), the contemporaneous structural shocks ε can be derived from the values of the estimated residuals e using the

relationship $e_t = \mathrm{B}_0 \varepsilon_t$ which implies $\varepsilon_t = B_o^{-1} e_t$. To find ε_t the elements of matrix B_0 need to be computed. As B_0 is a 2x2 matrix, this requires four restrictions. The first restriction comes from (1.4), i.e. the assumption that the long-run effect of a demand shock on real-output growth is zero. The other three restrictions come from the variance-covariance matrix of the residuals. For this matrix, say Ψ, we have

$$\Psi = \mathrm{E}(e_t e_t^{'}) = \mathrm{E}(\mathrm{B}_0 \varepsilon_t \cdot (\mathrm{B}_0 \varepsilon_t)^{'}) = \mathrm{B}_0 \mathrm{E}(\varepsilon_t \varepsilon_t^{'}) \mathrm{B}_0^{'} \tag{2.1}$$

Two restrictions follow from normalizations, namely from setting the variance of the shocks ε_{dt} and ε_{st} equal to unity. The third restriction comes from the assumption that demand and supply shocks are contemporaneously uncorrelated so that $cov(\varepsilon_{dt}, \varepsilon_{st}) = 0$. Accordingly, (2.1) becomes:

$$\Psi = \mathrm{B}_0 \mathrm{B}_0^{'} \tag{2.2}$$

Having found in this way the elements of B_o and thus having decomposed the residuals of the estimated VARs into demand and supply innovations for each country, the next step is to compute correlation coefficients of shocks between trading partners. Such correlations are computed versus Germany, France and the euro zone for two sub-periods of equal length, namely 1996Q1-2000Q4 and 2001Q1-2005Q4.

III.2. Measuring trade intensity and intra-industry trade

Trade intensity between trading partners i and j is measured as:

$$TRADE_{ij,\tau} = \left[\frac{X_{ij} + M_{ij}}{X_i + M_i + X_j + M_j} \right]_\tau \tag{3}$$

where X_i (M_i) are total exports (imports) of partner i, X_j (M_j) are total exports (imports) of j, X_{ij} (M_{ij}) are bilateral exports (imports) of i and j, and τ refers to the average of the relevant period. Quarterly trade data drawn from COMEXT (Eurostat) are used to construct (3).

An index of intra-industry trade *(INTRA)* is constructed from quarterly disaggregated trade data at the SITC-2 level, again drawn from Eurostat (COMEXT). The disaggregation involves 78 industries. *INTRA* is computed along the lines suggested by Grubel and Lloyd (1975), i.e.

$$INTRA_{ij,\tau} = 1 - \omega_{ij,\tau} \tag{4a}$$

$$\text{with} \quad \omega_{ij,\tau} = \left[\frac{\sum_k \left| X_{ij} - M_{ij} \right|}{\sum_k (X_{ij} + M_{ij})} \right]_\tau \tag{4b}$$

where κ is the number of industrial branches. Larger intra-industry trade flows will reduce the numerator of (4b), so *INTRA* will increase as more intra-industry trade takes place.

III.3. Trade and shock symmetry

Regression results from pooling the two sub-periods 1996Q1-2000Q4 and 2001Q1-2005Q4 are reported in Tables 2-4. As we consider two periods, time-varying characteristics, other than those reflected in the variables $TRADE_{ij,t}$ and $INTRA_{ij,t}$ may have had an impact on shock correlations. In the case of the countries in our sample, an important time-varying characteristic is monetary and fiscal co-operation across Europe, which was intensified after the second half of

2000 as the EU economies were preparing for the circulation of the common currency. To account for this, we have included as additional explanatory variable a dummy (*EURO*) that takes the value 0 for the period 1996Q1-2000Q4, when all EU member states still had their national currencies, and the value 1 for the 2001Q1-2005Q4 period, which on average was characterized by the free circulation of euro across the whole of Europe (even along national currencies in countries like the UK and Denmark, which did not participate in the euro zone). Alternatively, the discrepancy of short-term interest rates between partners i and j (*RATES$_{ij,t}$*) and the correlation of their cyclically-adjusted budget deficits as percentage of GDP (*BUDGET$_{ij,t}$*) are used respectively as proxies for monetary- and fiscal-policy convergence. To account for size (a country-varying characteristic), the real-GDP discrepancy between trading partners i and j (*INC$_{ij,t}$*) is also considered as explanatory variable. Larger countries may have a stronger influence on the shocks facing smaller countries in which case the *INC* variable will enter the regressions with a positive sign.[5]

TABLE 2	Supply Innovations			Demand Innovations		
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**
TRADE	2.853***	2.867***	4.115***	3.750***	3.755***	2.992***
	(0.851)	(0.831)	(0.747)	(0.724)	(0.714)	(0.614)
EURO		0.122***	0.123***		-0.085**	-0.079**
		(0.043)	(0.043)		(0.038)	(0.037)
INC			0.019***			-0.020***
			(0.007)			(0.006)
No. of observations	150	150	150	150	150	150
R-squared (adj.)	0.064	0.106	0.117	0.154	0.177	0.214
SER	0.271	0.265	0.267	0.233	0.23	0.224

Notes: OLS estimation; ***, ** and * indicate significance at 1%, 5% and 10% level respectively (standard errors in parenthesis). Dependent variable: correlations of supply/demand innovations versus Germany, France and the euro zone. For Luxemburg and Malta data are unavailable for the first sub-period 1996Q1-2000Q4.

The estimates in all three tables suggest that there are important links between trade flows and symmetry of shocks but the nature of these linkages differs depending on the source of the disturbance. Starting from Table 2, the results provide evidence for a strong positive association between increased overall trade and the cross-country correlation of demand-side as well as supply-side innovations: in both sets of columns ((a)-(c) and (d)-(f)) the estimated coefficient of the trade-intensity variable is highly significant (1% level) and also large in magnitude. From Table 2, however, one cannot identify the channels through which more intense trade affects shock correlations. To examine this, in Table 3 both overall trade intensity and intra-industry trade are introduced as explanatory variables. With both *TRADE* and *INTRA* included in the regressions, the *TRADE* variable can be taken to capture the effects of specialized trade, i.e. inter-industry trade.

   In the demand-shock regressions in columns (d)-(f) of Table 3, inclusion of the intra-industry-trade variable has little impact on the estimated trade-intensity coefficient. This coefficient remains positive and significant at 1%, and continues to be large in magnitude. By contrast, the coefficient of the intra-industry-trade variable is negative and significant at 5 percent (column (e)) or close to zero and insignificant (columns (d) and (f)), indicating that more intense intra-industry trade does not by itself imply greater cross-country symmetry of demand shocks. On the other hand, in the supply-shock regressions in columns (a)-(c) of Table 3, the intra-industry variable enters with a positive sign and is significant. The estimated coefficient of trade intensity, although it drops in magnitude relative to Table 2, also remains positive and significant at the 5% or 10% level in all specifications.

   These results suggest that international spillover effects, rather than specialization, dominate in the process through which more intense inter-industry trade affects the cross-country symmetry of supply-side shocks. Indeed, they provide support for a Frankel-Rose type of effect, rather than a Krugman-type effect, of increased trade on cross-country symmetry of business-cycles: the fact that the trade intensity variable is significantly and positively linked to supply-shock correlations even when intra-industry trade is included in the regressions implies that specialized trade (inter-industry trade) has on balance correlation-increasing effects through international spillovers.

   The results in Tables 2-3 also provide an explanation for the mixed evidence in the literature regarding the relationship between trade and cross-country cyclical output co-movements. They suggest that increased overall trade would tend to be strongly associated with greater cross-country synchrony of output fluctuations when the driving force of business cycles is a demand innovation. The association, while still positive, would be weaker if the main cause of business cycles is a demand innovation. The association, while still positive, would be weaker if the main cause of cycles is a supply-side innovation. At the same time, increased intra-industry trade would be associated with tighter cross-country output co-movements insofar as cycles are the result of mainly supply-side innovations. It would have little

TABLE 3	Supply Innovations			Demand Innovations		
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**
TRADE	2.026**	1.747*	2.463**	3.918***	4.085***	3.308***
	(0.996)	(0.977)	(1.241)	(0.852)	(0.850)	(1.041)
INTRA	0.134**	0.237***	0.172*	-0.067	-0.126**	-0.033
	(0.057)	(0.066)	(0.103)	(0.049)	(0.059)	(0.088)
EURO		0.117***	0.132***		-0.067*	-0.081**
		(0.040)	(0.043)		(0.037)	(0.037)
INC			0.007			-0.018**
			(0.010)			(0.009)
No. of observations	150	150	150	150	150	150
R-squared (adj)	0.079	0.123	0.128	0.151	0.164	0.209
SER	0.269	0.263	0.265	0.233	0.232	0.225

Notes: OLS estimation; ***, ** and * indicate significance at 1%, 5% and 10% level respectively (standard errors in parenthesis). Dependent variable: correlations of supply/demand innovations versus Germany, France and the euro zone. For Luxemburg and Malta data are unavailable for the first sub-period 1996Q1-2000Q4.

impact on cross-country synchrony of output fluctuations, and could even lead to less synchronization, when cycles are caused by demand disturbances.

Columns (b)-(c) and (e)-(f) of Tables 2-3 and Tables 4a-4b below report estimates when the policy-cooperation variables are included as additional regressors. Introducing the *EURO* variable increases the explanatory power of the regressions without affecting the results regarding the association between trade and shock symmetry. This variable is significant at 5% or 10% level in almost all specifications, suggesting that policy convergence in general among the EU member states, in addition to trade integration, has played a role in determining the extent of shock symmetry in Europe. The direction of the effect depends on the type of shock, with the results in Tables 2-4 suggesting that the circulation of the euro has caused supply innovations to become more correlated but has led to greater asymmetries of demand innovations.

TABLE 4a	Supply Innovations				
	(a)	**(b)**	**(c)**	**(d)**	**(e)**
TRADE	2.535**	2.566**	1.939*	2.622***	2.145**
	(1.046)	(1.296)	(1.046)	(1.118)	(1.037)
INTRA	0.152**	0.179*	0.143**	0.150**	0.231***
	(0.060)	(0.102)	(0.064)	(0.066)	(0.067)
EURO					0.112***
					(0.043)
INC		-0.006			
		(0.010)			
BUDGET	-0.058*	-0.074*		-0.062*	-0.029
	(0.032)	(0.039)		(0.036)	(0.038)
RATES			-0.002	-0.001	
			(0.002)	(0.002)	
No. of observations	144	144	144	144	144
R-squared (adj)	0.088	0.093	0.080	0.091	0.123
SER	0.268	0.270	0.270	0.268	0.262

Notes : OLS estimation; ***, ** and * indicate significance at 1%, 5% and 10% level respectively (standard errors in parenthesis). Dependent variable: correlations of supply/demand innovations versus Germany, France and the euro zone. Luxemburg and Malta are excluded due to non-availability of interest-rate and budget-deficit data.

The *RATES* variable enters with a minus sign in columns (c) and (d) of Tables 4a-4b suggesting that convergence of interest rates across Europe (reduced discrepancies of interest rates) has increased cross-country symmetry of both demand and supply shocks. But the effect is small and insignificant at 5 or 10 percent. This variable shows a large variance, as interest rates in the new EU member states had undergone large changes during the first sub-period considered here. As far as fiscal policy is concerned, the estimated coefficient of the budget-deficit variable in Tables 4a-4b is significant in most cases, an indication that the process of fiscal-policy convergence has been important in influencing shock similarity across Europe. Indeed, the estimates suggest that the process of fiscal-policy convergence

has increased symmetry of demand shocks in EU member states. The effect on symmetry of supply shocks is negative. The results regarding trade have remained unchanged overall.

Inclusion of the *INC* variable also does not change the results regarding trade. This variable is highly significant in column (c) of Table 2 and enters with a positive sign, confirming that large economies tend to influence the supply-side of smaller economies more strongly, regardless of the magnitude of trade flows. In column (c) of Table 3, the coefficient of the *INC* variable has the expected positive sign but is insignificant. This may be due to its strong correlation with *INTRA*: in our sample trading partners showing small GDP differences are also the ones that exhibit relatively high levels of intra-industry trade. The strong correlation between real-GDP differences and intra-industry trade may have also been the reason why with the inclusion of the *INC* variable in column (b) of Table 4a the *INTRA* variable is significant at 10% only. In the regression of column (f) of Tables 2-3 the coefficient of the *INC* variable is significantly negative while in column (b) of Table 4b it is close to zero and insignificant, something suggesting that as far as demand innovations are concerned, GDP differences have played no important role as a shock-transmission mechanism across Europe.[6]

TABLE 4b	Demand Innovations				
	(a)	**(b)**	**(c)**	**(d)**	**(e)**
TRADE	3.303***	3.315***	3.805***	2.927***	3.492***
	(0.895)	(1.096)	(0.995)	(1.052)	(0.905)
INTRA	-0.104**	-0.067	-0.057	-0.081	-0.138**
	(0.054)	(0.096)	(0.068)	(0.069)	(0.060)
EURO					-0.051
					(0.040)
INC		-0.008			
		(0.009)			
BUDGET	0.087**	0.066*		0.096**	0.070*
	(0.034)	(0.035)		(0.036)	(0.036)
RATES			-0.0003	-0.001	
			(0.006)	(0.006)	
No. of observations	144	144	144	144	144
R-squared (adj)	0.177	0.194	0.141	0.173	0.180
SER	0.233	0.231	0.237	0.236	0.235

Notes : OLS estimation; ***, ** and * indicate significance at 1%, 5% and 10% level respectively (standard errors in parenthesis). Dependent variable: correlations of supply/demand innovations versus Germany, France and the euro zone. Luxemburg and Malta are excluded due to non-availability of interest-rate and budget-deficit data.

IV. CONCLUSIONS

There is an ongoing debate in the literature regarding the impact of increased trade on business-cycle synchronization across national economies. Some authors argue that larger trade flows would be accompanied by greater specialization in production according to comparative advantage, thus resulting in less synchronized business cycles. Others stress that as trade increases, output co-movements across national economies would tend to become more synchronized through productivity and spending spillovers and through intra-industry trade. The existing empirical evidence is mixed, with some studies suggesting a strong positive link between intense trade ties and business-cycle synchronization while others indicate a weak association between increased trade flows and synchrony of business cycles.

Our results suggest that examining the role of trade in business-cycle synchronization by simply looking at its impact on cyclical cross-country co-movements of output can be misleading because the cause of fluctuations in output is not explicitly taken into account. Using data from the EU-27 countries and identifying demand and supply shocks in these economies during the period 1995Q1-2005Q4, we find evidence suggesting that trade strongly affects the international transmission of business cycles but the way in which this occurs depends on the source of the disturbance. Thus, as intra-industry trade becomes more dominant, synchrony of business cycles across Europe would increase if the main reason for them is supply-side innovations. If the driving force of cycles is a demand innovation, the effect can be just the opposite, with business-cycle fluctuations across Europe becoming less correlated.

On the other hand, our results suggest that increased overall trade, and thus higher bilateral trade intensities, has on balance correlation-increasing effects through international spillovers, via productivity and spending channels. Our results therefore provide evidence in support of a Frankel-Rose type of effect, rather than a Krugman-type effect, regarding the association between increased trade and cross-country business-cycle symmetry.

Our estimates also suggest that the circulation of the common currency has been accompanied by a fall in supply-shock asymmetries in Europe but has led to an increase in demand-shock asymmetries. By contrast, the process of fiscal-policy convergence has been associated with more symmetric demand shocks across the EU member states.

Acknowledgements

ENDNOTES

1. See also Gruben, Koo and Millis (2002), Otto, Voss and Willard (2001) and Traistaru (2004). See Baxter (1995) and Harrigan (2001) for a general discussion.

2. In some member states, including Ireland, the Netherlands and the UK, the rise in extra-EU trade in the late 90s exceeded that of intra-EU trade, resulting in a fall in the average ratio of intra-EU trade to total trade for the period 1996-2006 considered here.

3. A number of studies, following Bayoumi and Eichengreen (1993,1996), have employed the structural VARs methodology to identify demand and supply shocks across regions or countries. See, for example, Chamie, DeSerres and Lalonde (1994), Demertzis, Hughes-Hallett and Rummel (1998), Korhonen (2003), Fidrmuc and Korhonen (2003, 2004) and Frenkel and Nickel (2005).

4. Since a VAR model assumes stationary time-series, the Augmented Dickey-Fuller (ADF) test was applied to real-GDP and GDP-deflator data in each country and this suggested that the variables contained a unit root. So, for most countries, the first differences were stationary. Also, for most countries the Akaike and Schwarz criteria for lag structure indicated the inclusion of 3 to 4 lags. For all countries considered, long-run responses to the identified structural shocks were in accordance with economic theory. Short-run responses were also consistent with economic theory (i.e. in the short-run a positive demand shock increased real-GDP growth and inflation, while a positive supply shocks reduced inflation and increased output growth).

5. The possibility of simultaneity between increased trade and output co-movements is an issue in studies examining the relation between trade flows and business-cycle synchronization. To deal with this problem, most authors make use of instrumental variables. However, as pointed out by Grubel *et al.* (2002) and Inklaar *et.al.* (2005), instrumental variable estimation is not an adequate solution as the variables which, from gravity models, are commonly used as instruments for trade intensity (e.g. distance between the capitals of the trading partners, geographical adjacency and use of a common language) may also be reflecting the effects of other omitted variables, such as labor mobility and similarity of economic objectives. For this reason, and also to account for factors affecting business-cycle synchrony that are difficult to measure, Grubel *et. al.* (2002) included gravity variables directly into their regressions. For the same reason, Inklaar *et.al.*(2005) included policy variables, in addition to trade, in their regressions. Simultaneity is not a big problem here given that the upward trend of intra-EU trade that has been observed in recent years cannot be attributed to shocks. One can thus make the assumption that both the trade-intensity variable and the intra-trade variable are exogenous to the shocks considered (see also Babetskii (2005)). In any case, the estimation in Tables 1-3 attempts to take account of potential simultaneity by including policy-convergence variables which may themselves have affected symmetry of shocks, independently of trade flows, directly in the regressions.

6. Faustino and Leităo (2007), in the tradition of Greenaway *et. al.* (1995), distinguish between horizontal intra-industry trade (HIIT), i.e. intra-industry trade of a product of the same quality, and vertical intra-industry trade (VIIT), i.e. intra-industry trade of a similar product of different quality, stressing that the determinants of each type of trade may not be the same. Indeed, this is found to be the case for Portugal. Examining separately the effects on shock symmetry of HIIT and VIIT, in addition to trade intensity, would be an interesting extension of this paper.

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