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Abstract

This paper investigates the patterns and determinants of the co-movement of economic activity between regions in the European Union and the Euro Area. Using a panel data of 208 EU-15 regions over the period 1989-2002 we estimate a system of four simultaneous equations to analyse the impact of regional trade integration, specialisation and exchange rate volatility on correlations of regional growth cycles with the Euro area. We find that deeper trade integration with the Euro area had a strong direct positive effect on the synchronisation of regional growth cycles with the Euro area. Industrial specialisation and exchange rate volatility were sources of cyclical divergence. Industrial specialisation had however an indirect positive effect on growth cycles synchronisation via its positive effect on trade integration, while exchange rate volatility had an indirect additional negative effect on growth cycle correlations by reducing trade integration. Industrial specialisation had an indirect negative effect on growth cycle correlations by increasing the exchange rate volatility. The direct impact of trade integration on growth cycle correlations was stronger in the pre-EMU sub-period, while in the EMU sub-period, the negative direct effects of industrial specialisation and exchange rate volatility were stronger than in the pre-EMU sub-period. A distinct result is the positive and significant relationship between exchange rate volatility and growth cycle correlations in the pre-EMU sub-period, suggesting that over this period, country-specific exchange rate fluctuations acted as shock absorbers. Our analysis is relevant in the context of the discussion about the macroeconomic adjustment to region-specific shocks in the European Monetary Union.

Keywords: European Monetary Union, Business Cycles, Regional Growth

JEL Classification: E32, F33, F42

CONTENTS

1. Introduction

A common monetary policy has both benefits and costs. The benefits are gains in trade and growth due to the elimination of exchange rate uncertainty and the reduction of transaction costs; the costs are related to the possibility of increased volatility of economic activity due to losing independence over monetary and exchange rate policy as stabilisation tools. Since a common monetary policy can only address common shocks to the participating countries and regions, the presence of asymmetric shocks is associated with costs in terms of volatility of economic activity. Thus, the balance between benefits and costs depends on the occurrence of asymmetric shocks. Business cycle synchronisation is taken as an indication of a low probability of asymmetric shocks and a low cost of losing independence over monetary and exchange rate policies (Frankel and Rose, 1998; Alesina et al., 2002; Artis et al., 2003; Frankel, 2004).

The increased international economic integration has stimulated a growing academic and policy interest in the analysis of the synchronisation of business cycles and their international transmission. (Stockman, 1988; Canova and Marrinan, 1998; Kose, et al., 2003; Baxter and Kouparitsas, 2004; Bordo and Helbling 2003; Imbs, 2004). In particular, the impact of monetary integration on the business-cycle synchronisation has received increasing attention recently (Frankel and Rose, 1998; Artis et al., 2003, 2004; Barrios et al., 2003; Traistaru, 2004; Bergman, 2005).

Furthermore, the integration process is likely to have a stronger effect at regional level than at national level. This stronger effect can be expected because regions trade relatively more than countries and specialisation at regional level is higher than at national level (Krugman, 1993, Fatás, 1997). Thus, fluctuations of economic activity at regional level are expected to be more important than at national level which raises the question about the extent of synchronisation of regional business cycles. Barrios and de Lucio (2003) argue that the dynamics of regional business cycles may condition the adjustment of national economies to economic integration.

This paper identifies and explains the pattern of synchronisation of EU regional growth cycles with the Euro area. In particular, we analyse the role of trade integration, industrial specialisation and exchange rate volatility as determinants of regional growth cycle correlations with the Euro area over the period 1989-2002.

Up to date there are only a few studies which investigate the issue of regional growth cycle correlation in Europe. De Nardis et al. (1996) decomposed regional output growth and examined the correlation of the region-specific part with the home nation part as well as the pairwise correlation of the region-specific shares of output fluctuations. Similarly, Forni and Reichlin (2001) estimated a factor model of regional GDP growth with a European, a national and a region-specific component. Fatàs (1997) examined the correlation of regional employment growth with the national and European aggregate. Clark and Wincoop (2001) investigated the impact of differences in the production structure on bilateral correlations of employment growth rates. Barrios et al. (2003) analysed the impact of sectoral specialisation and exchange rate volatility on business-cycle correlations among eleven regions in the United Kingdom and six Euro area countries. Belke and Heine (2004) looked at regional employment cycles and examined as well the effect of industrial specialisation.

However, the scope of these studies remains limited. First, most of them looked at a fairly small group of European regions and a short observation period. By using richer datasets with respect to variables and additional time observations from the EMU Third Stage we go beyond the existing studies. Second, we extend the existing studies by testing the effect of a number of theoretically important determinants on region growth cycle correlations using improved econometric techniques to correct for the endogeneity and simultaneity in the underlying relationships.

This paper investigates the pattern and determinants of regional growth cycle correlations with the Euro area aggregate using data for all 208 NUTS 2 level EU 15 regions over the period 1989-2002. We analyse several key factors which can hypothetically influence the correlation of business cycles suggested by the above mentioned literature: trade integration, industrial specialisation and monetary policy co-ordination proxied with exchange rate volatility. Higher trade integration should lead to more correlated growth cycles. We examine to which extent industrial specialisation can explain growth cycle correlation, having in mind that dissimilar industrial structures lead to asymmetric propagation of shocks across regions in the case of a common, industry - specific shock. We use data on gross value added, disaggregated on seven NACE 2 digit branches, which is more detailed then in existing studies investigating the specialisation impact and allows us to test more adequately the effect of smaller differences in industry structures. Further, we test the impact of increasing monetary coordination, resulting in less exchange rate volatility and the introduction of the Euro, on the correlation of regional business cycles with the Euro area.

We test our hypotheses by estimating a model of simultaneous equations with panel data where trade integration, industrial specialisation and exchange rate volatility are considered simultaneously as explanatory factors of regional growth cycle correlations. As argued previously in the literature (Frankel and Rose 1998, Imbs 2004) these factors are likely to be endogenous, in the context of economic and monetary integration. Furthermore, due to their complex interactions, trade integration, industrial specialisation and exchange rate volatility are likely to have both direct and indirect effects on growth cycle correlations. In the simultaneous equations model these indirect effects are captured by separate structural equations for trade, industrial specialisation and exchange rate volatility. This statistical model addresses both the simultaneity and endogeneity in the relationships between growth cycle correlations, trade integration, industrial specialisation and exchange rate volatility. In order to capture the changes over time of these relationships we construct a panel data including five year rolling windows and control for time invariant unobserved region fixed effects.

The main findings of this paper are as follows. Deeper trade integration with the Euro area had a strong direct positive effect on the synchronisation of regional growth cycles with the Euro area. Industrial specialisation and exchange rate volatility were sources of cyclical divergence. Industrial specialisation had however an indirect positive effect on growth cycles synchronisation via its positive effect on trade integration, while exchange rate volatility had an indirect additional negative effect on growth cycle correlations by reducing trade integration. Industrial specialisation had an indirect negative effect on growth cycle correlations by increasing the exchange rate volatility.

The remainder of this paper is organized as follows: Section 2 discusses the theoretical framework of our analysis and derives hypotheses to be tested. Section 3 presents our model specification and estimation issues. Section 4 discusses summary statistics of regional growth cycle correlations and the main explanatory variables Section 5 presents the results of our econometric analysis and Sections 6 concludes.

2. Theoretical Framework and Related Literature

The theoretical framework for our analysis is the Optimum Currency Area (OCA) theory flowing from the seminal contributions of Mundell (1961), McKinnon (1963) and Kenen (1969). In the tradition of this literature, business cycle synchronisation is taken as a proxy for a low probability of asymmetric shocks and a low cost of forgoing monetary and exchange rate policies as stabilization tools. The main outcome of the OCA literature is the identification of the properties of an optimum currency area, including the mobility of labour, price and wage flexibility, economic openness, diversified production and consumption structures, similarity of inflation rates, fiscal integration and political integration.

Following the OCA literature we derive the following hypotheses to be tested in this paper. First, openness or economic integration results in higher correlated business cycles. Integration leads to increasing trade and investment flows and financial integration between the partners. Frankel and Rose (1998), Artis and Zhang (1997), Clark and Wincoop (2001) and Imbs (2004), among others, investigated the relationship between trade intensity and business cycle correlation for industrial countries and found that deeper trade integration was associated with higher business cycle correlations. Frankel and Rose (1998) postulate from their findings that members of a monetary union would *ex post* fulfil the OCA criteria since a common currency reduces transaction costs and thus leads to more trade and more business cycle synchronisation. Furthermore, Micco et al. (2003) find evidence of a positive and significant effect of the EMU on bilateral trade. This conjecture has led to a number of studies on the endogeneity of the OCA criteria (see De Grauwe and Mongelli 2005) confirming that monetary integration results in increased trade.

In this paper, we shall test the hypothesis that trade integration with the Euro area has a positive effect on the regional growth cycle correlations with the Euro area aggregate.

Second, following Kenen (1969), business cycle synchronisation will be lower in two economies if they have different economic structures. If that is the case, an external demand or supply shock will hit the two economies to a different extent. With differences in economic structures, e.g. if one is specialised in agricultural products while the other in manufacturing, a common, industry - specific shock results in asymmetric effects so that business cycles are less correlated. Similarly, if two economies have different energy intensity, then the more intensive energy user will suffer more from an oil price increase that can dampen output.

The empirical evidence for these arguments is inconclusive. Clark and Wincoop (2001) looked at various indicators of dissimilarity in economic structures (bilateral dissimilarity in industry sectors, manufacturing sectors, non-manufacturing sectors) and found that it can explain a low cross - country correlation of employment growth in the US and the EU. However, dissimilarity does not explain the low correlation of GDP growth. Imbs (2004) used a specialisation index with one-digit industries and two-digit manufacturing industries and could verify the argument of low business cycle correlation between countries which are highly specialised. Traistaru (2004) found that similarity of sectoral structures (6 sectors) has a positive effect, *ceteris paribus,* on business cycle correlations in the enlarged EMU. Barrios and De Lucio (2003) found that regions on the Iberian peninsula had more correlated employment cycles over the period 1975-1998 when having more similar sectoral structures (8 branches). Belke and Heine (2004) tested the impact of sectoral specialisation (6 sectors), measured with various indices, on bilateral regional employment cycles of 30 European regions over the period 1975-1996 and found that similarity was always linked to more business cycle correlation, irrelevant of the type of specialisation index applied. Barrios et al. (2003) found that, over the period 1966-1997, sectoral similarity (17 branches, goods and services) between eleven regions in the United Kingdom and six Euro area countries (Belgium, Germany, France, the Netherlands, Italy, and Ireland) fostered cyclical synchronisation.

In this paper we look at specialisation in manufacturing, distinguishing 7 different branches. Given the theoretical arguments on the role of specialisation for business cycle synchronisation, we test the hypothesis that regions, which are more dissimilar with the Euro area aggregate manufacturing industry structure, i.e. which are more specialized, have a lower business cycle correlation with the Euro area.

The third source of business cycle synchronisation, which we address here, is policy linkages. According to the real business cycle theory, policy coordination may have the effect to produce less business cycle variations among its members if such policy is itself considered as a source of business cycle fluctuation. If central banks have similar inflation targets and follow a similar exchange rate policy the output effect on their economies will be similar and should produce business cycle convergence. Furthermore, Mundell (1973a, 1973b) suggests that with flexible prices and wages and free capital mobility exchange rate movements may be a source of macroeconomic volatility, in particular in small, open economies. This view is, however, not uncontested, since the inability to conduct an independent monetary policy can mean an inadequate response to country specific shocks and may thus enforce asymmetry of business cycle fluctuations (Clark and Wincoop 2001, Fatás 1997).

Increasing monetary policy coordination took place between EU members after the creation of the ERM and the efforts of countries to move towards the EMU. As a result of policy coordination, exchange rate volatility between EU members decreased and exchange rates became eventually fixed between EMU members. Fatás (1997) showed that business cycle correlation of EU countries with the aggregate was higher after the foundation of the EMS than before. Artis and Zhang (1997) demonstrated that reduced exchange rate volatility corresponded to more business cycle synchronisation among European countries before the creation of EMU. Similarly, McKinnon and Schnabl (2003) showed that business cycle synchronisation among East Asian economies is linked to exchange rate fluctuations.

Based on these arguments we shall test whether regions that were subject to increasing monetary policy coordination, proxied with exchange rate stability, showed more business cycle correlation. To this purpose, we shall look at the volatility of the nominal exchange rates of national currencies vis-à-vis the Ecu/Euro.

3. Model Specification and Estimation Issues

In section 2 we proposed that business cycle correlations in the EU can be explained by trade intensity, specialisation and exchange rate volatility. Most of the existing studies look at the impact of different determinants of business cycle correlation using a single-equation approach. In contrast, we estimate the direct and indirect effects of these determinants using a system of simultaneous structural equations. This approach takes into account both the complex interlinks between business cycle correlations, trade intensity, industry specialisation and exchange rate volatility controlling for both simultaneity and endogeneity. We expect that a region shows a higher growth cycle correlation with the Euro area the more it trades with the Euro zone, the more similar is its industry structure and the less volatile is its exchange rate vis-à-vis the Ecu/Euro.

It is highly likely that the explanatory factors are interrelated with each other. First, neoclassical trade theory suggests that regions specialise when trading. To the extent that trade leads to more specialisation, the positive effect of trade on business cycle correlations should be lower. If trade is largely based on intra-industry trade, the positive effect on business cycle correlation should dominate (Fidrmuc 2004). Second, the previous literature on the endogeneity of OCA criteria tells us that trade will increase when monetary policies get more coordinated (Frankel and Rose 1998; De Grauwe and Mongelli 2005). Third, as suggested by Broda and Romalis (2003), exchange rate volatility between two economies may be related to the extent they trade with each other. Trade acts as an automatic stabilizer to the real exchange rate. Countries, which trade intensively, have similar consumption baskets. A price increase in a particular product will be passed to the trading partners so that the real exchange rate remains steady. We account for these types of endogeneity by estimating a simultaneous equations model. This allows us to model both direct and indirect effects of trade integration, industrial specialisation and exchange rate volatility on region growth cycle correlations.

Most of previous empirical studies have estimated cross-section models of business cycle correlations. In this paper we use a panel data of five year rolling windows over the period 1989-2002 allowing us to control for region-specific time invariant non-observed characteristics. Data and measures are explained in Appendix. We estimate the model for the full sample and two sub-periods corresponding to the pre-EMU (the first five time points with end year 1997) and EMU (the last five time points, end year 2002) periods. We also estimate the model separately for the Euro area and non-Euro area regions.

Our model specification contains 4 equations (Eq. 1 to 4) to be estimated simultaneously.[1]

$$CORRY_{it} = \alpha_1 TRADE_{it} + \alpha_2 SPEC_{it} + \alpha_3 EXCH_{it} + \alpha_4 R_i + \varepsilon_{1,it} \quad (1)$$

$$TRADE_{it} = \beta_1 SPEC_{it} + \beta_2 EXCH_{it} + \beta_3 I_{1,it} + \beta_4 R_i + \varepsilon_{2,it} \quad (2)$$

$$SPEC_{it} = \delta_1 TRADE_{it} + \delta_2 EXCH_{it} + \delta_3 I_{2,it} + \delta_4 R_i + \varepsilon_{3,it} \quad (3)$$

$$EXCH_{it} = \gamma_1 TRADE_{it} + \gamma_2 SPEC_{it} + \gamma_3 I_{3,it} + \gamma_4 R_i + \varepsilon_{4,it} \quad (4)$$

$$I_{1,it} \neq I_{2,it} \neq I_{3,it}$$

i = 1,...208 is the index of NUTS 2 regions in EU 15, t = 1,...10 is the time index. *CORRY* is the correlation between the region growth rate of real gross value added and the euro area growth rate. *TRADE* is the share of a region´s exports to the Euro area in the region's total gross value added. It measures the degree of economic integration, the importance of transmission of region-specific shocks through trade linkages. *SPEC* is an index of dissimilarity/specialisation of a region´s industrial structure with respect to the Euro area. It measures the importance of industry-specific shocks. *EXCH* is the exchange rate volatility and captures the importance of monetary policy induced shocks. The vector R contains dummy variables for the 208 regions. *CORRY*, *TRADE*, *SPEC* and *EXCH* are endogenous variables. $I_{1,it} \neq I_{2,it} \neq I_{3,it}$ are vectors that contain the exogenous determinants of equations (2), (3) and (4), They need to be different in order to identify the system. Each observation in *t* relates to a five-year rolling window. R_i is the region-specific fixed effect.

Equations (2), (3) and (4) contain the indirect effects on *CORRY* working via the endogenous variables. For example, *SPEC* has a direct effect on *CORRY* but also an indirect one through its effect on *TRADE*. The indirect effect implies that the total effect of TRADE consists of $\alpha_1\beta_1 + \alpha_1\beta_2 + \alpha_1\beta_3$.

Eq. (2) relates trade, specialisation and exchange rate volatility. Neoclassical trade theory suggests that economies producing specialised goods trade with each other. In contrast, the new trade theory suggests that economies with similar industry structures have intensive intra-industry trade. We expect a positive coefficient β_1 if higher inter- industry

[1] Imbs (2004) estimates a model of four simultaneous equations to identify the direct and indirect effects of trade intensity, industrial specialisation and financial integration on business cycle correlations using a cross section of 22 OECD countries. In contrast to Imbs, we use a panel data model allowing for time invariant unobserved region fixed effects.

specialisation leads to more trade. Exchange rate volatility leads to price changes and increases uncertainty and should therefore reduce trade. Empirically this argument was verified e.g. by Cushman (1983). If this applies in our context the coefficient β_2 should have a negative sign.

Finally, trade is determined by an exogenous variable contained in the vector I_1 .We consider the log of the product of the region real gross value added per capita and euro area gross value added per capita (*SUM)*. The choice of this exogenous variable is suggested by the arguments of gravity models, where the income level of two economies is a determinant of their bilateral trade volume. The variable *SUM* is correlated with *TRADE*. We should expect a positive coefficient of *SUM*, indicating that richer countries trade more. Gravity models use another important determinant of bilateral trade, namely the distance between two trading partners. Although we find that a region's trade is highly correlated with its distance to the EU centre, we cannot include this time invariant variable in our panel data model because it is time invariant.

Eq. (3) captures the argument that a region's specialisation evolves as it becomes more open to trade. When moving to more coordinated monetary policy, i.e. when the exchange rate volatility decreases, the ensuing higher trade integration leads to more specialisation. As an exogenous variable we include *GAP*, the log of the ratio between the region gross value added per capita and euro area gross value added per capita. Here we consider the argument of different stages in industrial development when an economy moves upward in its income position. Poorer economies would typically show a dominance of basic industries, whereas high tech products would be central in rich economies. Higher specialisation should therefore be related to an income gap[2]. In addition, we include a region's population size *POP* as exogenous variable, since larger regions are likely to host a full range of industries and thus should be less specialised.

The last equation (4) relates exchange rate volatility to trade and specialisation. The above argument, that increasing trade leads to similar price developments and hence less exchange rate volatility, should apply. Higher specialisation should coincide with differences in price development and thus more exchange rate fluctuations. As an exogenous variable contained in vector I_3, we consider the change in a region's interest rate differential with the Euro area. According to the interest parity theorem, a change in the interest parity would result in a variation of the exchange rate.

[2] Imbs and Wacziarg (2003) provide empirical evidence supporting this fact.

4. Descriptive Empirics

Table 1 shows summary statistics of the considered variables. Over the analysed period, region growth cycle correlations with the Euro area were on average 0.40. They were higher over the pre-EMU sub-period of the sample, 0.44, and for the Euro area regions, 0.51. Regions in the Euro area were more specialised than non-Euro area regions. The data also shows that the degree of industrial dissimilarity remained rather stable over the 1990s, increasing only slightly. This development partly confirms the predictions of Krugman (1993) who argued that specialisation grows with increasing integration. Trade integration with the Euro area was higher for the Euro area regions. Exchange rate volatility has decreased and was higher in the non-Euro area regions compared with the Euro-area regions.

Figure 1 shows the average growth cycle correlation of EU regions with the Euro area in different sub sets: in the full sample of regions, in regions in the Euro area, and in regions outside the Euro area. We note that region growth cycle correlations increased in both the Euro area and the rest of EU 15 in the period after the Maastricht Treaty announcement to create a monetary union, although there happened a sharp one-period drop in the mid 1990s. The average correlation for Euro area regions was 0.5, higher than that of regions outside the Euro area (below 0.2). In the latter group the correlation was even negative in the first years of the 1990s and improved only significantly for a short period after the Maastricht Treaty announcement.

Table 1: Summary statistics for main variables

Growth cycle correlation

	Obs	Mean	Std. Dev.	Min	Max
Full sample	2080	0.400	0.484	-0.982	0.998
Pre-EMU	1040	0.443	0.475	-0.946	0.997
EMU	1040	0.357	0.490	-0.982	0.998
Euro area	1600	0.507	0.417	-0.982	0.998
Non-euro area	480	0.046	0.524	-0.972	0.996

Industrial specialisation

	Obs	Mean	Std. Dev.	Min	Max
Full sample	2080	0.369	0.206	0.100	1.261
Pre-EMU	1040	0.367	0.203	0.101	1.261
EMU	1040	0.372	0.209	0.100	1.241
Euro area	1600	0.384	0.222	0.100	1.261
Non-euro area	480	0.322	0.134	0.108	0.794

Trade

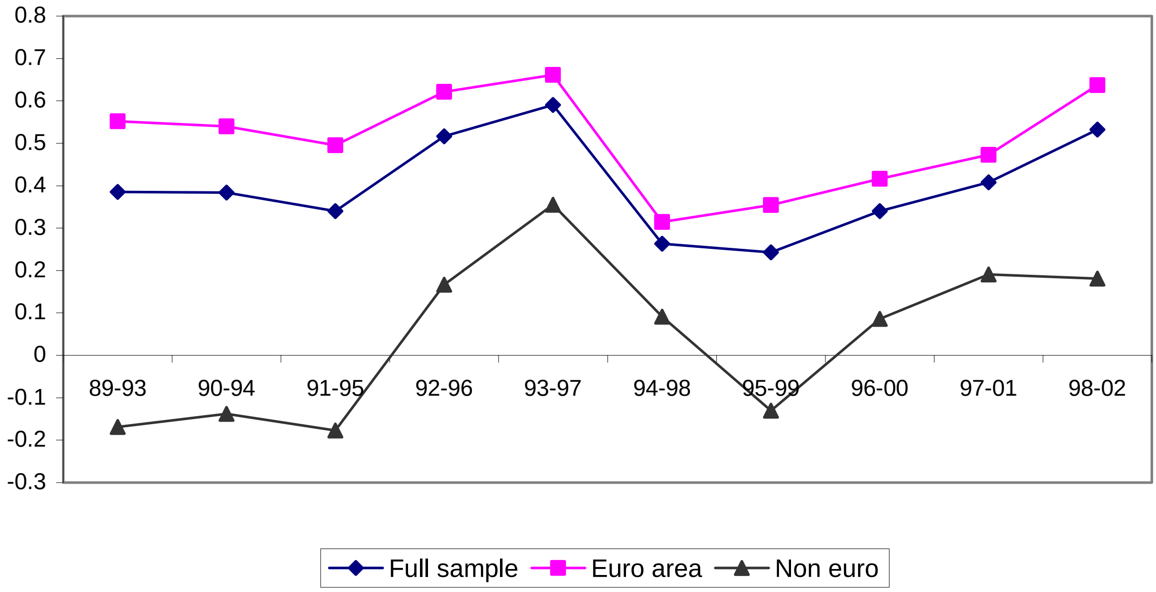
	Obs	Mean	Std. Dev.	Min	Max
Full sample	2080	0.152	0.106	0.011	0.859
Pre-EMU	1040	0.142	0.095	0.012	0.677
EMU	1040	0.163	0.116	0.011	0.859
Euro area	1600	0.153	0.119	0.011	0.859
Non-euro area	480	0.150	0.041	0.067	0.265

Exchange rate volatility

	Obs	Mean	Std. Dev.	Min	Max
Full sample	2080	4.528	4.014	0.186	18.591
Pre-EMU	1040	5.885	4.114	0.899	18.591
EMU	1040	3.171	3.409	0.186	11.831
Euro area	1600	3.672	3.910	0.186	18.591
Non-euro area	480	7.381	2.878	0.605	12.357

Source: Own calculations based on the European Regional Database, Cambridge Econometrics

Figure 1: Average business cycles correlations of EU regions with the Euro area

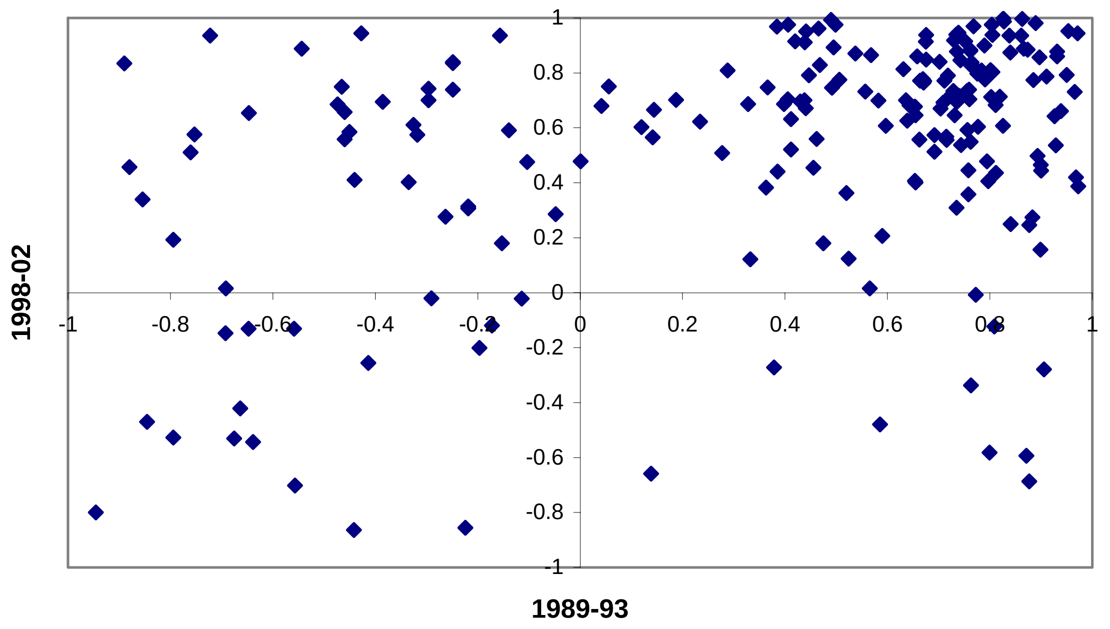


Source: Own calculations based on the European Regional Database, Cambridge Econometrics

Figure 2 shows the regional growth cycle correlations with the Euro area at the beginning and the end of the observation period. A major share of EU regions had a positively correlated cycle in the beginning and the end of the period (upper right hand quadrant). Only a few initially highly synchronized regions show lesser or negative correlations in the end of the period (upper and lower right hand quadrant). In contrast, a number of initially negatively correlated regions have reached high correlations (upper left hand quadrant). A small number of regions shows steady negatively related business cycles (lower left hand quadrant).

This summary statistics analysis suggests that the potential costs of monetary union have become smaller for the majority of EU regions, only in the case of 25 regions, growth cycle correlations with the Euro area has become worse.

Figure 2: Correlation of GVA growth rates between the EU regions and the Euro area



Source: Own calculations based on the European Regional Database, Cambridge Econometrics

5. Estimation Results

We first estimated the model for the full sample of regions, distinguishing between the whole period 1989-2002 and two sub-samples corresponding to the pre-EMU and EMU sub-periods[3] (results are shown in Table 2). Then the model was estimated separately for the Euro area regions and the non-Euro area regions (results are shown in Table 3).

The estimates in the primary equation of the simultaneous equations system (Eq. 1) shown in the first column in Table 3 indicate that, *ceteris paribus*, trade integration increases significantly regional growth cycle correlations while industrial specialisation and exchange rate volatility had a negative and significant effect. The growth cycle of European regions with highly specialized industrial structures was less correlated with the Euro area growth cycle. Further, the negative and significant coefficient of the exchange rate volatility suggests that *ceteris paribus*, country – specific exchange rate fluctuations were a source of cyclical divergence. The estimates for the two sub-periods confirm the relationships between regional

[3] The pre-EMU sub-period includes the first 5 time points over 1989-1997 and the EMU sub-period includes the next 5 time points over 1998-2002.

Table 2: Estimation results for different sub-periods.
Three-stage least squares regressions with region fixed effects

	Full period 1989-2002	Pre-EMU	EMU
Correlation (CORRY)			
TRADE	0.841*** (0.086)	1.111*** (0.139)	0.599*** (0.102)
SPEC	-0.281*** (0.014)	-0.199*** (0.022)	-0.297*** (0.017)
EXCH	-0.049*** (0.009)	0.039*** (0.015)	-0.148*** (0.012)
N	2080	1040	1040
R^2	0.390	0.419	0.447
Trade (TRADE)			
SPEC	0.044*** (0.005)	0.060*** (0.006)	0.038*** (0.007)
EXCH	-0.031*** (0.002)	-0.049*** (0.004)	-0.024*** (0.003)
SUM	0.012*** (0.000)	0.015*** (0.001)	0.011*** (0.000)
N	2080	1040	1040
R^2	0.675	0.702	0.663
Specialisation (SPEC)			
TRADE	0.977*** (0.083)	1.237*** (0.126)	0.800*** (0.108)
EXCH	0.063*** (0.009)	0.160*** (0.020)	0.038*** (0.012)
GAP	-0.476*** (0.024)	-0.354*** (0.036)	-0.521*** (0.034)
POP	-0.197*** (0.003)	-0.224*** (0.005)	-0.189*** (0.003)
N	2080	1040	1040
R^2	0.890	0.895	0.889
Exchange rate volatility (EXCH)			
TRADE	-1.896*** (0.131)	-0.290 (0.227)	-2.340*** (0.183)
SPEC	0.053*** (0.021)	-0.061** (0.028)	0.103*** (0.030)
INT	1.094*** (0.016)	0.934*** (0.021)	1.115*** (0.026)
N	2080	1040	1040
R^2	0.763	0.867	0.629

Note: Standard errors in parenthesis; *** significance at the 1 % level, ** significance at the 5 % level,
* significance at the 1 % level.

correlations, trade integration and industrial specialisation. The positive and significant coefficient for exchange rate volatility in the pre-EMU sub-period indicates that over this period, *ceteris paribus*, country-specific exchange rate fluctuations, as appearing during the ERM crisis, were not harmful for business cycle correlation but acted as shock absorbers and contributed to cyclical synchronisation.

The estimated structural equations for trade, specialisation and exchange rate volatility (Eq. 2-4) reveal additional information about the indirect effects of these business cycle determinants.

Industrial specialisation had a positive and significant impact on trade integration indicating that countries with different industrial structures with respect to the Euro area export more to the Euro area. This suggests that industrial specialisation had an indirect positive effect on business cycle correlation via trade. Exchange rate volatility had a significantly negative effect on trade, which can be explained by price variations and price uncertainty. This indicates that regions which are not following the tight margins of the ERM or which are not members of EMU have lower trade with the EU. Another interesting result is, that richer regions in the EU traded more. Again, these results are stable for the two sub-periods.

The equation of specialisation shows again the significant positive relation between trade and specialisation. Higher trade integration results in higher industrial specialisation consistent with the recent trade theories. Further, specialisation is positively related to higher exchange rate volatility. This result indicates that country - specific exchange rate fluctuations had an indirect negative effect on regional cycle correlations with the Euro area via industrial specialisation. The results also indicate that *ceteris paribus* specialisation is negatively related with the income gap. Poor regions with a large negative *GAP* are more specialized. As expected, smaller regions are more specialised. The signs and significance of the coefficients in the specialisation equation are the same in the two sub periods.

In the exchange rate volatility equation, higher trade integration is related to lower exchange rate volatility in line with the results obtained in the trade equation, indicating that country-specific exchange rate fluctuations had an indirect negative effect on regional cycle correlations with the Euro by reducing trade. Regional industrial specialisation was positively related to country-specific exchange rate fluctuations except in the pre-EMU sub-period suggesting that regional specialisation had an indirect negative effect on regional cycle correlations. Furthermore, changes in the interest rate differential are positively related with exchange rate volatility. Regions, which experienced large interest rate changes, also faced higher exchange rate fluctuations.

In the next step, we estimated the model for different groups of EU regions, namely for regions in the Euro area and for those not participating in the EMU (the results are shown in Table 3).

The results for the group of *Euro area regions* are fairly similar to the results for the full sample. For equations (2) – (4) the significant coefficients are of the same sign and almost of the same size. However, in the principal equation, the sign of the exchange rate volatility coefficient is positive and significant. These results suggest that the common monetary policy (and less exchange rate volatility) did not respond to region-specific shocks which were important. Once again, trade was the principal source for increasing growth cycle correlation in the Euro area. The coefficient for *SPEC* is negative and statistically significant. This result indicates that a region in the Euro area that is highly specialized would show a smaller business cycle correlation with the Euro area. To respond to region-specific shocks, policy makers should focus on market-based adjustment mechanisms including wage and price flexibility and risk sharing through financial integration and fiscal transfers.

Our hypotheses can not be confirmed for the group of regions not participating in the Third Stage of the EMU (regions from Denmark, Sweden and United Kingdom). In the principal equation, no coefficient is significant. This means that trade integration, industrial specialisation and exchange rate volatility are not significant determinants of regional growth correlations with the Euro area, shown also by the very low value of the R^2.

The estimates of the trade equation reveal interesting relationships. In contrast to the results for the full sample and the Euro area regions, in the case of non-Euro area, regions industrial specialisation is significantly (at the 10% level) negatively related with trade integration with the Euro area. This result indicates that regions with industrial structures similar to the Euro area trade more. The positive coefficient of *SUM* shows that the higher the regional income the higher the trade with the Euro area. Hence, intra-industry trade of rich regions with the EU seems to be pronounced. Furthermore, since the estimates indicate that country-specific exchange rate fluctuations are positively related with trade with the Euro area, exchange rate fluctuations do not seem to play a role for that type of trade.

Table 3: Estimation results for different samples.
Three-stage least squares regressions with region fixed effects

	Full sample 208 regions (EU 15)	**Euro area 160 regions (EU 15)**	**Non-Euro area 48 regions (EU 15)**
Correlation (CORRY)			
TRADE	0.841*** (0.086)	0.773*** (0.077)	0.192 (0.503)
SPEC	-0.281*** (0.014)	-0.307*** (0.013)	0.030 (0.055)
EXCH	-0.049*** (0.009)	0.068*** (0.009)	0.028 (0.039)
N	2080	1600	480
R^2	0.390	0.576	0.004
Trade (TRADE)			
SPEC	0.044*** (0.005)	0.059*** (0.006)	-0.009* (0.005)
EXCH	-0.031*** (0.002)	-0.042*** (0.003)	0.013*** (0.004)
SUM	0.012*** (0.000)	0.013*** (0.000)	0.006*** (0.000)
N	2080	1600	480
R^2	0.675	0.629	0.929
Specialisation (SPEC)			
TRADE	0.977*** (0.083)	1.096*** (0.083)	0.218 (0.390)
EXCH	0.063*** (0.009)	0.101*** (0.010)	0.181*** (0.035)
GAP	-0.476*** (0.024)	-0.551*** (0.025)	0.222*** (0.061)
POP	-0.197*** (0.003)	-0.198*** (0.002)	-0.216*** (0.012)
N	2080	1600	480
R^2	0.890	0.892	0.949
Exchange rate volatility (EXCH)			
TRADE	-1.896*** (0.131)	-1.808*** (0.137)	2.045*** (0.429)
SPEC	0.053*** (0.021)	0.086*** (0.023)	0.028 (0.046)
INT	1.094*** (0.016)	0.999*** (0.018)	0.959*** (0.040)
N	2080	1600	480
R^2	0.763	0.683	0.949

Note: Standard errors in parenthesis; *** significance at the 1 % level, ** significance at the 5 % level, * significance at the 1 % level.

In the specialisation equation, the exchange rate volatility and the income differential with the euro area are positively correlated with industrial specialisation. The positive relation between the income gap and specialisation stands in contrast to the result for the Euro area and suggest that in the non-Euro area specialisation does not increase when the income gap is largely negative. On the contrary, specialisation increases in rich regions. Further, the smaller the region size, the more specialised the non-euro area regions were.

The exchange rate volatility equation shows that trade is positively and significantly related with the exchange rate volatility, a result, which mirrors the relation found in equation (2). In line with the previous results, the change in interest rate differentials is positively and significantly associated with the exchange rate volatility.

Figure 3 and Table 4 summarize the key results of our analysis. Figure 3 shows the main relationships, which we found in our estimation for the full sample. Table 4 shows the implied elasticities from our estimation in the full sample.

The calculated elasticities indicate that trade is the most important factor that drives region growth cycle correlation with the Euro area. If the trade share increases by 10 percentage points, the correlation of growth will increase by 0.08. A quarter of the positive trade effect is directly counteracted by the negative effect of specialisation.

From equations (2), we see that, when the specialisation of a region is 10 % higher, its trade share increases by 0.4 percentage points. Regions with higher exchange rate volatility trade less. If volatility is 10 % higher then trade decreases by 0.3 percentage points.

The elasticities from equation (3) indicate that a 10 % increase in the trade ratio manifests in an upward move of the specialisation index by 0.19, mirroring the results in equation (2). Trade is the most important factor behind specialisation. Further, the elasticities show that poorer and smaller regions are more specialised. However, the impact is subordinate related to the trade effect on specialisation.

The elasticities from equation (4) indicate that intensive trade is likely to reduce exchange rate volatility to a major extent. The second most important determinant of exchange rate volatility is changes in the interest rate differential. A reduction in the interest rate differential reduced exchange rate fluctuations in the EU at the same magnitude.

In summary, trade was the key factor for the synchronisation of regional growth cycles with the Euro area. Trade and specialisation evolved at the same time. Increasing trade fostered specialisation which, in turn, lead to more trade. If European regions trade intensively, the negative impact of specialisation on growth cycle correlation is balanced by the transmission of shocks via trade.

Table 4: Estimation results – Marginal effects

Estimation results: implied elasticities	**(full sample)**
elasticities growth cycle correlation	
	change growth correlation coefficient
trade to GVA share: + 10%	+ 0.084
specialisation: + 10% (= index + 0.2)	- 0.028
exchange rate volatility: + 10%	- 0.005
elasticities trade share (trade in % GVA)	
	change trade in % GVA
specialisation: + 10% (= index + 0.2)	+ 0.44 % points
exchange rate volatility: + 10%	- 0.31 % points
elasticities specialisation	
	change in specialisation (absolute)
trade to GVA share: + 10%	+ 0.195
exchange rate volatility: + 10%	+ 0.013
income GAP larger by 10% points	+ 0.095
population: + 10%	- 0.039
elasticities exchange rate volatility	
	change st.d. exchange rate in % points
trade to GVA share: + 10%	- 18.96
specialisation: + 10% (= index + 0.2)	+ 0.53
interest rate differential: + 10% points	+10.94

To the extent that monetary policy coordination in the EU increased trade it had a positive effect on business cycle correlations. Income differences coincided with more specialisation and fostered growth cycle divergence. Rich regions traded more intensively with the Euro area and consequently showed more correlated growth cycles. Higher trade can not only directly contribute to business cycle correlation, but also indirectly via its positive effect to lower exchange rate fluctuations.

6. Conclusions

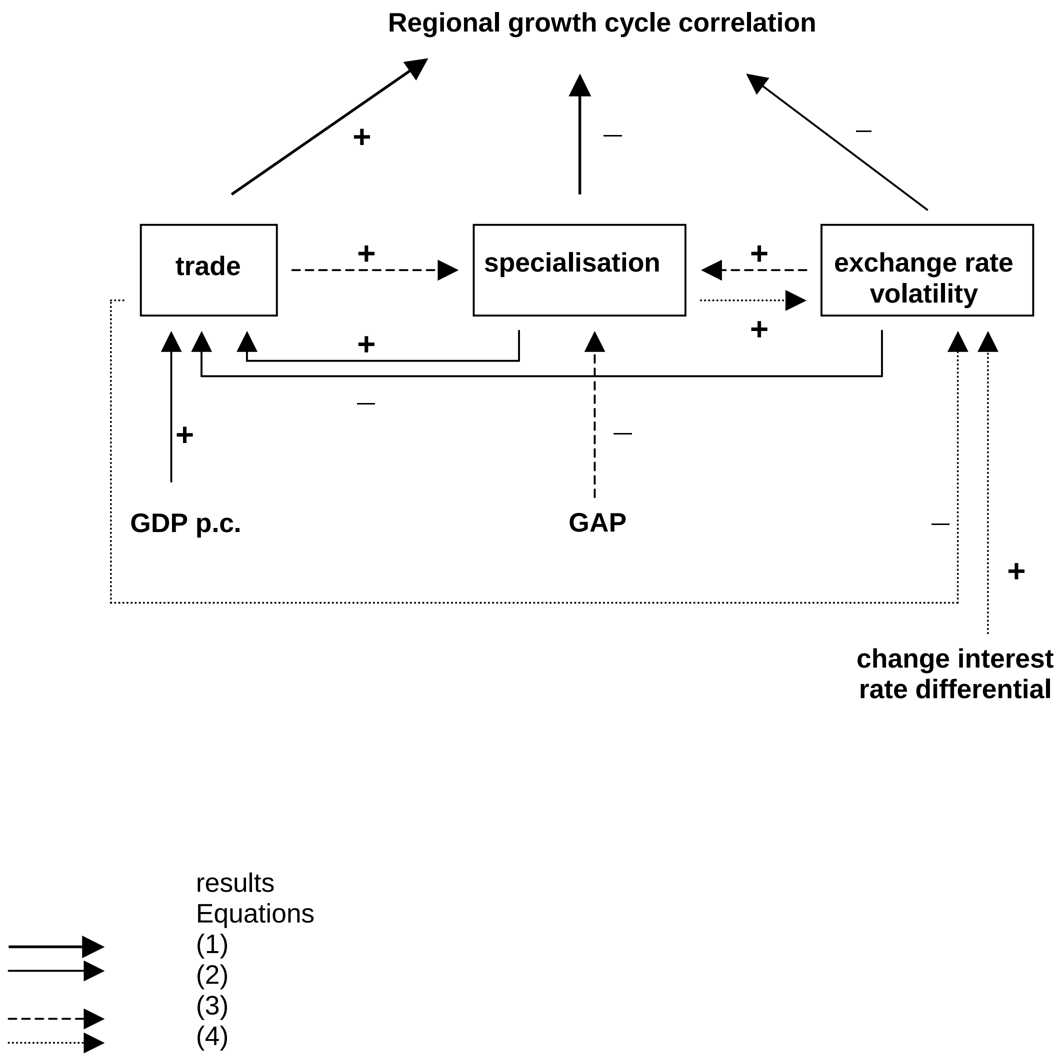
In this paper we investigated the patterns and determinants of the growth cycle correlations between EU regions and the Euro area. Using a panel data over the period 1989-2002 we estimated a system of four simultaneous equations and analysed the role of trade integration, industrial specialisation and exchange rate volatility in explaining the regional business cycle correlations with the Euro area.

Over the analysed period, region growth cycle correlations with the Euro area were on average 0.40. They were higher over the pre-EMU sub-period of the sample, 0.44, and for the Euro area regions, 0.51. Industrial specialisation, - relative to the Euro area average -, has become more pronounced in the Euro area than in the rest of the EU. Euro area regions achieved a higher trade integration than other regions. Exchange rate volatility has generally decreased in the EU, but was higher in the non-euro area regions compared with the Euro-area regions.

The main results of our econometric analysis of growth cycle correlations between EU regions and the Euro area are as follows (see Figure 3).

Deeper trade integration with the Euro area had a strong direct positive effect on the synchronisation of regional growth cycles with the Euro area. Industrial specialisation and exchange rate volatility were sources of cyclical divergence. Industrial specialisation had however an indirect positive effect on growth cycles synchronisation via its positive effect on trade integration, while exchange rate volatility had an indirect additional negative effect on growth cycle correlations by reducing trade. Industrial specialisation had an indirect negative effect on growth cycle correlations by increasing the exchange rate volatility. The direct impact of trade integration on growth cycle correlations was stronger in the first sub-period, 1989-1997, while in the EMU period the negative direct effects of industrial specialisation and exchange rate volatility were stronger than in the first sub-period. A distinct result is the positive and significant relationship between exchange rate volatility and growth cycle

Figure 3: Estimation results: direct and indirect effects on regions growth cycle correlations (full sample)



correlations in the pre-EMU period, suggesting that over this period, country-specific exchange rate fluctuations acted as shock absorbers.

The close monetary policy co-ordination in the ERM and common monetary policy after the adoption of the euro justify the analysis of the growth cycle correlations with the Euro area separately for the Euro area and the rest of the regions. In the case of the Euro area regions the only distinct result in comparison with the analysis for the full sample is the direct positive and significant effect of exchange rate volatility on growth cycle correlations. To the extent that region-specific shocks were more important than monetary policy shocks this finding suggests that the common monetary policy contributed to region growth cycle divergence.

The pattern of growth cycle correlations for the non-Euro area regions is distinct. Neither trade integration nor industrial specialisation nor exchange rate volatility appeared to have direct significant effects on the growth cycle correlations. Rich regions in the non-Euro area maintain intensive intra-industry trade relations with the Euro area, which is not hindered by exchange rate fluctuations.

Our results suggest a number of relevant policy implications for the EMU and EMU enlargement. First and foremost, promoting trade integration with the Euro area is likely to foster regional growth cycle convergence and thus to lower the probability of regions' exposure to asymmetric shocks. Real income convergence with the Euro area average is expected to increase trade integration and at the same time affect the pattern of industrial specialisation towards more similarity, which in turn will increase region growth cycle convergence with the Euro area. Furthermore, in addition to reducing exposure to asymmetric shocks, policy makers should focus on increasing labour and product market flexibility as adjustment mechanisms and financial integration as risk-sharing mechanism to insure against asymmetric shocks.

Appendix: Data and Measurement

We describe below the variables used in this paper and their data sources.

CORRY: Growth cycle correlation

The growth cycle correlations are calculated using the first difference of the logarithm of annual real gross value added for regions and the Euro area. Data is taken from the European Regional Database, Cambridge Econometrics.

SPEC: Industrial specialisation index

The industrial specialisation index is calculated using regional gross value added disaggregated on seven industry sectors: mining and energy; food, beverages and tobacco; textiles and clothing; fuels, chemicals, rubber and plastic products; electronics; transport equipment; other manufacturing. If s_{ij} is the share of sector *j* in region *i* and $s_{Euro,j}$ is the share of sector *j* in the Euro area, then the specialisation index of region *i* is:

$$SPEC_i = \sum_{j=0}^{N} \left| s_{ij} - s_{Euro,j} \right|$$

This index takes values from 0 to 2. A value equal to 0 indicates complete similarity of industrial structure, and 2 total specialisation. The variable is included in the model in logs. Data is taken from the European Regional Database, Cambridge Econometrics.

TRADE: Regional exports to the Euro area as share of gross value added

TRADE is proxied by the following calculation: Input series are national exports by NACE 2 digits provided by the WIFO-World Trade Databank (based on UN trade statistics) and regional gross value added by NACE 2 digits from the European Regional Database, Cambridge Econometrics. National exports of a product sector j are divided onto regions according to the region's gross value added share of sector j in total national gross value added of sector share. Total regional exports is then the sum of exports in all sectors j,…N.

EXCH: Exchange rate volatility

Starting data is monthly market exchange rates of national currencies per unit of Ecu/Euro from IMF, International Financial Statistics. Volatility is the standard deviation of the exchange rate index. The variable is taken in logs.

INT: Change in the difference between a region's real interest rate and the Euro area interest rate

This variable is calculated using short-term national interest rates from IMF, International Financial Statistics. Regional real interest rates are obtained by subtracting regional remuneration growth, - used to proxy regional inflation -, from the national interest rate. Regional nominal remuneration is taken from the European Regional Database, Cambridge Econometrics.

GAP: Ratio of a regions´s gross value added per capita and Euro area gross value added per capita

Regional gross value added per capita, taken in logs, from the European Regional Database, Cambridge Econometrics. Cambridge Econometrics**. GAP** > 0 for rich regions, GAP < 0 for poor regions.

SUM: Log of product of regional and Euro area gross value added per capita

Regional gross value added per capita from the European Regional Database, Cambridge Econometrics.

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