This draft 16 May 2006

Regional Growth Cycle Convergence in the European Union*

Gabriele Tondl[a] and Iulia Traistaru-Siedschlag[b]

[a] Europainstitut, University of Economics and Business Administration Vienna
Althanstrasse 39-45, Vienna, Tel.: +43-1-31336 5566; Fax: +43 1 31336 758
E-mail: gabriele.tondl@wu-wien.ac.at

[b] Economic and Social Research Institute, Dublin and Center for European Integration Studies, University of Bonn
4 Burlington Road, Dublin 4; Tel.:+353-1-667 1525; Fax: +353-1-668 6231;
E-mail: iulia.traistaru@esri.ie

* We thank Fritz Breuss, David Bell and participants at the European Regional Science Association Congress 2005 and the Irish Economic Association 2006 for helpful comments and suggestions. Iulia Traistaru-Siedschlag gratefully acknowledges financial support from the 5th RTD Framework Programme of the European Communities (research project No. HPSE-CT-2002-00118)

Abstract

This paper investigates the patterns and determinants of the co-movement of economic activity across regions in the European Union. 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, specialization 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

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 synchronization 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 and Barro and Tenreyro, 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 synchronization of business cycles and their international transmission. (Stockman, 1988; Canova and Marrinan, 1998; Kose, Otrock and Whiteman, 2003; Baxter and Kouparitsas, 2004; Bordo and Helbling 2003; Imbs, 2004). In particular, the impact of monetary integration on the business-cycle synchronization has received increasing attention recently (Frankel and Rose, 1998; Artis et al., 2003, 2004; 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 specialization 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 synchronization 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 synchronization of EU regional growth cycles with the Euro area. In particular, we analyse the role of trade integration, industrial specialization 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. 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 II 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 should permit 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 introduces our data set and measures. Section 5 discusses summary statistics of regional growth cycle correlations and the main explanatory variables. Section 6 presents the results of our econometric analysis and Sections 7 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 synchronization 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 synchronization. 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 synchronization 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 (2003) 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 in the period 1975-1996 and found that similarity was always linked to more business cycle correlation, irrelevant of the type of specialisation index applied.

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 synchronization, 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 synchronization 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. 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 synchronization among European countries before the creation of EMU. Similarly, McKinnon and Schnabl (2003) showed that business cycle synchronization 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. For that 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 correlation 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 specialize 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 in selecting 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.

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

$$CORRY_{it} = a_1 TRADE_{it} + a_2 SPEC_{it} + a_3 EXCH_{it} + a_4 R_i + e_{1,it} \qquad (1)$$

$$TRADE_{it} = b_1 SPEC_{it} + b_2 EXCH_{it} + b_3 I_{1,it} + b_4 R_i + e_{2,it} \qquad (2)$$

$$SPEC_{it} = d_1 TRADE_{it} + d_2 EXCH_{it} + d_3 I_{2,it} + d_4 R_i + e_{3,it} \qquad (3)$$

$$EXCH_{it} = g_1 TRADE_{it} + g_2 SPEC_{it} + g_3 I_{3,it} + g_4 R_i + e_{4,it} \qquad (4)$$

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

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 gross value added share of a region´s exports to the Euro area. It measures the degree of economic integration, the importance of transmission of region-specific shocks through trade linkages. *SPEC* is an index of similarity/specialization 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.

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 $a_1 b_1 + a_1 b_2 + a_1 b_3$.

[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.

Eq. (2) relates trade, specialisation and exchange rate volatility. Neoclassical trade theory suggests that economies producing specialized 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 b_1 if higher inter- industry 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 b_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 accounts for 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 center, we cannot include this time invariant variable in a panel data model.

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 real 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 specialized.

The last equation (4) relates exchange rate volatility to trade and specialisation. The above argument, that increasing trade leads to similar price development 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. Data and Measurement

Variables definition and data sources are given below.

CORRY: correlation of region´s i real gross value added growth and the Euro area growth

Real gross value added is from Cambridge Econometrics European Regional Database. Time observations relate to five year moving averages.

SPEC: industrial specialisation of region i relative to the Euro area

Specialisation index is calculated based on regional gross value added of seven industry sectors: mining and energy; food, beverages and tobacco; textiles and clothing; fuels, chemicals, rubber and plastic products; electronics; transport equipment; and other manufacturing from Cambridge Econometrics. 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:

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

Index runs from 0 to 2. 0 indicates complete similarity of industrial structure, 2 total specialisation. Variable is taken in logs. Time observations relate to five year moving averages.

TRADE: Regional export with Euro area as share of gross value added

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 Cambridge Econometrics. National exports of a product sector j are devided onto regions according to the region´s gross value added share of sector j in total national GVA of sector share. Total regional exports is then the sum of exports in all sectors j,…N. Time observations relate to five year moving averages.

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 in 5 year rolling windows. Variable is taken in logs.

INT: change in the difference between a region´s real interest rate and the Euro area interest rate

Data is calculated from 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 from Cambridge Econometrics. Time observations relate to five year moving averages.

POP: regional population

Regional population is from Cambridge Econometrics. Variable is taken in logs. Time observations relate to a five year moving averages.

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 Cambridge Econometrics**.** Time observations relate to five year moving averages. Value > 0 for rich regions, value < 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 Cambridge Econometrics**.** Time observations relate to a five year moving averages.

5. Descriptive Empirics

Table 1 summarizes the development 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 are more specialized than non-Euro area regions. The data also shows the degree of dissimilarity remained rather stable over the 1990s, increasing only slightly. This development partly confirms the projections of Krugman (1993) who considered 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.

Insert Table 1 here

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. With 0.5 the average correlation of Euro area regions is distinctly higher than that of regions outside the Eurzone (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.

Insert Figure 1 here

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).

Insert Figure 2 here

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.

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).

Insert Table 2 here

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 specialization 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 cycle correlations, trade integration and industrial specialization. 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 synchronization.

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

Industrial specialization 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 specialization 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 specialization shows again the significant positive relation between trade and specialization. Higher trade integration results in higher industrial specialization consistent with the recent trade theories. Further, specialization 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 specialization. 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

[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.

expected, smaller regions are more specialised. The signs and significance of the coefficients in the specialisation equation are the same in the two subperiods.

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 a 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).

Insert Table 3 here

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 coefficient sign of exchange rate volatility 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 significantly negative. This indicates that a region in the Euro area which 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 specialization is significantly (at the 10% level) negative related with trade integration with the Euro area. This 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.

In the specialisation equation, the exchange rate volatility and the income differential with the euro area are positively associated with industrial specialisation. The positive relation between the income gap and specialization 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 significantly positively 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 % 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 are 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 synchronization of regional growth cycles with the Euro area. Trade and specialisation evolved at the same time. Increasing trade provoked specialisation and the same, 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.

To the extent monetary policy coordination in the EU increased trade it had a positive effect on business cycle correlations. Income differences coincided with more specialisation and were therefore not good for business cycle correlation. 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).

Insert Figure 3 here

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 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 the regional growth cycles 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.

References

Artis, M., A. B. Galvao, and M. Marcellino (2003) "The Transmission Mechanism in a Changing World", *CEPR Discussion Paper* No. 4014. CEPR, London

Artis, M., M. Marcellino, T.Proietti (2004). Characterising the business cycles for accession countries. Discussion Paper No. 4457. CEPR, London.

Artis, M. and W. Zhang (1997). "The International Business Cycle and the ERM: Is there a "European" Cycle?, *International Journal of Finance and Economics*, 2:1-6

Alesina, A., R. Barro and S.Tenreyro, 2002 Alesina, A., R. Barro, and S. Tenreyro (2002) "Optimal Currency Area", *NBER Working Paper* No. 9702

Barrios, S. and J. de Lucio (2003). "Economic Integration and Regional Business Cycles: Evidence from the Iberian Regions", *Oxford Bulletin of Economics and Statistics*, 65, 497-515

Barrios, S., M. Brülhart, R. Elliott, M. Sensier (2003)."A Tale of Two Cycles: Co-Fluctuations Between UK Regions and the Euro Zone," *Manchester School*, Blackwell Publishing, vol. 71(3), 265-292.

Baxter, M. and M. Kouparitsas (2003). "Trade Structure, Industrial Structure, and International Business Cycles", *American Economic Review*, May, 51-56

Belke, A. and J. A. Heine (2004). "Specialisation Patterns and the Synchronicity of Regional Employment Cycles in Europe", IZA Discussion Paper No. 1439, Bonn

Bergman, M. (2005) "How Synchronized are European Buisness Cycles?, in L. Jonung (ed.), Proceedings of the 2004 First Annual DG ECFIN Research Conference on "Buisness Cycles and Growth in Europe", *European Economy* No. 227

Bordo, M. and T. Helbling (2003) "Have National Business Cycles Become More Synchronized", *NBER Working Papers* No. 10130

Broda, Ch. and and Romalis, J. (2003), Identifying the relationship between trade and exchange rate volatility, Federal Reserve Bank N.Y./NBER, January 2003.

Clark, T.E., E. van Wincoop (2001) "Borders and Business Cycles", *Journal of International Economics*, 55, 59-85

Cushman, D.O. (1983) "The Effects of Real Exchange Rate Risk on International Trade", *Journal of International Economics*, 15, 45-63.

De Grauwe, P. and Mongelli, F. (2005) "Endogeneities of Optimum Currency Areas. What Brings Countries Sharing a Single Currency Closer Together?", *ECB Working Paper* No. 468

De Nardis, S., A. Goglio and M. Malgarini (1996), *Weltwirtschaftliches Achiv*, vol. 132(2), 197-214.

Fatás, A. (1997). “EMU: Countries or Regions? Lessons from the EMS Experience”, *European Economic Review*, vol. 41, 743-751.

Fidrmuc, J. and I. Korhonen (2003). Similarity of supply and demand shocks between the euro area and the CEECs. *Economic Systems* 27, 313-334.

Fidrmuc, J. (2004). “The endogeneity of the optimum currency area criteria, intra-industry trade, and EMU enlargement”. *Contemporary Economic Policy* 22, 1-12.

Forni, M. and L. Reichlin (2001). "Federal policies and local economies: Europe and the US," *European Economic Review*, vol. 45(1), 109-134.

Frankel, F. and A. Rose (1998) “The Endogeneity of the Optimum Currency Area Criteria”, *The Economic Journal*, 108, 1009-1025

Imbs, J. (2004) “Trade, Finance, Specialization and Synchronization”, *Review of Economics and Statistics*, 86(3), August

Imbs, J. and R. Wacziarg (2003) “Stages of Diversification”, *American Economic Review*, 93(1), March

Kenen, P. (1969) “The Theory of optimum Currency Areas: An Eclectic View”, in Mundell, R. and A. K. Swoboda (eds.) *Monetary Problems of the International Economy,* University of Chicago Press, 41-60

Krugman, P. (1993) “Lessons of Massachusetts or EURO AREA”, in T. Giavazzi, and F. Torres, (eds.), *Adjustment and Growth in the Economic and Monetary Union in Europe*, New York: Cambridge University Press, 241-261

Kose, A., C. Otrock and C. Whiteman (2003) “International Business Cycles: World, Region, and Country-Specific Factors”, *American Economic Review*, Vol.93(4), 1216-1239

McKinnon, R. (1963) “Optimum Currency Areas”, American Economic Review, vol. 52, 717-725

McKinnon, R. and G. Schnabl (2003), Synchronized business cycles in East Asia and fluctuations in the Yen/Dollar exchange rate, *World Economy*, vol. 26, August, pp. 1067-1088.

Mundell, R. (1961) “A Theory of Optimum Currency Area”, *American Economic Review*, vol. 51, 657-665

Stockman, A. (1988). “Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries”, *Journal of Monetary Economics*, March/May, 21(2/3), 387-409

Traistaru, I. (2004). “Transmission channels of business cycles synchronization in an enlarged EMU”. Working Paper No. B04-18. Center for European Integration Studies, ZEI, University Bonn.

Table 1: Summary statistics of variables

Business cycle correlations

	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 integration

	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

Interest rate differential

	Obs	Mean	Std. Dev.	Min	Max
Full sample	2080	4.516	3.711	0.496	35.762
Pre-EMU	1040	5.668	4.297	0.650	35.762
EMU	1040	3.364	2.537	0.496	19.036
Euro area	1600	4.171	4.062	0.496	35.762
Non-euro area	480	5.668	1.723	1.721	8.919

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

	Full sample	**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
Specialization (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 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

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

	Full sample		Euro area		EU non euro area	
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	
Specialization (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 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	

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

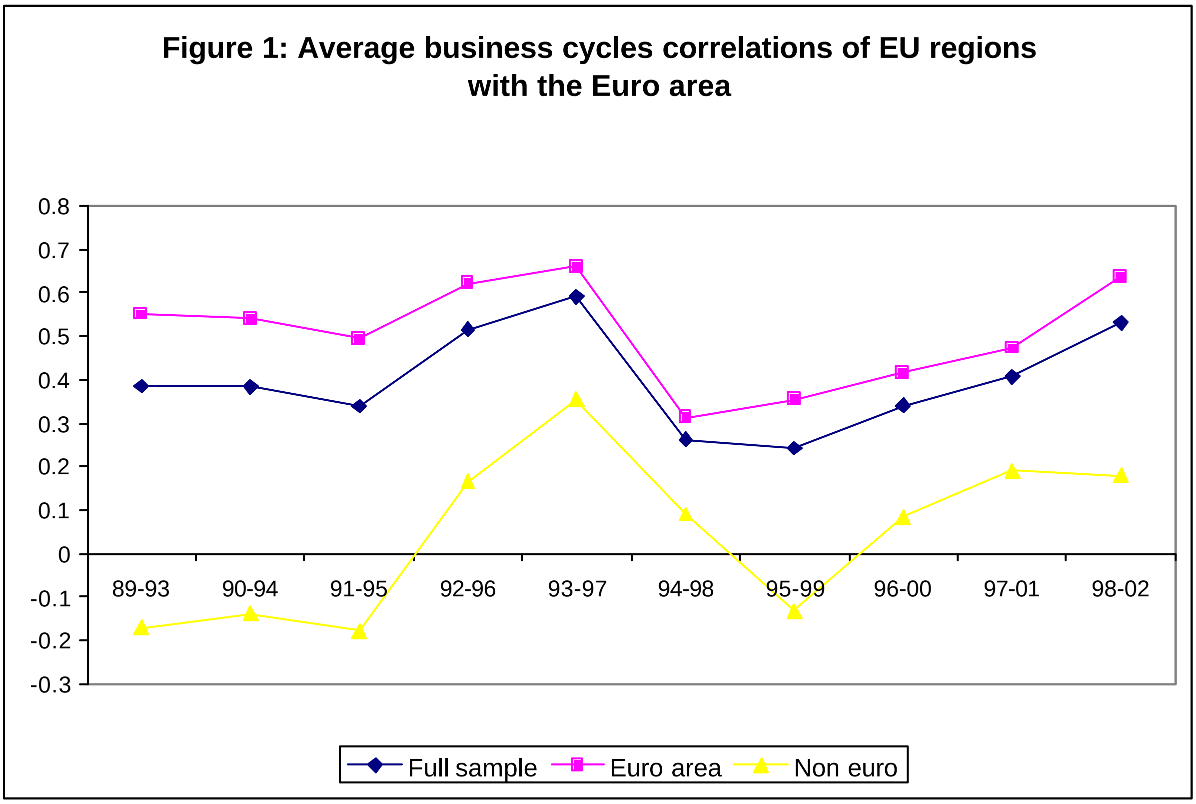
Figure 1: Average business cycles correlations of EU regions with the Euro area
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
89-93
90-94
91-95
92-96
93-97
94-98
95-99
96-00
97-01
98-02
Full sample
Euro area
Non euro

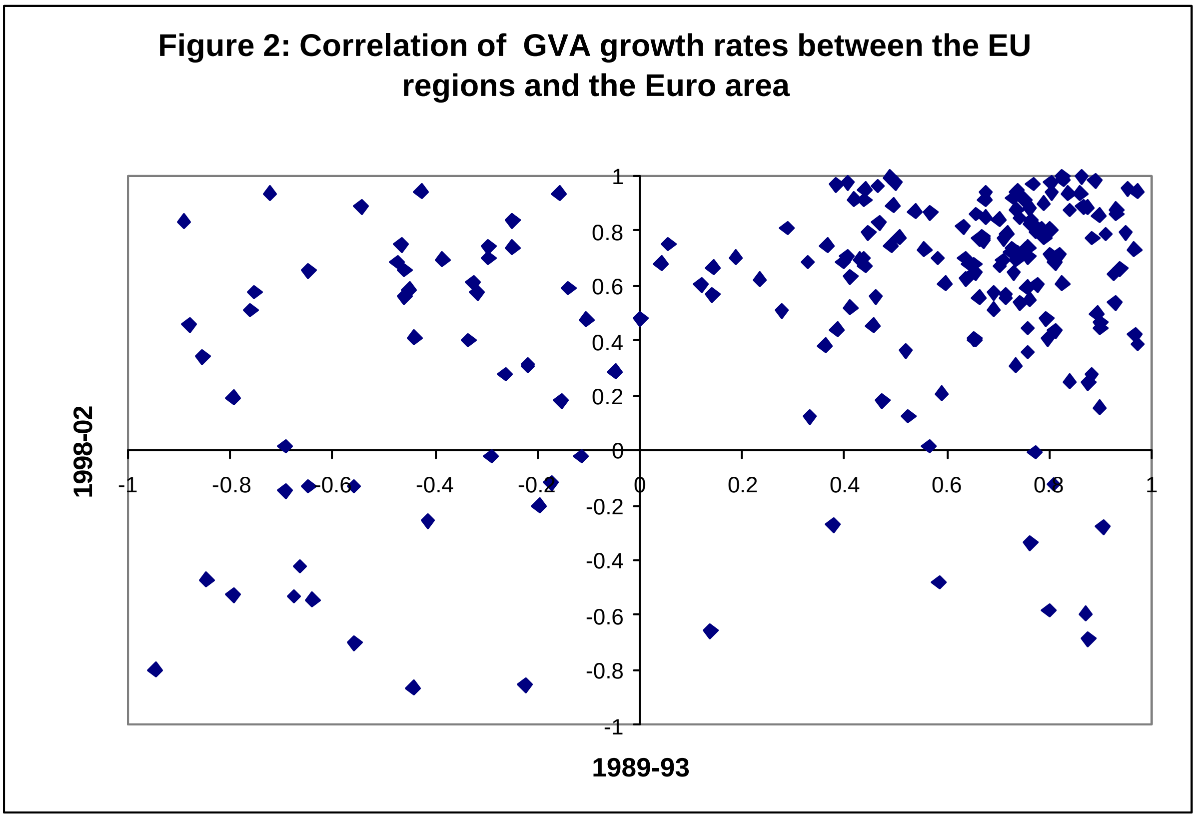
Figure 2: Correlation of GVA growth rates between the EU regions and the Euro area
1998-02
1989-93
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

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