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What drives regional business cycles? The role of common and spatial components

Michael Artis, Christian Dreger, Konstantin Kholodilin[1]

Abstract: We examine real business cycle convergence for 41 euro area regions and 48 US states. The results obtained by a panel model with spatial effects indicate that the impact of national business cycles for the regional development has been rather stable over the past two decades, in particular across US states. A tendency for convergence in business cycles often detected in country data is not confirmed at the regional level. The pattern of synchronization across the euro area is similar to that across US states. Although cyclical heterogeneity is detected, it does not indicate a serious impediment to a common monetary policy of the European Central Bank.

JEL: E32, C51, E37

Keywords: Business cycle convergence, spatial correlation, spatial panel model

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1 Introduction

The degree of comovement of economic activity across states or regions is an issue of utmost importance to policy-makers. Asymmetric business cycles are often seen as an impediment to the formation of a common currency area. On the other hand, it has been argued that a common monetary policy in itself could reduce the cyclical asymmetry (Frankel and Rose 1998).

Economic theory does not provide a clear answer regarding the impact of economic integration on the synchronization of output fluctuations, see Backus, Kehoe and Kydland (1995) and Baxter and Kouparitsas (2005). For example, intensified trade relationships can generate demand and supply side spillovers, and might therefore induce a higher comovement of economic fluctuations. However, if stronger openness to trade is associated with higher intra-industry specialization across regions, cycles might become less synchronized because of the presence of asymmetric shocks. Since the issue is theoretically unsettled, it has to be explored empirically.

Many authors have investigated the synchronization of business cycles, typically (but not exclusively) with particular reference to the European integration process, see for example Artis and Zhang (1997), Kose, Otrok and Whiteman (2003), Artis, Krolzig and Toro (2004) and Canova, Ciccarelli and Ortega (2006). Most contributors have detected a tendency for national business cycles to converge in the integrative period of the second globalization from the 1960s. Artis and Okubo (2008) provide a long-run historical perspective which, by revisiting the era of the first globalization before the First World War, demonstrates a tendency for globalization to produce a high degree of synchronization in national business cycles. Stock and Watson (2005) concluded from their

analysis that comovement has fallen during the 1984–2002 period relative to 1960–83, due to the absence of common shocks.

While these studies are based on country data, little work has been done at the regional level. There is some indication that European monetary integration has boosted convergence, although the impact of national borders is quite strong, see Montoya and De Haan (2007). While deeper trade integration exerts a positive effect on synchronization, specialization and exchange rate volatility appear to be the main drivers of dispersion (Tondl and Traistaru-Siedschlag, 2006).

As the industrial structure at the country level represents an average of heterogeneous regional patterns, evidence in favor of convergence might be easier to come by when the analysis is conducted at the national level. It is important to note that recent examination of the scope of consumption risk-sharing offers an explanation for this (Kalemli-Özcan, Sørensen and Yosha, 2003): if institutions and policies can be relied upon *within the nation* to promote risk-sharing, by the same token they may encourage regional specialization of production.

By looking at the regional dimension, a larger information set can be exploited and may offer new insights. Regions tend to be more open to trade than countries and the degree of specialisation is usually higher than at the national level. If diverging trends cancel out in the aggregate, policy conclusions based on national evidence could be misleading. In general, regional comovements may be caused not only by common business cycles, but also by other factors due to location. They can be linked to industrial structures and migration, but can also reflect non-economic factors like habits, heritage, and culture. Spatial spillovers have been largely neglected in previous studies, thereby creat-

ing omitted variable bias. A panel model allowing for spatial correlation is a convenient way to capture these effects.

Furthermore, the analysis is relevant from a monetary policy point of view. By comparing the synchronization of economic fluctuations in US states and comparable euro area regions, the perspectives of a common monetary policy in Europe can be assessed. The US provides a natural benchmark in this respect. Both the US and the euro area share similar socio-economic characteristics, regarding the size, the level of development, culture etc. Business cycles differ also across US states; see Owyang, Piger, and Wall (2005). Therefore, the response to monetary policy is not uniform (Carlino and De Fina, 1998 and 1999, Fratantoni and Schuh, 2003, Hanson, Hurst and Park, 2006). In fact, there is some evidence that synchronization has decreased since the late 1980s, implying that the US matches the optimum currency area criteria less well than in earlier periods, see Partridge and Rickman (2005). The contradiction between what is commonly seen as being a highly successful monetary policy at the national level and this evidence of increasing asymmetry between regional cycles might be traced to a trade-off between national cycle volatility and regional synchronization.

The results obtained by a panel model with spatial effects indicate that the impact of national business cycles for the regional development has been rather stable over the past two decades. Hence, a tendency for convergence in business cycles often detected in country data is not confirmed at the regional level. The pattern of synchronization across the euro area is similar to that across US states. Although cyclical heterogeneity is detected, it does not indicate a serious impediment to a common monetary policy of the European Central Bank.

The paper is structured as follows. Section 2 presents the spatial panel models employed as a workhorse in the analysis. Section 3 describes the data and discusses the estimation results. Finally, section 4 concludes.

2 Panel models with spatial dependencies

Dependencies along the regional dimension can be approximated by a spatial ARMA model

$$(1) \qquad y = \beta X + \lambda W y + u \quad , \quad u = \rho W u + \varepsilon$$

where y is the endogeneous variable with observations from n regions, X a matrix of k explanatory variables and ε the error term (see Anselin, 2001). Spatial spillovers are captured by the introduction of spatial lags of the endogeneous variable, by spatial correlation in the error term, or both. The spatial lag captures a direct impact of the business cycle in a neighborhood region on the respective regional cycle. A spatial error specification might point to forces that are behind similarities in the regional business cycles, such as unobserved technical spillovers or knowledge flows. W denotes a $n \times n$ matrix of spatial weights, with elements equal to 0 or 1, depending on whether two regions share a common border (1) or not (0)[2]. In case the first order lags are not sufficient to model the regional spillovers, higher lags can be embedded. Information criteria can serve as a guideline to arrive at a parsimoneous specification. If more complex lag structures are needed, however, it might be convenient to define W in a cumulative form

[2] Alternative spatial weighting schemes such as great circle distances between the centroids of regions have been also used to get some insights into the robustness of the results. The findings are quite similar to those presented here. The full set of results is available from authors upon request.

(Anselin, 2001). Moreover, a row-standardized form of the matrix is often used to extract the mean of observations from contiguous regions.

The Moran statistic

$$(2) \qquad m = \frac{y'Wy}{y'y}$$

serves as an overall measure of the strength of regional dependencies. It represents a measure of first-order global correlation between the spatial units in a particular year. If the null hypothesis cannot be rejected, the regression error does not exhibit significant signs of spatial autocorrelation. The higher the Moran statistic the stronger the spatial correlation. Note that the linkages may be driven by different forces, including business cycle comovements.

The model (1) refers to a pure cross-sectional framework. To explore the impact of common drivers on regional business cycles, the time series dimension has to be added. This is done by estimating a panel model allowing for spatial effects: in this we follow the instructive leads given by Elhorst (2003) and Baltagi and Li (2006). In particular, we are using two panel models with fixed-effects: the spatial lag and the spatial error model. Both variants turn out to be sufficient to remove the spatial autocorrelation patterns in the regression residuals.

3 Data and results

Data for 41 EU regions and 48 US states are exploited: see Table 1 for the list of regions. Annual data on regional economic activity are available for the 1982-2007 period. Some regions are excluded for data reasons. Euro area series refer to GVA at 2000

prices reported by Cambridge Econometrics. Real GDP data for US states chained in 2000 dollars are from the BEA. State level data prior to 1991 are reconstructed using BEA quantity indices. The regions are broadly in the two datasets are broadly comparable in terms of per capita output, see Table 2. The analysis refers to the cyclical component of regional GDP. This is defined either as a deviation from trend, where the latter is obtained by a Hodrick-Prescott filter, or by annual growth rates. Following Ravn and Uhlig (2002), the smoothing parameter is set equal to 6.25.[3]

-Table 1 and Table 2 about here-

Figure 1 displays the rolling Moran coefficient, i.e., (2) calculated as an average over a moving window of eight years. The eight-year period corresponds to the average length of business cycles, approximately. The dependencies between EU regions were rather weak in the 1980s. Perhaps fostered by the European integration process, the correlation has increased until the mid-1990s. After a decline during the new economy boom, regional spillovers regained importance in recent years. The initial correlation was quite high in US regions; after that the dependencies decreased until the middle of the sample period. Subsequently, over more recent years the strength of spillovers again risen gradually.

The Moran coefficient serves as an overall measure of regional dependencies. It does not provide any clue on the appropriate specification of the spatial panel model. In order to distinguish between the spatial lag and the spatial error specification within the panel

[3] For robustness, we have cross-checked the results obtained for growth rates instead of the filtered variables. The findings are not much affected by this choice.

context, Lagrange Multiplier tests can be conducted, see Elhorst (2009). According to Anselin (2001), the superior model is characterized by the lowest *p*-values. Both for the euro area and the US, the spatial error alternative finds slightly more support from the data, see table 3.

-Figure 1 and Table 3 about here-

In the next step, the regional business cycle is explained by the area wide cycle and spatial spillovers. To explore the role of supraregional forces, the area wide cycles are proxied by the common factors of the regional business cycles[4]. These factors represent the comovements of the regional series, which may be caused by shocks occurring at the national or international level. They are extracted by principal component analysis, where the number of factors is determined on the grounds of information criteria. For both the US and the euro area, two factors are found to be optimal. They account for the bulk of the overall variance of the regional series (between 60 and 70 percent). To capture the impact of spatial spillovers, spatial lag and spatial error models have been estimated. The different specifications can provide additional insights into the robustness of results.

The relevance of the supraregional components for individual regions can be measured by the corresponding factor loadings. See Figure 2 for the loadings of the first common factor. For the US, the correlation is particular strong for the New England states, and

[4] In principle, this could introduce an endogeneity bias, However, the role of individual regions is quite low, as the cross section dimension is relativelylarge. Moreover, we have also worked with lagged principal components and obtained very similar results.

the Western coast. For the euro area cycle, the dominance of the German development is striking.

-Figure 2 about here-

Regression results are reported in Table 4. The top panel reports the results for the entire sample period, the lower two for successive subsamples. The first two rows of each panel contain the estimated parameters of the first two principal components. The next two rows contain the estimates of the spatial coefficients of the spatial lag model and spatial error model, respectively. For most of the years the residuals appear to display no or very low spatial autocorrelation. Therefore, both specifications are appropriate to model the spatial pattern.

-Table 4 about here-

Business cycle comovements are important to explain regional output fluctuations. Thus, the first factor is always significant, regardless of the time period. The second factor is only significant in case of the euro area over the whole period. The parameters are fairly robust across subperiods. The inclusion of spatial effects (spatial lag or spatial error) improves the model fit. Spatial coefficients are always significant, indicating the strong presence of cyclical dependencies across regions. The positive sign of the coefficients shows that neighbour regions tend to be in the same phase of the business cycle.

In case of the euro area, the spatial parameters do not differ systematically over the two subperiods. However, for the USA, they decline quite substantially over time: in the second subsample they are about 1.5 times smaller than in the first period. This finding is in line with the behaviour of the smoothed Moran's *I* coefficient, see Figure 1. Common supraregional business cycles, as represented by the first two common factors, did not account for a larger share of the regional economic evolution in more recent years. Therefore, a tendency towards higher cyclical synchronization often found in country studies cannot be confirmed at the regional level.

4 Conclusion

In this paper we have examined real business cycle convergence for 41 euro area regions and 48 US states. Results obtained by a panel model with spatial correlation indicate that the impact of national business cycles for the regional development has remained rather stable over the past two decades, in particular across US states. A tendency for convergence in business cycles often detected in country data is not confirmed at the regional level. The degree of synchronization across the euro area is similar to that found for the US states. As a common monetary policy works for the US, the existing heterogeneity in the cyclical experience of European regions cannot be seen as an impediment for a common monetary policy in the euro area.

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Table 1: Euro area and US regions

A Euro area regions[5]

Belgium: Brussels, Vlaams Gewest, Wallonne. *Germany*: Baden-Wuerttemberg, Bayern, Bremen, Hamburg, Hessen, Niedersachsen, Nordrhein-Westfalen, Rheinland-Pfalz, Saarland, Schleswig-Holstein. *Spain*: Noroeste, Communidad de Madrid, Centro, Este, Sur. *France*: Île de France, Bassin Parisien, Nord–Pas-de-Calais, Est, Ouest, Sud-Ouest, Centre-Est, Méditerranée. *Italy*: Nord Ovest, Nord Est, Centro, Sud, Isole. *Luxembourg*: Luxembourg. *Netherlands*: Nord-, Oost-, West-, Zuid-Nederland. *Austria*: Ost-, Sued-, Westoesterreich. *Portugal*: Continente.

B US regions

All states excluding Alaska and Hawaii

[5] The euro area regions correspond to the NUTS 1 regions. NUTS stands for Nomenclature des unités territoriales statistiques. This is a standard classification defined by Eurostat.

Table 2: Comparison of GVA/GDP per capita for euro area and US regions

	Euro area	United States
Minimum	5,798.5	14,833.0
Mean	19,465.0	28,768.0
Maximum	55,481.0	58,935.0
Standard deviation	7,416.7	7,009.8
Coefficient of variation	0.381	0.244

Thousands of chained 2000 US dollars, 1982-2007. Sources: Cambridge Econometrics; Bureau of Economic Analysis; US Census Bureau.

Table 3: LM specification tests

	Euro area	US
LMLag	0.000 (0.987)	0.032 (0.858)
Robust LMLag	377.98 (0.000)	579.78 (0.000)
LMError	16.38 (0.000)	47.47 (0.000)
Robust LMError	394.36 (0.000)	627.21 (0.000)

Note: 1982-2007, 41 EU regions, 48 US states. Lagrange Multiplier tests of spatial effects for panel data. LMLag refers to the spatial lag model and LMError to the spatial error model.

Table 4: Components of regional output growth

1982-2007

	Euro area		US	
Factor 1	0.131 (14.37)	0.177 (20.15)	0.118 (12.72)	0.188 (17.24)
Factor 2	0.035 (2.67)	0.047 (2.70)	0.010 (0.76)	0.016 (0.769)
Spatial lag	0.262 (7.32)		0.371 (11.30)	
Spatial error		0.258 (7.71)		0.362 (11.30)
R-squared	0.429	0.430	0.415	0.417
Log likelihood	3400.27	3400.26	3802.34	3802.93

1982-1994

	Euro area		US	
Factor 1	0.128 (9.73)	0.174 (12.98)	0.107 (8.62)	0.194 (12.00)
Factor 2	0.033 (1.94)	0.044 (1.94)	0.020 (1.20)	0.036 (1.26)
Spatial lag	0.264 (5.22)		0.447 (10.34)	
Spatial error		0.269 (5.72)		0.428 (10.02)
R-squared	0.399	0.397	0.486	0.483
Log likelihood	1578.46	1577.35	1907.90	1905.50

1995-2007

	Euro area		US	
Factor 1	0.143 (11.64)	0.186 (18.34)	0.137 (9.03)	0.189 (11.50)
Factor 2	0.061 (1.81)	0.080 (1.80)	-0.021 (0.79)	-0.028 (0.791)
Spatial lag	0.231 (4.48)		0.279 (5.61)	
Spatial error		0.235 (4.90)		0.285 (5.936)
R-squared	0.529	0.527	0.342	0.340
Log likelihood	1939.95	1935.61	1902.72	1900.52

Note: 41 EU regions, 48 US states. Regional GVA and GDP growth rate explained by first two principal components (factor 1, factor 2), spatial lags and spatial errors of first order. Panel regression with fixed regional effects, *t*-values in parantheses. R-squared adjusted.

Figure 1: Rolling Moran coefficient

Note: Average Moran coefficient for first order spatial autocorrelation between EU (continuous line) and US (dashed line) regions.

Figure 2: Correlation between the regional cycles and the national cycle

Euro area and US, 1983-2007