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Business Cycles in Post-Reunified Germany: Closer Together or Further Apart?*

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Abstract

In this article we document the features of business cycles in German Länders from 1970 and 2007. Specifically, we answer the question if German Länders are becoming more synchronized or not. All results indicate that the synchronization of cycles is stronger inside the former Western Germany and inside the former Eastern Germany. The reunification process has had a strong influence in terms of business cycle association. However, a process of cyclical convergence has begun, although slowly, after the reunification.

JEL Classification: $C14$, $C65$, $E32$, $F33$, $O52$.

Keywords: Business Cycle Association, Synchronization, and Convergence, Germany Reunification.

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1 Introduction

In this article, we document the features of business cycles in German Länders from 1970 and 2007. Specifically, we answer the question if German Länders are becoming more synchronized or not. Since Germany became a political and monetary union, after reunification, the questions whether each Länder is synchronized with the whole union and the evolution of the synchronization pattern are important, namely when considering policy decisions to face idiosyncratic regional shocks. This question is also important regarding the relation between Länders from the former Eastern Germany and Länders from the former Western Germany.

Germany has been a Federation since 1871, born out of fear of Prussia and the existing German Confederation with their neighbour Austria. The Federation has held a common currency since that date, and a Central Bank was established in 1876. Before 1871 a customs union was already functioning. From the end of World War II until 1989, Germany was divided between Western and Eastern Länders. After German reunification, the sixteen Länders were joined again, although a very different Germany arose from this event, with strong disparities between the West and the East. We also want to study the impact of reunification in business cycles features.

This article follows the line of Artis and Zhang (1997, 1999), asking wether there is a European business cycle. In fact, considering the largest European economy, which has been subjected to a significant shock (reunification) and highly integrated in the European economic space, is, in our view, an important contribution to the understanding of European business cycle(s) features. To our knowledge, only a few studies analyzed business cycles behaviour in Germany. Haan et. al. (2002) studied Germany business cycles as part of a comparison with USA and OECD. They observed a synchronization of German business cycles, considering only Western Länders and analyzed the dynamics of bilateral correlations. We extend their work, performing an analysis that integrates the Eastern Länders (between 1991 and 2007), making use of rolling windows analysis technique. Moreover, we also address the formation of a core-periphery pattern within Germany. To our knowledge, this is the first article that looks at the effects of reunification on the business cycles features of the German Länders. Buch et al. (2004) analyzed the evolution of business cycle volatility in Germany and found a reduction in output volatility. Canova and Ravn (2000) had studied the German unification by means of a business cycles model which predicts high losses for capital owners and skilled workers due to reunification.

This work has the following structure: In section 2 we present the data, section 3 is dedicated to cyclical association, section 4 discusses business cycle synchronization, and section 5 reunites the results of the two previous sections and analyzes business cycles convergence. Finally, section 6 concludes.

2 Data

The variable used in the remaining section is the annual output gap. We calculated this variable by subtracting the value for potential output from the log real output for each Länder. To detrend the data we have resorted to two widely used methods, both with standard parameter values: the Hodrick-Prescott (HP) filter with $\lambda = 100$, and the Baxter and King (BK) band-pass filter with $L = 2$, $H = 8$, and $K = 3$. For conciseness, results presented in the main text are for the HP filter, whereas those obtained with the BK filter are available upon request.

Ideally, to fully assess the behaviour of business cycles due to German Reunification, data starting before this event would be needed. However, regional data for Eastern Länders (the former German Democratic Republic) are not available for the same period as for Western Länders (the former Federal Republic of Germany). For the sixteen Länders of Germany, data for gross domestic product at 2000 prices is available between 1991 and 2007. In addition, we have data between 1970 and 2004 for the eleven Western Länders, although data for West Berlin is only available until 1991.[1] Länder data was taken from the German Federal Statistics Office (Statistisches Bundesamt). We extracted data for the Gross Domestic Product by Länder at 2000 prices.

In analyzing business cycles results for Eastern Länders we have to be carefull, since these regions are on their transition paths and the number of time series available is still limited.

3 Cyclical Association

In this section we analyze the degree of cyclical association of each Länder with Germany. This question is important since the sixteen Länders are now forming a political and monetary union and monetary and fiscal policy are jointly decided.[2] Before we analyze this issue we show some business cycle statistics for the Länders and also for Germany, presented in Table 1, which shows standard-deviations (volatility) and autocorrelations coefficients (persistence). Numbers presented are for the 1991-2007 period, except numbers in brackets which are for the 1970-2007 period (for Western Länders only, West Berlin not included).

[1] In Appendix A we have available a list of Germany Länders and a map of the country. The list also provides the abbreviation of the name for each Länder and its relative weight in Germany's total output. The base year for this calculation is 2007.

[2] Due to the time period available to study all Länders, the study of the dynamics of cyclical association is not possible.

Table 1 - Business Cycle Statistics for German Länders

	Volatility (%)	*Persistence*
Baden-Württemberg (BAW)	2.46 (2.22)	0.47 (0.57)
Bayern (BAY)	2.11 (1.85)	0.59 (0.64)
Berlin (BLN)	2.11	0.48
Branderburg (BRA)	4.18	0.65
Bremen (BRE)	2.22 (2.54)	0.49 (0.67)
Hamburg (HBG)	2.08 (2.19)	0.56 (0.56)
Hessen (HES)	2.22 (2.19)	0.58 (0.67)
Mecklenburg-Vorpommern (MEV)	4.58	0.67
Niedersachsen (NSA)	2.03 (2.03)	0.61 (0.62)
Nordrhein-Westfalen (NRW)	1.66 (1.84)	047 (0.59)
Rheinland-Pfalz (RPF)	1.64 (1.52)	0.31 (0.38)
Saarland (SAA)	2.29 (1.90)	0.32 (0.43)
Sachsen (SAF)	4.67	0.65
Sachsen-Anhalt (SAN)	4.23	0.60
Schleswig-Holstein (SHO)	1.65 (2.02)	0.50 (0.68)
Thüringen (THU)	4.89	0.46
Germany	1.23	0.45

As can be seen in Table 1, Eastern Länders present more volatility than Western ones, which is reasonable, since these Länders are making a transition from a central planning economy to a market economy. Results for Western Länders do not present significant changes, wether we consider 1970-2007 or 1991-2007. Persistence is not very high in all Länders and also in Germany, and decreased in Western Länders in the period between 1991 and 2007. Results for the BK filter are consistent with those above.

3.1 Pearson Correlation, Concordance, and Spearman's Rank Correlation

To analyze the degree of cyclical association for the 1991-2007 period between each Länder with Germany we recur to three statistics - the Pearson correlation coefficient, the concordance statistic, and the Spearman's rank correlation. Results are presented in Table 2 below.

Table 2 - Correlation, Concordance, and Spearman's Rank Correlation between each Länder and Germany

	Correlation	*Concordance*	*Spearman's Rank*
Baden-Württemberg (BAW)	0.85***	0.68	0.90***
Bayern (BAY)	0.66***	0.57	0.62***
Berlin (BLN)	0.04	0.04	0.10
Branderburg (BRA)	-0.15	0.08	0.03
Bremen (BRE)	0.52**	0.43	0.61***
Hamburg (HBG)	0.54**	0.45	0.49**
Hessen (HES)	0.63***	0.52	0.64**
Mecklenburg-Vorpommern (MEV)	-0.23	0.12	-0.03
Niedersachsen (NSA)	0.50**	0.43	0.54**
Nordrhein-Westfalen (NRW)	0.68***	0.64	0.84***
Rheinland-Pfalz (RPF)	0.75***	0.72	0.81***
Saarland (SAA)	0.73***	0.61	0.72***
Sachsen (SAF)	-0.37	0.18	-0.23
Sachsen-Anhalt (SAN)	-0.34	0.18	-0.13
Schleswig-Holstein (SHO)	0.65***	0.60	0.63**
Thüringen (THU)	-0.40	0.19	-0.21

Note: (*), (**), and (***) denote significance at 10%, 5%, and 1% levels, respectively.

The Pearson correlation coefficient measures the degree of linear association between the business cycles of one Länder and Germany.[3] Correlations are substantially high and significant for Western Länders and negative and non-significant for Eastern Länders. Results for Berlin point to a non-existent linear association with Germany.

Since the correlation coefficient is a measure of linear association we recur to two statistics that allow the existence of a non-linear association between two variables - the concordance statistic and the Spearman's Rank Correlation. The first is a non-parametric statistic that measures the proportion of time that the cycles of two variables spend in the same cycle phase and varies between 0 and 1. A positive association between two variables imply a concordance statistic above 0.5. As we can see in the third column, Eastern Länders and Berlin do not present a positive association with Germany as well as the Länders of Bremen, Hamburg, and Niedersachsen (these Länders are geographically close), although the value of these last three is close to 0.5. All other Western Länders present a value above 0.5. Of all Western Länders, the three referred Länders presented the lowest correlation with Germany, so results are confirmed by the concordance statistics.

The Spearman's rank correlation is the correlation coefficient of the ranks of two series. The rank is calculated as the ordered values of the cycle for each Länder. Results are similar to the two previous statistics, confirming the existence of a linear association. Results using the BK filter confirm those presented above.

[3] Usually designated simply by correlation coefficient.

3.2 Multiple Correlation

Until now we have analyzed the degree of cyclical association not considering the existence of lags and leads in business cycles between the studied Länders. One way of assessing the degree of cyclical association in the presence of non-contemporaneous relationships between two series is to estimate the following equation:

$$y\_cic_t^i = \beta_1 y\_cic_{t-2}^{Ger} + \beta_2 y\_cic_{t-1}^{Ger} + \beta_3 y\_cic_t^{Ger} + \beta_4 y\_cic_{t+1}^{Ger} + \beta_5 y\_cic_{t+2}^{Ger} + \varepsilon_{it} \quad (1)$$

where y_cic^i is the cyclical component (output gap) of Länder i and $y\_cic_{t+j}^{Ger}$ is the cyclical component of Germany with lags and leads.[4] If R^2 is the coefficient of determination in the equation presented above, the square root of this coefficient (R) is the correlation coefficient between X^i and $\hat{X}^i$, where $\hat{X}^i$ are the fitted values of X^i, so R can be interpreted as the multiple correlation coefficient between Länder i and Germany.

Table 3 - Multiple Correlation between each Länder and Germany

Länders	$1991 - 2007$
Baden-Württemberg (BAW)	0.96
Bayern (BAY)	0.87
Berlin (BLN)	0.60
Branderburg (BRA)	0.51
Bremen (BRE)	0.69
Hamburg (HBG)	0.74
Hessen (HES)	0.90
Mecklenburg-Vorpommern (MEV)	0.59
Niedersachsen (NSA)	0.72
Nordrhein-Westfalen (NRW)	0.83
Rheinland-Pfalz (RPF)	0.79
Saarland (SAA)	0.74
Sachsen (SAF)	0.63
Sachsen-Anhalt (SAN)	0.41
Schleswig-Holstein (SHO)	0.74
Thüringen (THU)	0.49

Results are shown in Table 3 above and clearly confirm the statistics results. The higher degree of cyclical association is between each Western Länder and Germany. Results for Eastern Länders are lower, although higher than the ones presented for correlation statistics, maybe suggesting some degree of cyclical convergence but with absence of synchronization.

[4] We did not perform this estimation with data detrended with the BK filter, since the time period (1994-2004) would be very short, hence estimation results would not be robust.

3.3 Idiosyncratic Component of the Cycle

One other exercise to test if cyclical association is strong, is to calculate the specific or idiosyncratic component of the cycle in each Länder, i.e., the part of the Länder cycle that is not explained by the German business cycle nor by the past behaviour of the Länder cycle. If this component is very high, cyclical association between each Länder and Germany will not be very strong. For that purpose we estimate the following equation:

$$y\_cic_t^i = \beta_1 y\_cic_{t-1} + \beta_2 y\_cic_{t-2} + \beta_3 y\_cic_t^{Ger} + \beta_4 y\_cic_{t-1}^{Ger} + \beta_5 y\_cic_{t-2}^{Ger} + \varepsilon_{it} \quad (2)$$

ε_{it} can be regarded as the idiosyncratic component of each Länder fluctuations. For each Länder we try several estimations in order to achieve the best possible fit. This means that whenever variables were not statistical significant, they were removed.[5]

Our purpose with these calculations was to assess the proportion of the business cycle explained by idiosyncratic shocks in each of the Länders. This proportion is calculated in the following way: $\frac{\sigma_{\varepsilon_t}}{\sigma_{y\_cic_t}}$, where σ_{ε_t} is the standard deviation of the idiosyncratic component of the cycle and $\sigma_{y\_cic_t}$ is the total standard deviation of the cycle in the Länder. So, the bigger the value of this ratio, the bigger the proportion of the business cycle is due to specific Länder shocks.

Table 4 shows the results for each Länder for the period between 1991 and 2007. Länders with the higher specific component are Saarland, Hamburg, Berlin, and Rheinland- Pfalz and Länders with the lowest are Bayern, Thüringen, Baden-Württemberg, Nordrhein-Westfalen, Branderburg, and Hessen. It does not seem to exist any significant difference between Western and Eastern Länders regarding the specific cyclical component, hence it seems that the reunification process can be an explanatory factor at this point.

[5] We did not perform this estimation with data detrended with the BK filter, since the time period (1994-2004) would be very short, hence estimation results would not be robust.

Table 4 - % of the Variability of the Idiosyncratic Component in the Total Variability of the Cycle

Länders	$1991 - 2007$
Baden-Württemberg (BAW)	22%
Bayern (BAY)	21%
Berlin (BLN)	39%
Branderburg (BRA)	24%
Bremen (BRE)	31%
Hamburg (HBG)	45%
Hessen (HES)	24%
Mecklenburg-Vorpommern (MEV)	29%
Niedersachsen (NSA)	26%
Nordrhein-Westfalen (NRW)	23%
Rheinland-Pfalz (RPF)	38%
Saarland (SAA)	46%
Sachsen (SAF)	27%
Sachsen-Anhalt (SAN)	32%
Schleswig-Holstein (SHO)	33%
Thüringen (THU)	22%

Figure 1 presents the evolution of the idiosyncratic component of the cycle for each Länder. In more recent years, Länders which presented in Table 4 high values for the idiosyncratic component seem to be reducing it, such as Berlin, Mecklenburg-Vorpommern, Rheinland- Pfalz, and Schleswig-Holstein. On the other hand, Länders which presented low values in Table 4 are, in recent years, exhibiting an opposite behaviour, like Bayern and Baden-Württemberg. The behaviour of the specific component of Niedersachsen, Sachsen, and Sachsen-Anhalt remained constant over time.

Figure 1 - Idiosyncratic Component of the the Cycle for each Länder

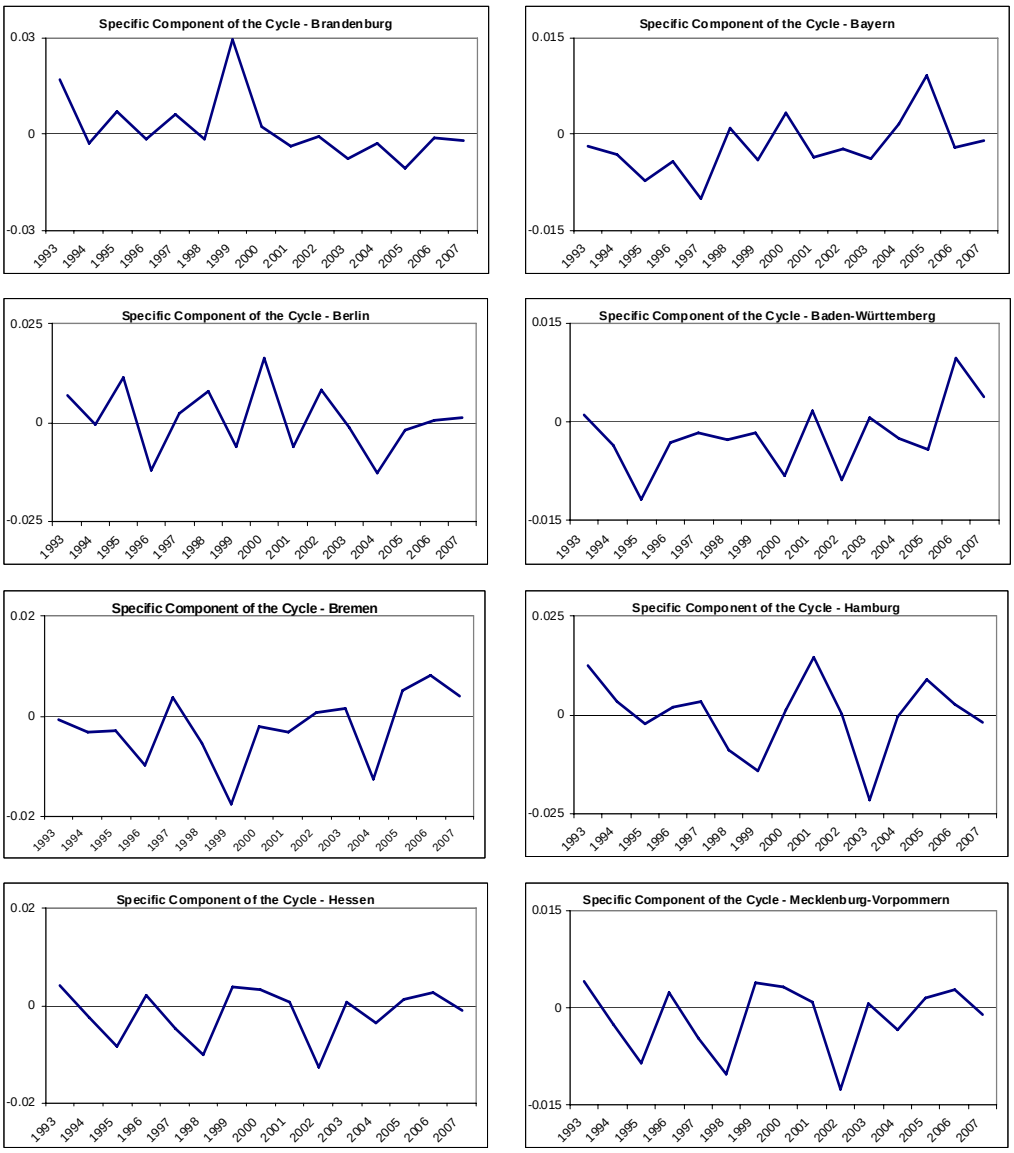
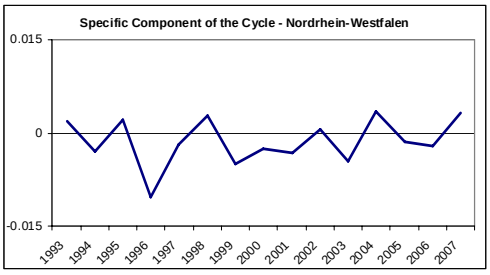
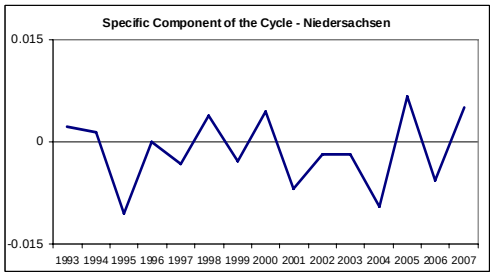
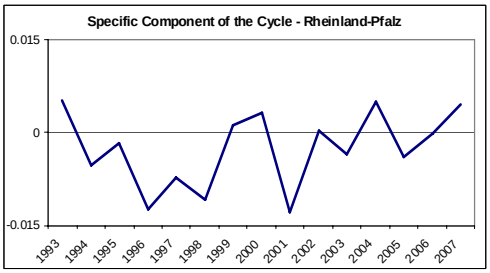
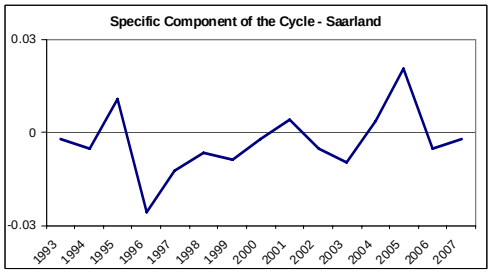


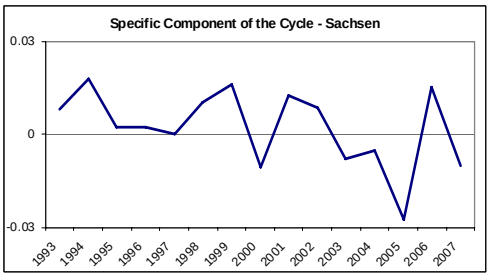
Figure 1 - Idiosyncratic Component of the Cycle for each Länder (Contin.)

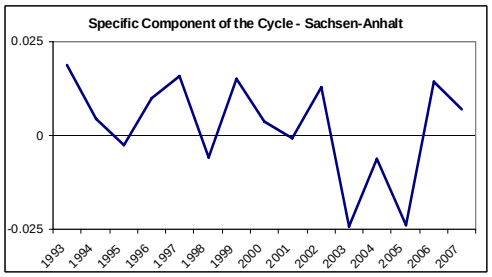


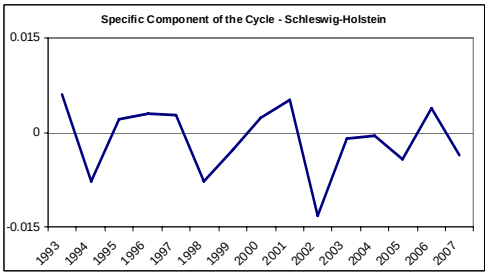


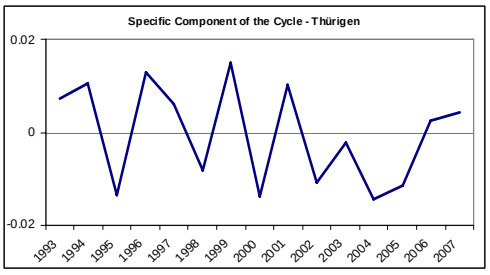












4 Business Cycle Synchronization

In this section we assess the degree of business cycle synchronization between each Länder and Germany. The synchronization will be measured by defining the number of lagging or leading periods (in our case, years) at which we have the maximum value for the correlation coefficient. For a given Länder X^i and Germany, $\rho_{\pm N}\left(x^i_{t\pm N}, Germany_t\right)$ is the correlation coefficient between X^i and Germany at any given period N ($N \in \mathbb{N}$). The maximum value for $\rho_{\pm N}$ is the maximum correlation coefficient. Synchronization is obtained when the maximum value for the correlation coefficient is when N is at period 0.

Table 5 - Maximum Correlation between each Länder and Germany

Länders	$1991 - 2007$
Baden-Württemberg (BAW)	0.85 (0)
Bayern (BAY)	0.66 (0)
Berlin (BLN)	0.38 (-5)
Branderburg (BRA)	0.49 (-5)
Bremen (BRE)	0.52 (0)
Hamburg (HBG)	0.59 (+1)
Hessen (HES)	0.63 (0)
Mecklenburg-Vorpommern (MEV)	0.51 (-5)
Niedersachsen (NSA)	0.50 (0)
Nordrhein-Westfalen (NRW)	0.68 (0)
Rheinland-Pfalz (RPF)	0.75 (0)
Saarland (SAA)	0.73 (0)
Sachsen (SAF)	0.54 (-5)
Sachsen-Anhalt (SAN)	0.46 (-5)
Schleswig-Holstein (SHO)	0.65 (0)
Thüringen (THU)	0.41 (-5)

Results in Table 5 show that business cycles for Western Länders, with the exception of Hamburg are fully synchronized with the German business cycle. Eastern Länders and Berlin present a lagged relationship (at lag 5) between their business cycle and Germany's. BK results broadly confirm these ones, although the lag is at period 6.

5 Cyclical Convergence

In order to obtain an increase in cyclical convergence both cyclical association and synchronization have to show signs of improvement over time. To assess if cyclical convergence has increased (or not) in the analyzed time period we need to perform a dynamic analysis. The following exercises will assess the behaviour of cyclical convergence for German Länders.

But first, Table 6 gives us a general picture of the bilateral correlations for German Länders between 1991 and 2007. Correlations are usually positive

and significant between Western Länders and also between Eastern Länders. Correlations between Western and Eastern Länders are mostly negative (and high) and significant, except correlations between Berlin and Western Länders. Results for the BK filter support these results.

Table 6 - Business Cycle Correlations for German Länders between 1991 and 2007

	1991-2007															
	BAY	**BLN**	**BRA**	**BRE**	**BAW**	**HBG**	**HES**	**MEV**	**NRW**	**NSA**	**RPF**	**SAA**	**SAF**	**SAN**	**SHO**	**THU**
Bayern (BAY)																
Berlin (BLN)	-0.34															
	(0.19)															
Branderburg (BRA)	-0.65***	0.79***														
	(0.21)	(0.09)														
Bremen (BRE)	0.89***	-0.34	-0.71***													
	(0.07)	(0.32)	(0.19)													
Baden-Württemberg (BAW)	0.89***	-0.19	-0.53**	0.83***												
	(0.05)	(0.38)	(0.27)	(0.09)												
Hamburg (HBG)	0.84***	-0.12	-0.42*	0.82***	0.75***											
	(0.07)	(0.35)	(0.29)	(0.10)	(0.11)											
Hessen (HES)	0.95***	-0.29	-0.62***	0.91***	0.91***	0.85***										
	(0.03)	(0.33)	(0.24)	(0.06)	(0.04)	(0.08)										
Mecklenburg-Vorpommern (MEV)	-0.74***	0.77***	0.98***	-0.73***	-0.58***	-0.50**	-0.67***									
	(0.15)	(0.09)	(0.01)	(0.16)	(0.23)	(0.25)	(0.20)									
Nordrhein-Westfalen (NRW)	0.92***	-0.25	-0.60**	0.92***	0.92***	0.81***	0.94***	-0.63***								
	(0.04)	(0.35)	(0.25)	(0.05)	(0.04)	(0.09)	(0.04)	(0.22)								
Niedersachen (NSA)	0.79***	-0.06	-0.46*	0.85***	0.76***	0.69***	0.86***	-0.48*	0.88***							
	(0.13)	(0.39)	(0.31)	(0.09)	(0.13)	(0.19)	(0.08)	(0.29)	(0.07)							
Rheinland- Pfalz (RPF)	0.85***	-0.23	-0.54**	0.83***	0.88***	0.61***	0.85***	-0.56***	0.92***	0.82***						
	(0.07)	(0.34)	(0.25)	(0.10)	(0.07)	(0.18)	(0.07)	(0.22)	(0.04)	(0.09)						
Saarland (SAA)	0.81***	-0.14	-0.47**	0.78***	0.82***	0.65***	0.79***	-0.51**	0.88***	0.80***	0.88***					
	(0.09)	(0.33)	(0.27)	(0.10)	(0.10)	(0.13)	(0.10)	(0.24)	(0.06)	(0.09)	(0.07)					
Sachsen (SAF)	-0.78***	0.73***	0.94***	-0.74***	-0.67***	-0.52**	-0.73***	0.97***	-0.69***	-0.54**	-0.64***	-0.59***				
	(0.11)	(0.11)	(0.05)	(0.15)	(0.18)	(0.23)	(0.16)	(0.01)	(0.18)	(0.25)	(0.18)	(0.20)				
Sachsen-Anhalt (SAN)	-0.74***	0.77***	0.96***	-0.73***	-0.65***	-0.49**	-0.71***	0.97***	-0.68***	-0.50**	-0.63***	-0.61***	0.97***			
	(0.15)	(0.09)	(0.02)	(0.18)	(0.23)	(0.26)	(0.19)	(0.02)	(0.22)	(0.28)	(0.22)	(0.21)	(0.01)			
Schleswig-Holstein (SHO)	0.82***	-0.11	-0.44	0.86***	0.87***	0.80***	0.94***	-0.47*	0.92***	0.88***	0.84***	0.81***	-0.54**	-0.54**		
	(0.11)	(0.40)	(0.33)	(0.10)	(0.06)	(0.12)	(0.04)	(0.30)	(0.06)	(0.07)	(0.08)	(0.10)	(0.29)	(0.26)		
Thüringen (THU)	-0.67***	0.76***	0.92***	-0.72***	-0.63***	-0.48**	-0.67***	0.91***	-0.66***	-0.45*	-0.64***	-0.58***	0.91***	0.96***	-0.53**	
	(0.15)	(0.11)	(0.02)	(0.17)	(0.20)	(0.25)	(0.18)	(0.02)	(0.19)	(0.29)	(0.20)	(0.21)	(0.02)	(0.01)	(0.27)	

Note: (*), (**), and (***) denote significance at 10%, 5%, and 1% levels, respectively. Numbers in parentheses are Newey-West standard errors.

5.1 Rolling Windows

We analyzed the dynamics of the correlation coefficients for the output gap between German Länders using rolling windows analysis. Since results in Table 2 point to the existence of a linear association between the variables, we only analyze, in terms of the dynamic evolution, the Pearson correlation coefficient. Rolling-window analysis works like a moving sample, when some specified number of observations is dropped from each window and others are added in; with each window always having the same length.

To perform rolling windows analysis, we specified a window length of ten years, usually the average duration of a complete business cycle.[6] The window

[6] Sorensen and Whitta-Jacobsen (2005) and the seminal work of Burns and Mitchell (1946) are good references of studies about business cycles length.

is moved forward by an increment of one year. So we began by using observations 1 to 10 of the data, then using observations 2 to 11, and so on.[7]

In each window we calculated the bilateral correlation matrix between the Länders. Thus, given that there is 16 Länders for Germany, in each window we calculate $\frac{16*15}{2} = 120$ bilateral correlations, and compute their average and standard deviation. In the figures presented below, we called these values "bilateral average" and "standard deviation (bilateral)", respectively.[8]

We also calculated a vector (16×1) of correlations of the Länders with Germany and obtained the average and standard deviations of these correlations. In the figures presented below, we designated these values as "national average" and "national standard-deviation", respectively.

The figures presented in the text are for the rolling windows analysis of ten years length. Because the choice of the optimal period of time for a rolling window is not yet a consolidated topic in the literature, we also performed another calculation, where we use a period of 15 years.[9]

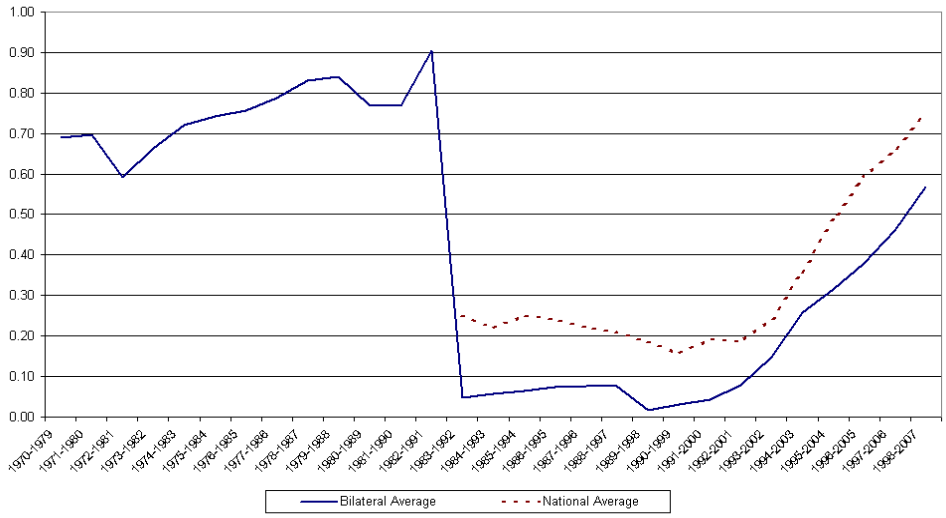


Figure 2 - Average Bilateral Correlations for German Länders

[7] Notice however, that computation of the output gap was performed only once, using the full sample.

[8] The calculation of average correlations and standard deviations for Germany as whole, as seen in Figures 2 and 3 below, with the sixteen Länders, is only possible after 1991, when data for all Länders is available.

[9] Results are available upon request.

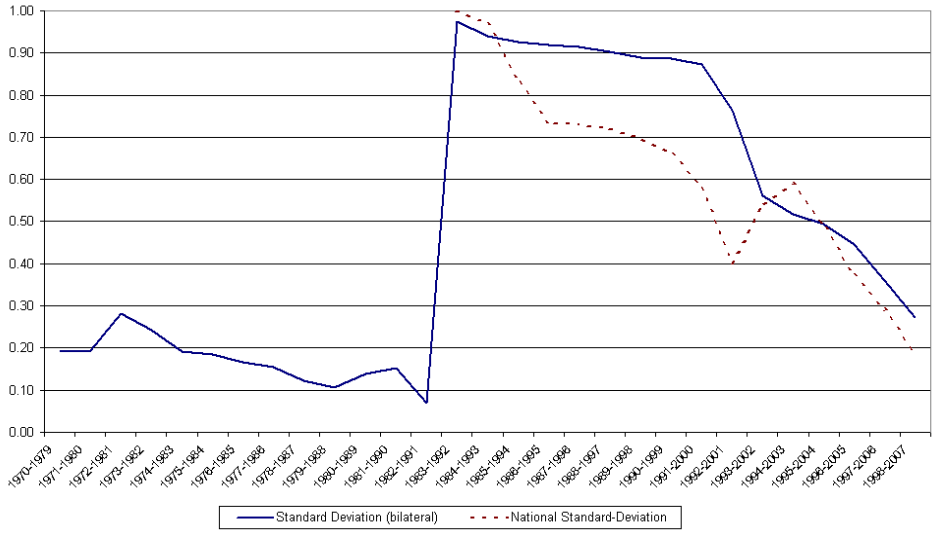


Figure 3 - Standard Deviation of Bilateral Correlations for German Länders

Figure 2 shows that the average correlations between Western Länders were very high in the period before unification, but also that the average correlations between all Länders after unification are very low, although they are increasing. Figure 3 shows that the standard deviations for all Länders substantially increased due to the reunification process, but have exhibited a declining trend afterwards, clearly demonstrating the strong impact of the reunification on the country. Performing the same exercise with a fifteen year window results in the same conclusions, although average bilateral correlations and standard-deviations are smoother. Also, results for the BK filter strongly support these results.

Results from the rolling windows analysis suggest a strong division between Western and Eastern Länders and also a strong impact of the process of reunification. So, we will assess the statistical significance of the trends suggested by the rolling windows analysis, both as regards differences between Western and Eastern Länders and also differences between periods (before and after reunification) regarding only the behaviour of Western Länders. As previous studies have done - e.g. Wynne and Koo (2000), Clark and van Wincoop (2001), and Beine and Coulombe (2003) - we estimate the variance-covariance matrix of the bilateral correlation coefficients by the generalized method of moments (GMM). More specifically, we compute Newey-West standard errors and covariances.

Table 7 gives us significance results for the period 1991-2007 for average bilateral correlations between all Länders, Western Länders, and also Eastern Länders. As we can see average bilateral correlations are all statistically significant but reflect strong differences between the Western and Eastern parts of Germany, as we can see by the value of average bilateral correlations for all

Länders.

Table 7 - Significance of Average Bilateral Correlations 1991-2007

All Länders	*Western Länders*	*Eastern Länders*
0.16*	0.65***	0.95***
(0.09)	(0.04)	(0.02)

Note: (*), (**), and (***) denote significance at 10%, 5%, and 1% levels, respectively. Numbers in parentheses are Newey-West standard errors. Berlin is included in Western Länders.

It is also assessed if there is a significant difference in average bilateral correlations between Western and Eastern Länders - what Clark and van Wincoop (2001) called the border effect in their Europe versus USA comparison. The difference in average bilateral correlations between Western and Eastern Länders between 1991 and 2007 is statistically significant as can be seen in Table 8. This result can be one evidence that supports the existence of two very distinct and separate groups (or clusters) in Germany, which we will test when we explore cluster analysis.

Table 8 - Average Bilateral Correlations: Comparing Eastern and Western Germany (1991-2007)

	Western Länders
Eastern Länders	-0.30^{***}
	(0.04)

Note: (***) denotes significance at 1% level. The entry is the difference in average pairwise correlations between Eastern Germany in row and Western Germany in column. Numbers in parentheses are Newey-West standard errors. Berlin is included in Western Länders.

Although average bilateral correlations between Western Länders have increased in the period after reunification (1989-2007), the difference between the two periods is not statistically significant, as we can see in Table 9. These Länders did not diverge cyclically due to the reunification process.

Table 9- Significance of Average Bilateral Correlations

	Western Länders
$1970-1988$	
	0.75***
	(0.04)
$1989-2007$	
	0.83***
	(0.07)
Change	0.08
	(0.08)

Note: (***) denotes significance at 1% level. Numbers in parentheses are Newey-West standard errors. West Berlin is excluded.

Results for the BK filter strongly support this evidence.

5.2 Core-Periphery Patterns

We performed cluster analysis to analyze the evolution of convergence between the Länders and Germany. Since the standard deviations of the output gap correlations have increased since the reunification process, as we have seen in the last section, and also differences in average bilateral correlations are significant, this may also be a consequence of an increasing difference between Western and Eastern Länders. Maybe these regions are becoming closer to each other in terms of comovements and others are getting farther apart. This in turn, may lead to the formation of a core-periphery situation in Germany.

Cluster analysis was performed for the evolutions of the output gaps, with a ten-year span for each cluster analysis. This time span was also used as a benchmark in the rolling windows analysis, so, for comparison reasons it was also used here.

The hierarchical agglomerative cluster method was used, i.e., a method which begins with each individual region being a single cluster and ends with all the regions in the same cluster, if not stopped earlier. In order to use this method, an aggregation (or desegregation) criterion must also be chosen, and in this case the complete linkage (or furthest neighbour) method was chosen. With this method the distance between two groups is defined as the distance between its least similar members. Given two groups (l, j) and (k), the distance (d) between them is the biggest distance between their members:

$$d_{(l,j)k} = \max\{d_{lk}; d_{jk}\}$$

The Pearson correlation coefficient was chosen as a distance measure. This distance measure was chosen so that it would be possible to compare between these results and the results from the other sections. The first cluster that is formed tends to be the most homogeneous, i.e., the one that presents the highest correlations between its members.

We decided to stop cluster formation before the correlation coefficient goes below the average bilateral correlations of the Länders. These values were obtained in the previous section. With this method, the number of clusters in each period can be obtained. Sensitivity analysis was also performed on the hypothesis for cluster formation, in order to check if the results change substantially with the change in the criterion. Thus, in this last exercise it was decided to stop cluster formation before the correlation coefficient went below the value for average bilateral correlations plus half a standard deviation of those bilateral correlations.[10]

The German economy was subject, in recent years, to a process of reunification of two very different economies. Cluster formation strongly highlights this fact, as shown in Table 10. Western Länders exhibited a strong common cycle both after and before German reunification, whilst the Eastern Länders share common business cycles characteristics and most of them belong to the same cluster (they are represented in bold). However, we must be careful in drawing

[10] Results are available upon request.

conclusions, since the time span is too short to make robust conclusions for these economies, given that they are still on their transition paths. Results for the sensitivity analysis do not change the results significantly, especially after reunification, due to the substantial differences in correlations between the "two parts" of Germany.

Table 10 - Cluster Evolution for Germany

	1970-79	1978-87	1988-1997	1998-07
Cluster 1	HES, BAY, NSA NRW, BAW RPF, HBG	BAY, NSA, BAW HES, RPF NRW, HBG	NRW, SHO, HBG, BAY, BRE, SAA, RPF NSA, BAW, HES,	**SAN, BRA, MEV, THU**
Cluster 2	BLNW, BRE	BRE, SAA		NRW, SHO, HBG, BAY BRE, BAW, HES
Cluster 3		BLNW, SHO		**BLN**, NSA, SAA, RPF
Average for the Bilateral Correlations	0.69	0.83	0.08	0.57
Value for Correlations when Cluster is stopped	0.75	0.84	0.58	0.57
Value for Correlations after Cluster is stopped	0.61	0.70	-	0.47

We can verify that there is a core (Western Länders) and a periphery (Eastern Länders), but this is due to a specific historical event in modern German history. In Western Länders a core-periphery situation does not seem evident. Strong correlations are present in every cluster, and clusters do not exhibit any type of pattern for these regions, since they are different between periods. When we tighten up the criterion for cluster formation, the Länders of Hamburg and Schleswig-Holstein are mostly left out of cluster formation, but the other Länders who remain out of cluster formation change substantially between periods. So the existence of a core-periphery in Germany is due only to a specific historical event and did not change the pattern of synchronization of Western Germany. Results for the BK filter corroborate the above results.

6 Conclusions

This paper analyzes the business cycles patterns between German Länders and its relationship with the German business cycle. We have compared business cycle volatilities, bilateral correlations, and other business cycles measures between Western and Eastern Länders, analyzing the impact of the reunification process which begun in 1990. Business cycle literature envolving Eastern Länders is still very recent and our work is a contribution to this literature. All results indicate that the synchronization of cycles is stronger between Länders of the former Western Germany and Länders of the former Eastern Germany. This indicates still strong differences between Western and Eastern Länders, concerning business cycles features. The reunification process has had a strong

influence in terms of output bilateral correlations and volatility, decreasing correlations and increasing standard-deviations in the year of the reunification. However, a process of cyclical convergence had begun, although slowly, after the reunification. Results are robust, since the use of two detrending methods, the HP filter and the BK filter, do not change conclusions.

One obvious avenue for future research is to study the main variables that explain business cycles differences between Western and Eastern German Länders.

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7 Appendix A - Map and List of Länders

Table A1 - Länders of Germany

German Länders	Weight in the Country (2007)
Baden-Württemberg (BAW)	14.7%
Bayern (BAY)	18.3%
Berlin (BLN)	3.4%
Branderburg (BRA)	2.2%
Bremen (BRE)	1.1%
Hamburg (HBG)	3.4%
Hessen (HES)	8.7%
Mecklenburg-Vorpommern (MEV)	1.4%
Niedersachen (NSA)	8.6%
Nordrhein-Westfalen (NRW))	21.4%
Rheinland-Pfalz (RPF)	4.4%
Saarland (SAA)	1.2%
Sachsen (SAF)	3.9%
Sachsen-Anhalt (SAN)	2.1%
Schleswig-Holstein (SHO)	3.0%
Thüringen (THU)	2.0%

Figure A1 - Map of German Länders

Note: Taken from http://www.planetware.com/map/germany-germany-the-Lander-map-d-germany.htm.