

Gießler, Stefan; Heinisch, Katja; Holtemöller, Oliver

**Article — Published Version**

## (Since When) Are East and West German Business Cycles Synchronised?

Jahrbücher für Nationalökonomie und Statistik

**Provided in Cooperation with:**

Halle Institute for Economic Research (IWH) – Member of the Leibniz Association

*Suggested Citation:* Gießler, Stefan; Heinisch, Katja; Holtemöller, Oliver (2020) : (Since When) Are East and West German Business Cycles Synchronised?, Jahrbücher für Nationalökonomie und Statistik, ISSN 2366-049X, De Gruyter Oldenbourg, Berlin, Boston, Iss. Ahead of Print, pp. 1-28, <https://doi.org/10.1515/jbnst-2019-0026>

This Version is available at:

<https://hdl.handle.net/10419/225272>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<http://creativecommons.org/licenses/by/4.0>

# Stefan Gießler, Katja Heinisch\* and Oliver Holtemöller (Since When) Are East and West German Business Cycles Synchronised?

<https://doi.org/10.1515/jbnst-2019-0026>

Received April 10, 2019; revised January 20, 2020; accepted January 23, 2020

**Abstract:** We analyze whether, and since when, East and West German business cycles are synchronised. We investigate real GDP, unemployment rates and survey data as business cycle indicators and we employ several empirical methods. Overall, we find that the regional business cycles have synchronised over time. GDP-based indicators and survey data show a higher degree of synchronisation than the indicators based on unemployment rates. However, synchronisation among East and West German business cycles seems to have become weaker again recently.

**Keywords:** business cycles, synchronization, East Germany

**JEL Classification:** C32, E32, R11

## 1 Introduction

Convergence between the East and the West German economies is a very important topic in German policy debates. Several contributions within a special issue of this journal on 25 years of German Reunification (Pfeifer et al. 2016) investigated core areas such as labor markets, productivity, trade, and convergence and found that there are still substantial differences between both parts of Germany (see also Maseland 2014). Thirty years after the fall of the Berlin wall, East Germany is still structurally and economically different from West Germany in terms of GDP per capita, productivity and unemployment (Gropp/Heimpold 2019). For instance, GDP per capita in East Germany is still 20 % lower compared to West Germany. These differences are much larger than the differences between North and South Germany. However, whether and to what degree regional business cycles

---

\*Corresponding author: **Katja Heinisch**, Halle Institute for Economic Research, Kleine Maerkerstraße 8, Halle (Saale) D-06108, Germany, E-mail: [katja.heinisch@iwh-halle.de](mailto:katja.heinisch@iwh-halle.de)  
<https://orcid.org/0000-0002-2664-4950>

**Stefan Gießler:** E-mail: [stefan.giessler@iwh-halle.de](mailto:stefan.giessler@iwh-halle.de), **Oliver Holtemöller:**  
E-mail: [oliver.holtemoeller@iwh-halle.de](mailto:oliver.holtemoeller@iwh-halle.de), Halle Institute for Economic Research, Kleine Maerkerstraße 8, Halle (Saale) D-06108, Germany

are synchronised is still an open question. Even before unification, East and West Germany established a monetary union in July 1990. While not being an optimal currency area (OCA) at that time according to the criteria discussed by Mundell (1961) and by McKinnon (1963), business cycles were expected to synchronise between East and West Germany due to common monetary policy, labor mobility, fiscal transfers and a single market for goods and capital. Frankel and Rose (1998) argued that a common currency increases trade and reduces asynchronous shocks. Consequently, we test whether East and West German business cycles became more synchronised over time.

The identification of business cycle fluctuations in East and West Germany is also important for the ongoing assessment of economic convergence between East and West. Comparing actual GDP (growth) in East and West Germany may be misleading in terms of economic convergence if business cycles are not synchronised. Even in the case of synchronised booms and recessions, different amplitudes in East and West can lead to misleading views of convergence. It is also important to get deeper insights into the patterns of regional business cycles, which provide the basis for (regional) fiscal policy decisions and federal policies to mitigate economic differences. Regional analyses are also highly relevant at the European level, especially regarding regional policies dealing with diminishing interregional differences (“Cohesion Policy”).

Business cycle synchronisation has extensively been analysed in the light of the enlargement of the European Union (EU) and with regard to the question whether the new EU member states are eligible to join the European Monetary Union (see, e. g. Artis/Zhang 1997; Fidrmuc/Korhonen 2006; Darvas/Szapáry 2008; Belke et al. 2017). Recently, the synchronisation literature has analysed in more detail the effects of trade and financial integration on business cycle synchronisation (e. g. Gong/Kim 2018) and the role of *Animal Spirits* (De Grauwe/Ji 2017). It has been shown that synchronisation has weakened after the Great Recession, both within Europe and between Europe and the US, although synchronisation of business cycles was high prior to 2008 (Grigoraş/Stanciu 2016; Belke et al. 2017). However, business cycle analyses at a regional level are rare. Often it is assumed that all regions of a country have identical economic structures. However, regions with asymmetric industrial specialisation will also tend to face asymmetric shocks. Regional specialisation stimulates economic integration more on the regional level than on the national level (Fatás 1997). Barrios and de Lucio (2003) argue that the dynamics of regional business cycles affect the way that national economies adjust to economic integration. Meanwhile, some studies have analysed synchronisation across European NUTS regions (e. g., Barrios/de Lucio 2003; Belke 2007; Montoya/de Haan 2008; Siedschlag/Tondl 2011; Bierbaumer-Polly et al. 2016; Gómez-Loscos et al. 2019). Recently, regional

business cycle analyses for US states have been conducted by Aguiar-Conraria et al. (2017), for provincial business cycles in Canada by Lange (2017) or for Australian states by Dixon and Shepherd (2013). For Germany, Inklaar et al. (2008), Schirwitz et al. (2009a,b,c) and Ferreira-Lopes and Sequeira (2011) have analysed synchronisation of business cycles across German states and found stronger synchronisation within West Germany and East Germany. To our knowledge, no study has provided evidence that the East and West German business cycles are synchronised. The purpose of this paper is therefore to analyse whether the cyclical economic development in East Germany is like that in West Germany, and hence whether Germany exhibits a single synchronised business cycle or if separate regional business cycles exist. Our analysis builds on a variety of business cycle indicators and it makes use of a new dataset that was provided by the Halle Institute for Economic Research (IWH) for quarterly GDP data at the regional level.

The structure of this paper is as follows: Section 2 describes the relevant economic indicators, Section 3 provides the empirical analysis, and Section 4 concludes and summarises the main findings.

## 2 Business cycle indicators in East and West Germany

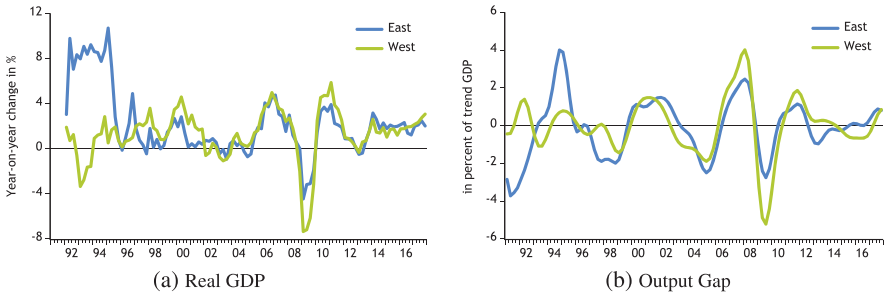
### 2.1 Data

We distinguish between two regions—East Germany and West Germany. The former consists of Brandenburg, Saxony, Saxony-Anhalt, Thuringia, Mecklenburg-West Pomerania and Berlin. The remaining 10 states belong to West Germany. We refer to common business cycle indicators, such as GDP and (un)employment rate.<sup>1</sup> Since quarterly GDP data for East Germany is not provided by the German Federal Statistical Office, we make use of a new dataset on quarterly regional GDP series provided by the Halle Institute for Economic Research (IWH).<sup>2</sup> We assess quarterly, seasonally adjusted GDP growth for the period 1991 to 2017. As a measure for the cycle, we calculate the deviation from a trend (output gap). Trend GDP is based on a full sample asymmetric band-pass

---

<sup>1</sup> In contrast to Ferreira-Lopes and Sequeira (2011), our main analysis is not based on per capita indicators.

<sup>2</sup> See Claudio et al. (2020) for further description of the data. The data is available at <http://www.iwh-halle.de/en/research/data-and-analysis/macroeconomic-reports/macro-data-download/>



**Figure 1:** Production in East and West Germany.

Note: Year-on-year percentage changes for GDP growth. The output gap is based on an asymmetric band-pass filter (Christiano/Fitzgerald 2003).

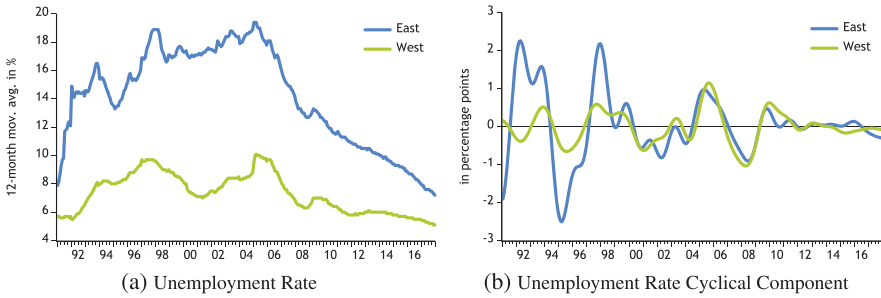
Sources: German Federal Statistical Office, IWH and own calculations.

(frequency) filter by Christiano and Fitzgerald (2003) that eliminates both high and low frequency fluctuations.<sup>3</sup> Figure 1 shows the year-on-year GDP growth rates in East and West Germany and the corresponding output gaps.

Data for monthly unemployment is provided by the Federal Employment Agency (BA) for East and West Germany at monthly frequency. First differences of seasonally adjusted unemployment rates are used for the period 1991M1 to 2017M12. The unemployment rate can be divided into a component linked to the business cycle (cyclical component of unemployment rate) and a longer-term component (structural component). The first is obtained by using the asymmetric band-pass filter that was developed by Christiano and Fitzgerald (2003). Unemployment rates and cyclical component of unemployment rates are shown in Figure 2.

Both figures indicate that the business cycle patterns of East and West became more similar over time. While GDP growth was higher in East Germany than in West Germany at the beginning of the 1990s, the catching-up process has slowed down substantially since the mid-1990s. During the financial crisis, the East German economy was less affected. However, also the subsequent recovery was weaker than in West Germany. The unemployment rate in East Germany is much higher over the whole sample, with peak values above 19% in 2006. In the subsequent years, both the labor market reforms and the migration from East to West Germany contributed to an ongoing decrease of the East German unemployment rate. In recent years, the unemployment rate in West Germany has stabilised

<sup>3</sup> Although the Hodrick-Prescott (HP) filter is heavily criticised in the literature (Hamilton 2018), such as for spurious dynamic relations and spurious dynamics, we apply this filter for robustness. The results are very similar to the results presented here.

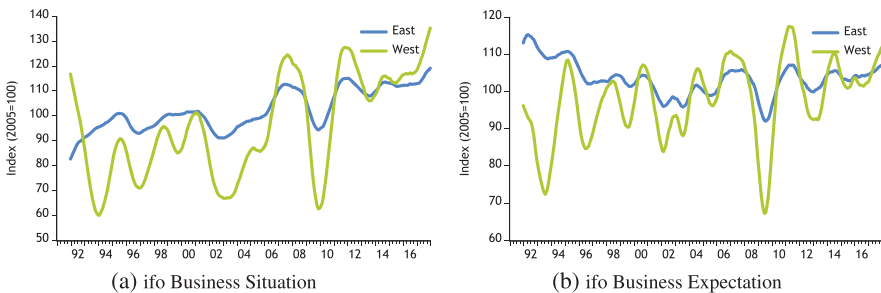


**Figure 2:** Unemployment in East and West Germany.

Note: 12 months moving averages for unemployment rate. The cyclical component of the unemployment rate is calculated with asymmetric band-pass filter (Christiano/Fitzgerald 2003). Sources: Federal Employment Agency and own calculations.

at around 5%. Although there was a huge decline in East German rates to around 7% at the end of 2017, there is still a gap between East and West German unemployment rates of about two percentage points.<sup>4</sup> The cyclical components of the unemployment rates also show that there are still huge differences between East and West Germany.

In addition to the hard indicators, we use the ifo business survey indicators for business situation and business expectations in manufacturing, construction, wholesaling and retailing (Figure 3).



**Figure 3:** Business surveys in Germany.

Note: 12 months moving averages for ifo business surveys. Sources: ifo institute and own calculations.

<sup>4</sup> By analysing the effect of regional specialisation patterns on the synchronisation of regional employment cycles, Belke (2007) find that employment growth is more synchronised when regions have a more identical sectoral structure.

A shortcoming of these indicators is that the ifo business surveys for East Germany do not include Berlin. Seasonally adjusted values are considered at a monthly frequency. In the 1990s, the survey results were different in East Germany compared to West Germany; however, both the business situation and business expectations for East and West Germany have recently become aligned with each other with regard to direction, but not amplitude. This development is even more pronounced for business expectations. Both indicators are less pronounced at their turning points for East Germany. In addition to the visual analysis, Table 5 in the Appendix summarises the business cycle statistics for the considered indicators.

## 2.2 Factor analysis of business cycle indicators

Business cycles reflect the co-movement of various indicators. For instance, the NBER's Business Cycle Dating Committee uses various measures of broad economic activity—such as real GDP, economy-wide employment, and real income—and also indicators that do not cover the entire economy—such as real sales and industrial production. To incorporate all of the indicator information on GDP, ifo expectations, ifo situation and unemployment, we construct a coincident index determined by an inverse standard deviation weighting for all indicators  $i$  (see Stock/Watson 2014):

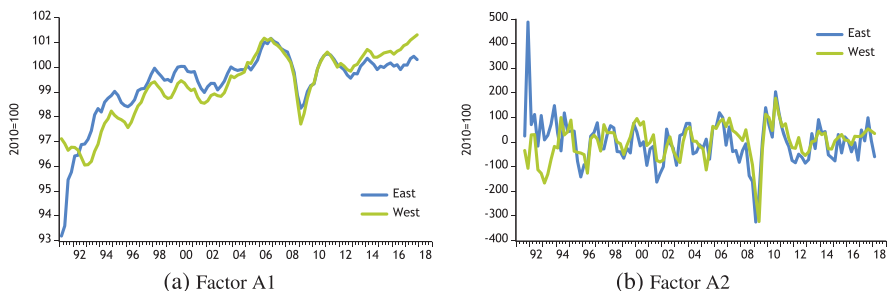
$$\text{Factor A1}_t = \exp \left[ \sum_{i=1}^4 \alpha_i \ln (X_{it}) \right], \quad (1)$$

where  $X_{it}$  is the level data in native units. Using the standard deviation  $s_i$  of the log differences  $y_{it}$ , we determine the parameter  $\alpha_i = s_i^{-1} / \sum_{j=1}^4 s_j^{-1}$ .

Furthermore, we estimate a factor model of the indicators (see, e.g. Stock/Watson 2002) where the indicators are represented by two unobservable components: the common component (factor)  $F$  and the idiosyncratic component  $\epsilon_t$ :

$$X_t = \Lambda F_t + \epsilon_t, \quad (2)$$

where  $X_t = [x_{1t}, \dots, x_{4t}]$  is a vector of stationary time series with zero mean and  $\Lambda$  is the loading matrix. To compare the common factors of both approaches we set 2010=100. Figure 4 indicates that the common factors based on the coincident index (factor A1) were only highly synchronised in the early-1990s. Since 2013, the West German common factor deviates from the East German one. Based on the principal component analysis (factor A2), the relationship among East



**Figure 4:** Common factors in East and West Germany.

Note: Common factor based on four indicators. Factor A1 based on coincident index, Factor A2 based on a factor model.

and West German common factors is less obvious because both factors are very volatile.

For robustness, we additionally check whether synchronisation increases if only three indicators (ifo expectations, ifo situation, unemployment) are considered.<sup>5</sup> In general, the results are similar to those of factors A1 and A2. However, the coincident indicator B1 is more volatile than factor A1. The East-West-factors based on the factor model B2 are much closer compared to factor A2.

### 3 Econometric analysis

Various methods have been applied in the literature to assess synchronisation between business cycles, such as correlations, synchronisation indices and historical decompositions. Using these techniques, we conduct the analysis for the East and West German business cycle.

#### 3.1 Correlation

Starting with a benchmark analysis, we determine the degree of synchronisation of the East and West German business cycles using correlations of quarterly GDP growth, output gap, first differences of unemployment rates, the cyclical component of unemployment rates and first differences of survey data for the time period between 1991 and 2017. First, contemporaneous correlation coefficients

<sup>5</sup> Results for factor B1 (coincident index) and factor B2 (DFM) are provided in the appendix (Figure 8).



between the indicators are considered. Cycles are synchronised if the coefficients are positive and statistically significant. The higher the coefficient of correlation, the higher the degree of business cycle synchronisation. Second, we consider leads/lags in correlation (cross correlations) to identify whether the East German cycle is leading, lagging or coincident to the West German cycle.

Table 1 illustrates the results of the correlation coefficients (panel A) for different samples and presents the results of the test of difference for the correlation coefficients (panel B). In the first column of panel A, the results are presented for the full sample period from 1991 to 2017. The correlation coefficient for the output gap (0.59) is slightly higher than for the cyclical component of the unemployment rates (0.55) for contemporaneous synchronisation. Correlation of business situation surveys did not differ from correlation of business expectations surveys (0.47). Correlation of GDP growth in East and West Germany is weak. However, this result is heavily biased given large growth rates of East German GDP in the beginning of the 1990s. In the second and third column of panel A, the results are illustrated for two sub-samples with equal length. For all variables, the first sub-sample ranges from 1991Q1 to 2004Q2 and the second sub-sample ranges from 2004Q3 to 2017Q4, and the corresponding month, respectively. The correlation coefficients are larger for the second sub-sample as compared to the first sub-sample ( $\rho_1$  and  $\rho_2$ ) for all considered variables. This implies that the correlation, and hence synchronisation, has increased over time. For robustness, the third column of panel A presents the results of the correlation coefficients for the last 8-years, which allows an assessment of how the great recession and the subsequent recovery has affected the correlation pattern in recent years. The coefficients of the last 8-years window ( $\rho_3$ ) are smaller compared to the second sub-sample ( $\rho_2$ ) for all the considered variables. The synchronisation among the East and West German business cycles has abated after the Great Recession, this finding has also been identified by Grigoraş and Stanciu (2016) for the Euro Area.<sup>6</sup>

Panel B shows the results of two hypothesis tests, which refer to the test of difference for correlation coefficients. First, we check the null hypothesis  $H_0: \rho_1 = \rho_2$  and second  $H_0: \rho_1 \geq \rho_2$ . The null hypotheses are rejected for almost all indicators, which implies that correlation coefficients of the second sub-sample are significantly larger than those of the first sub-sample. This implies that the correlation of all indicators has increased over the considered time period, which indicates that the business cycle of East and West Germany has become more synchronised.

---

<sup>6</sup> Belke et al. (2017) finds that peripheral countries decreased synchronisation with regards to the core, non-EMU countries and among themselves.

Table 1: Correlation coefficients.

Variables	A Correlation coefficients			B Correlation coefficients test of difference		
	1991Q1–2017Q4	1991Q1–2004Q2	2004Q3–2017Q4	2010Q1–2017Q4	$H_0: \rho_1 = \rho_2$ Prob. 2-tailed	$H_0: \rho_1 \geq \rho_2$ Prob. 1-tailed
GDP growth	$\rho$ 0.05	$\rho_1$ -0.30	$\rho_2$ 0.77	$\rho_3$ 0.59	0.00***	0.00***
Output gap	0.59	0.34	0.89	0.65	0.00***	0.00***
Unemployment rate (first diff.)	1991M1–2017M12 $\rho$ 0.32	1991M1–2004M6 $\rho_1$ 0.19	2004M7–2017M12 $\rho_2$ 0.68	2010M1–2017M12 $\rho_3$ 0.29	$H_0: \rho_1 = \rho_2$ Prob. 2-tailed 0.00***	$H_0: \rho_1 \geq \rho_2$ Prob. 1-tailed 0.00***
Unemployment rate (cyclical component)	0.55	0.56	0.91	0.42	0.00***	0.00***
Business situation (first diff.)	1991M1–2017M12 $\rho$ 0.47	1991M1–2004M6 $\rho_1$ 0.29	2004M7–2017M12 $\rho_2$ 0.60	2010M1–2017M12 $\rho_3$ 0.57	$H_0: \rho_1 = \rho_2$ Prob. 2-tailed 0.00***	$H_0: \rho_1 \geq \rho_2$ Prob. 1-tailed 0.00***
Business expectation (first diff.)	0.47	0.40	0.54	0.46	0.10*	0.05**
Factor A1	0.85	0.81	0.89	0.70	0.14	0.07*
Factor A2	0.44	0.08	0.82	0.84	0.00***	0.00***
Factor B1	0.75	0.50	0.95	0.89	0.00***	0.00***
Factor B2	0.58	0.32	0.84	0.89	0.00***	0.00***

Note: \*, \*\*, \*\*\* denote rejection of the null at the 10 %, 5 % and 1 % significance level, respectively.

To assess the degree of business cycle correlation between East and West Germany, we take into account a number of lagging or leading periods (quarters or months, respectively) to measure phase shifts and analyse whether the correlation coefficient increases (Artis/Zhang 1997). Table 2a shows that correlation did not increase if a particular lead or lag of the respective indicator is considered for the full sample. However, a non-contemporaneous relationship between the two cycles may exist, if various leads/lags are taken into account. We follow the approach of multiple correlation suggested by Ferreira-Lopes and Sequeira (2011),

$$y_t^{East} = \beta_1 y_{t-3}^{West} + \beta_2 y_{t-2}^{West} + \beta_3 y_{t-1}^{West} + \beta_4 y_t^{West} + \beta_5 y_{t+1}^{West} + \beta_6 y_{t+2}^{West} + \beta_7 y_{t+3}^{West}, \quad (3)$$

where  $y_t^{East}$  is the East indicator and  $y_{t-j}^{West}$  the West German counterpart with various lead and lags, and the vice versa. The (multiple) correlation coefficient between both indicators can be calculated as square root of the  $R^2$  of regression (eq. 3). The results in Table 2b indicate that coefficients for non-contemporaneous relationships among indicators for East and West Germany do not differ much from the contemporaneous one.<sup>7</sup> Interestingly, for all of the analysed indicators, the higher degree of cyclical association is between West and non-contemporaneous East German data. Overall, both non-contemporaneous analyses indicate that correlation did not increase if lags or leads are considered. Hence, the level of synchronisation is determined by the maximum correlation at period 0.

Next, we analyse the correlations of different consecutive sub-samples. The results of the correlation coefficients in Table 1 have already revealed first evidence that the business cycle between East and West Germany has converged over time. However, correlation coefficients are prone to potential outliers that can bias the results. Therefore, we conduct a rolling window correlation analysis, which allows us to analyse the evolution of the correlation coefficients for each point in time.<sup>8</sup> For this analysis, we choose a rolling window of eight years that covers at least one cycle; additionally, we also provide results for a six-year rolling window as a robustness check.

Figure 5 shows the correlation coefficient for different indicators between East and West Germany with an 8-year (6-year) rolling window. The business cycles between East and West Germany have synchronised over the considered sample, while the GDP variables show a higher degree of synchronisation compared to unemployment. The highest synchronisation among the East and West

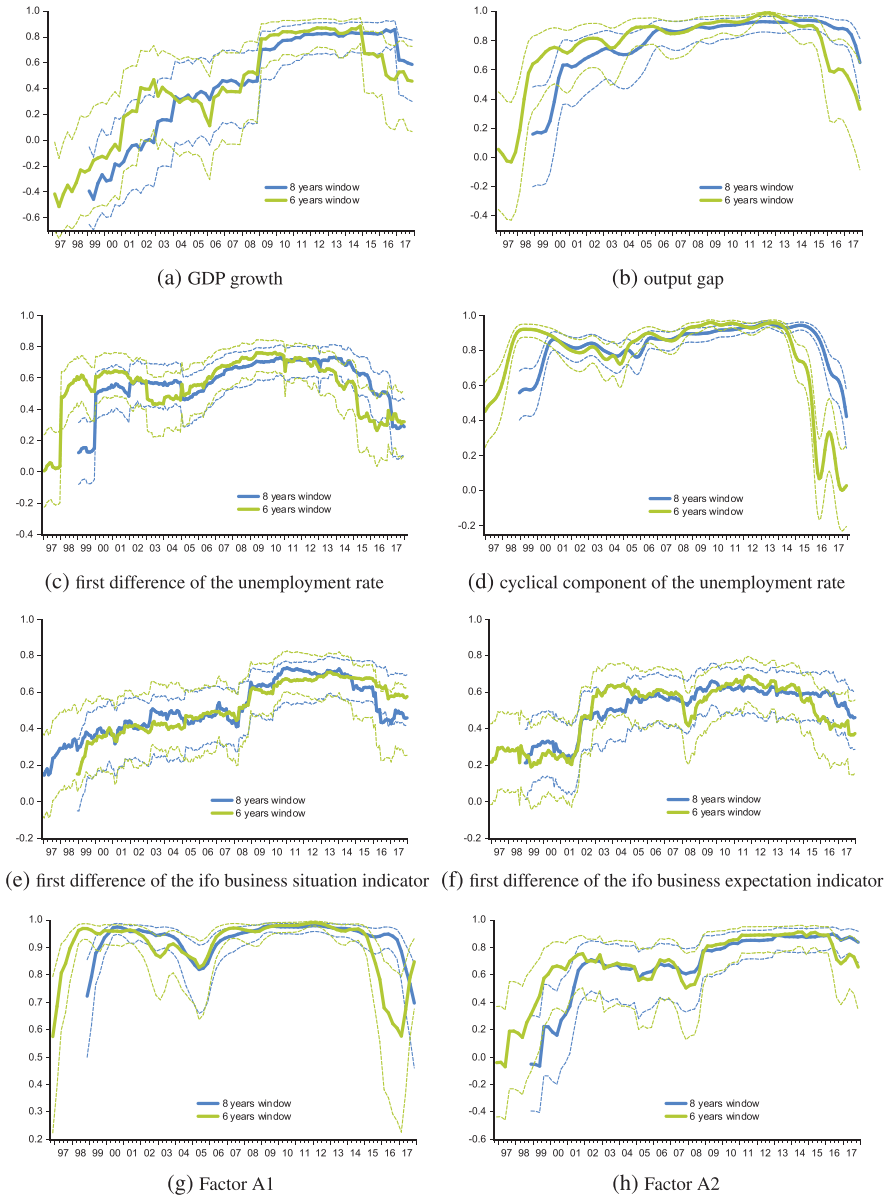
<sup>7</sup> The correlation coefficient for GDP growth in 1993–2017 is 0.30.

<sup>8</sup> To capture the time variability of correlation, several other approaches have been proposed in the literature (Cerqueira/Martins 2009; Cerqueira 2013).

Table 2: Correlation coefficients.

(a) cross correlation													
GDP qoq growth		Output gap		Unemployment rate				Business situation		Business expectation			
lag	lead	lag	lead	first diff.	lag	lead	cyclical comp.	lag	lead	lag	lead	first diff.	lead
0	0.05	0.05	0.59	0.32	0.32	0.55	0.55	0.47	0.47	0.47	0.47	0.47	0.47
1	0.08	0.17	0.55	0.25	0.22	0.54	0.56	0.08	0.08	0.08	0.08	0.08	0.19
2	0.09	0.11	0.44	0.09	0.19	0.52	0.56	0.07	0.08	0.08	0.17	0.10	0.10
3	-0.08	-0.13	0.27	0.23	0.08	0.13	0.50	0.20	0.24	0.20	0.20	0.10	0.10
4	-0.17	-0.15	0.09	0.05	0.11	0.12	0.47	0.04	0.08	0.08	0.08	0.05	0.05
5	-0.09	0.05	-0.07	-0.11	0.12	0.17	0.43	0.09	0.12	0.12	0.03	-0.02	-0.02
6	-0.04	-0.11	-0.18	-0.24	0.11	0.03	0.39	0.10	0.05	0.05	0.01	-0.01	-0.01
7	-0.18	-0.08	-0.24	-0.35	0.06	0.11	0.34	-0.04	0.01	-0.05	-0.05	-0.08	-0.08
8	-0.18	-0.09	-0.26	-0.43	0.06	0.16	0.29	0.09	0.10	-0.04	-0.04	-0.10	-0.10
(b) multiple correlation													
GDP qoq growth		output gap		unemployment rate				Business situation		Business expectation			
East / West( $\pm t$ )		lag	lead	first diff.	lag	lead	cyclical comp.	lag	lead	lag	lead	first diff.	lead
0.29 <sup>a</sup>	0.60			0.36			0.58	0.49				0.50	
0.37 <sup>a</sup>	0.70			0.41			0.59	0.57				0.69	

Note: Correlation coefficients for seasonally adjusted series are shown for 1991–2017. <sup>a</sup> Given negative R<sup>2</sup>-values, the sample is adjusted to 1993–2017. GDP and output gap at quarterly frequency. Unemployment indicators and survey data at monthly frequency. The grey line refers to contemporaneous correlation (see Table 1). The columns lag and lead indicate that West German variables lag or lead n quarters/months behind its East German counterpart. For the multiple correlation analysis, line East / West( $\pm t$ ) indicates the coefficient of correlation of East German indicators with various leads and lags for West Germany, and vice versa.



**Figure 5:** Rolling correlations.

Note: Blue-solid line – rolling correlation of the 8 year rolling window; green-solid line – rolling correlation of the 6 year rolling window; dashed lines – corresponding confidence bands based on a 5% significance level.

Sources: German Federal Statistical Office and own calculations.

German business cycles is given if common factors are considered, with coefficients above 0.9. However, all of the indicators display that the relationship between the East and West German business cycles is ambiguous since 2014; in other words, correlation is declining.

By analysing the indicators in more detail we find that in the 1990s, the correlation between East and West German GDP growth was negative and about  $-0.45$  ( $-0.45$ ), due to high growth rates in East Germany (reunification boom) and even negative growth rates in West Germany (Figure 5a). During the 2000s, the correlation coefficient increased to about 0.80 (0.85) and remained at this high level from 2009 onwards. Recently, the correlation decreased to 0.6 (or 0.4). Moreover, the rolling correlation coefficients of the 8-year rolling window show a different shape from the late-1990s through to 2005 compared to the rolling correlations of the 6-year rolling window, and the confidence bands have a wide range around the correlation curves. After 2005, the rolling correlations coefficients of the 8-year and 6-year rolling windows align to each other and the range of the confidence bands are slightly tighter around the rolling correlation curves, which indicates that the regional GDP growth rates are relatively similar. However, the cycles seem to deviate from each other from 2014 onwards.

Figure 5b indicates a strong link in the development of East and West German output gaps until 2013. Recently, the GDP trend rate in East Germany is somewhat higher, and hence correlation of output gaps decreases. Similar to GDP growth, the correlation coefficients of the 8-year and 6-year window align to each other from 2005 until 2013 and the range of the confidence bands narrows, which indicates a decline in the fluctuation of the output gap over time. After 2013, the correlation between the East and West German output gap decreases sharply to values of 0.6 (0.35) and the confidence bands widen.

For first differences of the unemployment rate of East and West Germany (Figure 5c) correlation coefficients increase slightly above 0.70 (0.75) and remain at this level until 2013/2014. From 2014 onwards, correlation coefficients decrease gradually to values above 0.35 (0.35) which is related to a more severe decline of the East German unemployment rate compared to the West German unemployment rate since 2012. The range of the confidence bands does not vary much over time when compared to the cases of GDP growth and output gap, which implies that fluctuations in the first difference of unemployment rate vary only modestly over time.

The correlation between the cyclical component of the unemployment rate of East and West Germany (Figure 5d) was high in the 1990s and increased gradually to levels above 0.9 for both the 8-year and 6-year rolling windows, and it remained at this level until 2014. From 2014 onwards, the correlation coefficients of the 8-year and 6-year rolling windows decreased to values close to 0.40 (0.0),

which is related to a sharper decline of the unemployment rate in East Germany compared to West Germany.

The correlation of ifo survey data for East Germany and West Germany (Figures 5e and 5f) indicate an increase from low to large values close to 0.70 over time and remain at this high level until 2014 and declined slightly thereafter until recently. The range of the confidence bands for both business situation and business expectations get very tight from 2000 onwards. The results of the correlation analysis for the factors (Figures 5g and 5h) support the results of the correlation analysis of the previous indicators. Results are similar for common factors B1 and B2 (Figure 9).

Overall, our results indicate that the synchronisation of the business cycle has increased over time and, in particular, the results referring to the rolling correlation analysis reveal strong evidence. Moreover, the results show that the business cycle synchronisation is more pronounced for GDP variables and is less pronounced for indicators based on unemployment rates and business confidence indicators. However, all of the indicators indicate that synchronisation has weakened again since 2014.

Furthermore, the relationship between regional sectoral patterns and the synchronisation of business cycles is important (Figure 11). Usually industry-specific shocks play a more relevant role at the regional rather than at the national level (Barrios/de Lucio 2003). Although our core analysis has not considered any sectoral perspective, we would like to point out that the sectoral structure in East Germany is only slightly different from West Germany, with less contribution by manufacturing and more contribution by construction to gross value added.<sup>9</sup> With regard to sectoral correlation, we find that sectoral synchronisation has increased and is particularly high in the manufacturing sector (see Table 6 and Figure 12). Overall, the sectoral analysis confirms our earlier results that the synchronicity of regional business cycles decreases in the most recent years. This finding has already been adumbrated by Belke (2007).

Although correlation of regional business cycles is tight, Belke et al. (2017) emphasise that different amplitudes affect the impact of policy measures. Therefore, we evaluate the amplitudes of regional cycles by measures of standard deviation of the cyclical component of GDP and unemployment rate in different periods (Table 7). In the second half of our period, the amplitudes of both cycles have aligned to each other and are even closer in the period 2010–2017. In all periods, the volatility is higher in West Germany than in East Germany.

---

<sup>9</sup> In West Germany, the share of manufacturing in total gross value added in the period 1992–2017 is about 27% , construction 5% and services 67%. In East Germany, the corresponding shares are 19% , 8% , 72%.

## 3.2 Synchronisation of business cycles phases

### 3.2.1 Cycle synchronisation index

In this section, we employ a cycle synchronisation index (CSI) to assess the degree of business cycle synchronisation (Gogas 2013). The CSI counts the sum of sign concordances ( $k_t$ ) of two indicators and relates this sum to the number of observations ( $N$ ) of the time series. The cycle synchronisation index of East Germany and West Germany is defined as follows:

$$CSI_{East,West} = \frac{\sum_{j=1}^N k_t}{N} \quad (4)$$

$$k_t = \begin{cases} 1 & \text{if } \text{sign}(x_{East,t}) = \text{sign}(x_{West,t}) \\ 0 & \text{if } \text{sign}(x_{East,t}) \neq \text{sign}(x_{West,t}) \end{cases}$$

where  $x_{East,t}$  and  $x_{West,t}$  are the values of the corresponding variables at time  $t$  of East and West Germany, respectively. The CSI value ranges between zero and one, and can be interpreted as a percentage of quarters/months for which the specific variables indicate synchronisation between the East and West German business cycle.

Table 3 illustrates the results of the cycle synchronisation index (CSI). For this analysis, we choose the same sub-samples as for the correlation analysis. In column A, the results for the entire sample from 1991 to 2017 are presented for all variables. Columns B and C report the results for the two sub-samples of equal length. Column D shows the results for the last 8 years of the sample. Column E reports the difference between the CSIs of the two sub-samples in column B and C for each of the variables. Additionally, this column reports the results of the test of difference for the two CSIs.<sup>10</sup>

The results show that the CSI is larger in the second sub-sample (C) compared to those of the first sub-sample (B) for almost all variables except for the output gap. For GDP growth and first difference of unemployment rate, the test of difference shows that the CSI of second sub-sample is significantly larger from CSI of the first sub-sample at the 1% and 5% significance level, respectively. For the output gap, the cyclical component of unemployment rate and for the ifo business confidence indicators, the tests of difference show insignificant results, which implies that the synchronisation has not increased significantly from the first to

<sup>10</sup> While the  $k_t$ -variable follows a binomial distribution, the test statistic (difference of the CSIs) follows a normal distribution.



Table 3: Cycle synchronisation indices.

Variables	A	B	C	D	E
	1991Q1–2017Q4	1991Q1–2004Q2	2004Q3–2017Q4	2010Q1–2017Q4	E = C-B
GDP growth	0.66	0.47	0.85	0.88	0.38***
Output gap	0.68	0.69	0.67	0.50	-0.02
	1991M1–2017M12	1991M1–2004M6	2004M7–2017M12	2010M1–2017M12	E = C-B
Unemployment rate (first diff.)	0.48	0.38	0.58	0.51	0.20***
Unemployment rate (cyclical component)	0.73	0.72	0.75	0.65	0.03
	1991M1–2017M12	1991M1–2004M6	2004M7–2017M12	2010M1–2017M12	E = C-B
Business situation (first diff.)	0.68	0.64	0.72	0.69	0.08
Business expectation (first diff.)	0.79	0.78	0.81	0.81	0.03
Factor A1	1.00	1.00	1.00	1.00	0.00
Factor A2	0.66	0.62	0.70	0.75	0.08
Factor B1	1.00	1.00	1.00	1.00	0.00
Factor B2	0.73	0.68	0.78	0.78	0.10

Note: \*, \*\*, \*\*\* denote rejection of the null at the 10 %, 5 % and 1 % significance level, respectively.

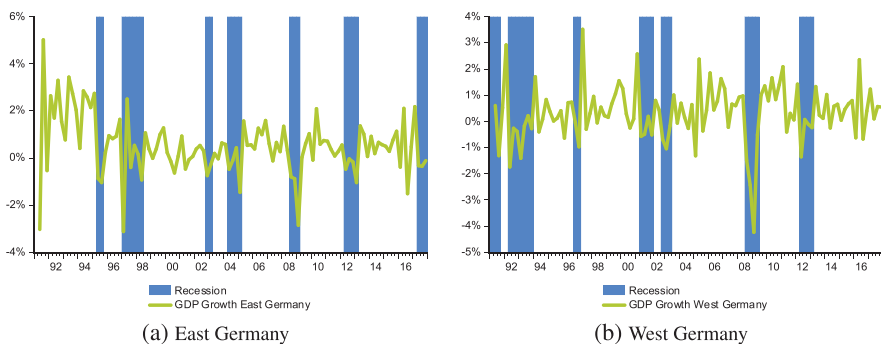
the second sub-sample. Nevertheless, the degree of synchronisation is already high for these indicators in both sub-samples. The CSI results for the common factors clearly confirm a high synchronisation among business cycles phases.

Overall, our results indicate that the synchronisation of the business cycle has increased over time. Moreover, the results show that the business cycle synchronisation is more pronounced for GDP variables and is less pronounced for indicators based on unemployment rates and business confidence indicators.

### 3.2.2 Classifying booms and recessions

Official dating of business cycle turning points does not exist for either Germany as a whole or the German states. Therefore, several authors have proposed a business cycle chronology for the German economy (Fritsche/Kuzin 2005; Schirwitz 2009) and the German states (Schirwitz et al. 2009b). However, none of them has distinguished between East and West Germany as aggregates. Therefore, we apply the methodology of Bry and Boschan (1971), which is called the BB method for describing the business cycle. This method allows isolation of turning points in the time series and detection of periods of expansion and recession. By adopting the procedure for quarterly series by Harding and Pagan (2002) (BBQ), we can calculate the different states of the business cycle for East and West Germany and, hence, can determine the recession periods.

Figure 6 shows quarterly GDP growth rates for the period 1991 to 2017, where the blue shaded areas indicate recession periods. The comparison of both figures indicates that the economic expansion and recession periods differ in the 1990s and early-2000s in terms of their occurrence and their time length. From 2004 onwards, periods of economic expansion and recession gradually aligned in



**Figure 6:** GDP growth & recession.

Note: Green line – quarterly GDP growth rate; blue-shaded areas – recession periods.

East and West Germany in terms of occurrence and time length. Synchronisation appears to be large over the entire sample and differences in the degree of synchronisation of the two consecutive sub-samples are hard to detect. Hence, we provide further analyses to address the question whether boom and recession periods have been aligned between East and West German business cycle indicators. Therefore, we apply the cycle synchronisation index for GDP, for the unemployment rate and for ifo business confidence indicators of East and West Germany, respectively. However, we use the CSI in a different way than in the previous section; that is, the concordance of boom and recession periods for each of the considered business cycle indicators are investigated.<sup>11</sup> In this context, the CSI of the respective business cycle indicator demonstrates the share of quarters/months with business cycle concordance relative to the total number of quarters/months of the (sub-)sample. Hence, a high value of the CSI implies a high degree of synchronisation of the business cycle phases in terms of GDP, the unemployment rate and the ifo business confidence indicators or among the common factors.

In Table 4, the results of the CSI calculations are illustrated. Column A reports the CSIs for the entire time period from 1991 to 2017. Column B and C report the CSIs for two sub-samples, which consist of the same time length as described in Table 2. Column D illustrates the CSIs for the last 8 years of the sample. The results show for all indicators that the CSIs are larger in the second sub-sample than the CSIs in the first sub-sample, except for the unemployment rate, where the indicator slightly decreases. This implies that the synchronisation of phases has increased over the considered period from the first to the second sub-sample for GDP and the ifo business confidence indicators. Column E reports the difference of the CSIs of the two consecutive sub-samples. Additionally, this column reports the results of the test of difference for the two CSIs for each of the four variables. For GDP, unemployment rate and ifo business situation the test of difference shows significant results, which indicates that the degree of synchronisation of booms and recessions has significantly increased for GDP and unemployment over the considered time period. For the ifo business expectation indicator, the test of difference is insignificant but the degree of synchronisation is high for both consecutive sub-samples. Furthermore, the test of difference for the factors indicates that there is significant increase of the degree of synchronisation from the first to the second sub-sample.

We conclude from these results that the degree of synchronisation of the business cycle with regard to common booms and recession has increased in

---

<sup>11</sup> The binary variable  $k_t$  is one if both the East and West German indicator  $k_t$  is in a boom or recession simultaneously, and  $k_t$  is zero otherwise.

Table 4: Cycle synchronisation indices for East-West-Germany.

Variables	A	B	C	D	E
	1991Q1–2017Q4	1991Q1–2004Q2	2004Q3–2017Q4	2010Q1–2017Q4	E = C-B
GDP	0.81	0.65	0.98	1	0.33***
	1991M1–2017M12	1991M1–2004M6	2004M7–2017M12	2010M1–2017M12	E = C-B
Unemployment	0.74	0.57	0.91	0.91	0.34***
	1991M1–2017M12	1991M1–2004M6	2004M7–2017M12	2010M1–2017M12	E = C-B
Business Situation	0.78	0.69	0.87	0.88	0.18**
Business Expectation	0.81	0.80	0.83	0.88	0.04
Factor A1	0.81	0.74	0.88	0.88	0.15**
Factor B1	0.81	0.70	0.91	0.88	0.21***

Note: \*, \*\*, \*\*\* denote rejection of the null at the 10%, 5% and 1% significance level, respectively.

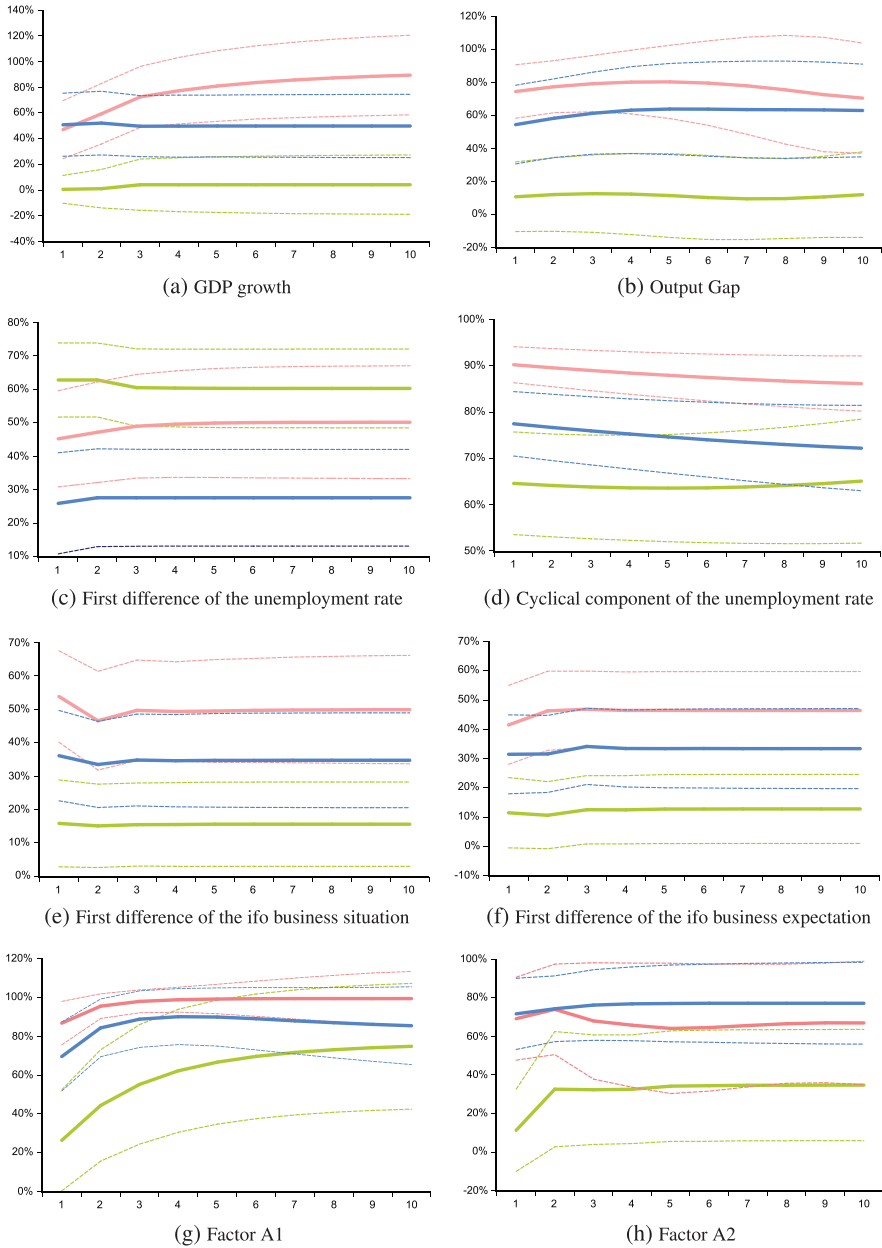
terms GDP and unemployment rate. For ifo business confidence indicators and the factors, the degree of synchronisation is high for the entire sample. These results are in line with the results of rolling correlations and CSI analysis in the previous sections.

### 3.3 Historical decomposition of business cycle fluctuations

In this section, we conduct a forecast error variance decomposition, which measures the contribution of national (total German) shocks and regional (East German) shocks to business cycle fluctuations. The analysis is based on bivariate structural vector-autoregressive models (SVAR) with two lags for national and East German GDP growth, national and East German output gap, and so on. National and regional shocks are identified by means of long-run restrictions. The identifying assumption is that regional East German shocks have no long-run effect on national variables (Chow/Kim 2003).

To investigate the stability of variance decompositions, we split the entire sample into three sub-samples of equal length (1991–1999, 2000–2008, and 2009–2017). The share of the variance that can be attributed to national shocks is illustrated in Figure 7. The remaining share of the variance that is not depicted here is accordingly attributed to East German regional shocks. The larger the variance share that is explained by national (aggregate) shocks, the higher the degree of synchronisation. After the Great Recession, the share of the variance in East German indicators that can be attributed to national shocks is above 50%. Aggregate German survey data explains about 30% of East German survey data variation. In particular, for the common factor based on the factor model (A2), there is a clear increase in the variance explained, from about 10% in first sample to almost 70% in the last sample. Similar results are obtained for common factor B2 (Figure 10).

Overall, the results from the forecast error variance decomposition analysis show inconclusive results depending on the business cycle indicator considered. The output-based indicators show a large and significant increase in business cycle synchronisation from the first to the second and third time period, although the change in the synchronisation from the second to the third time period is insignificant. For the business cycle indicators based on unemployment rates, the analysis of business cycle synchronisation lead to reverse conclusions compared to the results of the output-based indicators. From the first to the third time periods, the business cycle synchronisation declined substantially and significantly, at least for the cyclical component of the unemployment rate. However, the synchronisation is still at a high level. For the two ifo business confidence indicators,



**Figure 7: Variance decomposition.**

Note: Forecast error variance decomposition (FEVD) measures the share of the variance in East German indicators that can be attributed to national shocks: green line – 1991–1999; red line – 2000–2008; blue line – 2009–2017; dashed lines – corresponding confidence bands based on a 5% significance level.

business cycle synchronisation increases from the first to the third time period, but this increase is modest and insignificant.

## 4 Conclusions

In this paper, we analyse whether, and since when, East and West German business cycles are synchronised. While there have been considerable regional differences since the German monetary union was established in July 1990, regional business cycle synchronisation has overall increased until 2014. Our key finding is that all of the indicators indicate a high co-movement between the East and West German economies from the mid-2000s until 2014. This seems to support the hypothesis that optimum currency areas may emerge after a common currency has been established. However, the degree of business cycle conformity between East and West seems to have recently decreased again, which is in line with international evidence on synchronisation among national business cycles after the Great Recession. The West German labor force has increased during recent years due to migration, although the ageing population already reduces the labor force. In East Germany without the capital Berlin, population ageing is much stronger. Therefore, the East German population is older on average. The age composition of the population may effect business cycle volatility (Jaimovich/Siu 2009). However, we leave the detailed analysis of the reasons for this for future research. The business cycle indicators based on production data show larger evidence in favor of business cycle synchronisation than indicators based on unemployment rates and survey indicators. However, the findings for the ifo surveys might be distorted by the fact that they only refer to the manufacturing sector and Berlin is not included in the East German survey data. Labor market indicators still indicate differences, which arise mainly from different demographic structure and sectoral diversification.

**Acknowledgment:** We would like to thank Klaus Wohlrabe providing us the data for ifo surveys for West Germany, that are not officially published.

## References

- Aguiar-Conraria, L., P. Brinca, H.V. Gudjonsson, M.J. Soares (2017), Business Cycle Synchronization Across US States. The BE Journal of Macroeconomics 17 (1), online available. DOI:10.1515/bejm-2015-0158.
- Artis, M.J., W. Zhang (1997), International Business Cycles and the ERM: Is There a European Business Cycle? International Journal of Finance & Economics 2 (1): 1–16.

- Barrios, S., J.J. de Lucio (2003), Economic Integration and Regional Business Cycles: Evidence from the Iberian Regions. *Oxford Bulletin of Economics and Statistics* 65 (4): 497–515.
- Belke, A. (2007), Endogenous Optimum Currency Areas and the Blend of Sectors – On the Determinants of Business Cycle Correlation Across European Regions. *Journal of Economic Integration* 22 (1): 26–49.
- Belke, A., C. Domnick, D. Gros (2017). Business Cycle Synchronization in the EMU: Core vs. Periphery. *Open Economies Review* 28 (5): 863–892.
- Bierbaumer-Polly, J., P. Huber, P. Rozmahel (2016), Regional Business-Cycle Synchronization, Sector Specialization and EU Accession. *Journal of Common Market Studies* 54 (3): 544–568.
- Bry, G., C. Boschan (1971), *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*. National Bureau of Economic Research, New York.
- Cerqueira, P.A. (2013), A Closer Look at the World Business Cycle Synchronization. *International Economics and Economic Policy* 10 (3): 349–363.
- Cerqueira, P.A., R. Martins (2009), Measuring the Determinants of Business Cycle Synchronization Using a Panel Approach. *Economics Letters* 102 (2): 106–108.
- Chow, H.K., Y. Kim (2003), A Common Currency Peg in East Asia? Perspectives from Western Europe. *Journal of Macroeconomics* 25 (3): 331–350.
- Christiano, L.J., T.J. Fitzgerald (2003), The band pass filter. *International Economic Review* 44 (2): 435–465.
- Claudio, J.C., K. Heinisch, O. Holtemöller (2020), Nowcasting East German GDP Growth: a MIDAS Approach. *Empirical Economics* 58 (1): 29–54.
- Darvas, Z., G. Szapáry (2008), Business Cycle Synchronization in the Enlarged EU. *Open Economies Review* 19 (1): 1–19.
- De Grauwe, P., Y. Ji (2017). The International Synchronisation of Business Cycles: The Role of Animal Spirits. *Open Economies Review* 28 (3): 383–412.
- Dixon, R., D. Shepherd (2013), Regional Dimensions of the Australian Business Cycle. *Regional Studies* 47 (2): 264–281.
- Fatás, A. (1997), EMU: Countries or Regions? Lessons from the EMS Experience. *European Economic Review* 41 (3): 743–751.
- Ferreira-Lopes, A., T.N. Sequeira (2011), Business Cycles in Reunified Germany: Closer Together or Further Apart? *Review of Urban & Regional Development Studies* 23 (2–3): 94–113.
- Fidrmuc, J., I. Korhonen (2006), Meta-Analysis of the Business Cycle Correlation Between the Euro Area and the CEECs. *Journal of Comparative Economics* 34 (3): 518–537.
- Frankel, J.A., A.K. Rose (1998). The Endogeneity of the Optimum Currency Area Criteria. *Economic Journal* 108 (449): 1009–1025.
- Fritsche, U., V. Kuzin (2005), Prediction of Business Cycle Turning Points in Germany. *Jahrbücher für Nationalökonomie und Statistik* 225 (1): 22–43.
- Gogas, P. (2013), Business Cycle Synchronisation in the European Union: The Effect of the Common Currency. *OECD Journal: Journal of Business Cycle Measurement and Analysis* 2013 (1): 1–14.
- Gómez-Loscos, A., M.D. Gadea, E. Bandres (2019), Business Cycle Patterns in European Regions. *Empirical Economics*, published online. DOI:10.1007/s00181-019-01743-z.
- Gong, C., S. Kim (2018), Regional Business Cycle Synchronization in Emerging and Developing Countries: Regional or Global Integration? Trade or Financial Integration? *Journal of International Money and Finance* 84: 42–57.



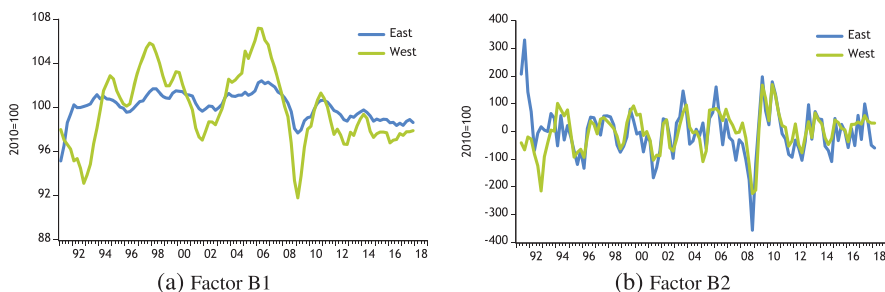
- Grigoraş, V., I.E. Stanciu (2016), New Evidence on the (de)synchronisation of Business Cycles: Reshaping the European Business Cycle. *International Economics* 147: 27–52.
- Gropp, R.E., G. Heimpold (2019). Ostdeutschland 30 Jahre nach dem Mauerfall: Erreichtes und wirtschaftspolitischer Handlungsbedarf. *Wirtschaftsdienst* 99 (7): 471–476.
- Hamilton, J.D. (2018), Why you Should Never use the Hodrick-Prescott Filter. *The Review of Economics and Statistics* 100 (5): 831–843.
- Harding, D., A. Pagan (2002). Dissecting the Cycle: A Methodological Investigation. *Journal of Monetary Economics* 49 (2): 365–381.
- Inklaar, R., R. Jong-A-Pin, J. De Haan (2008), Trade and Business Cycle Synchronization in OECD Countries – A Re-Examination. *European Economic Review* 52 (4): 646–666.
- Jaimovich, N., H.E. Siu (2009). The Young, the Old, and the Restless: Demographics and Business Cycle Volatility. *American Economic Review* 99 (3): 804–26.
- Lange, R.H. (2017), Regional Business Cycles in Canada: A Regime-Switching VAR Approach. *Journal of Regional Analysis & Policy* 47 (1): 61–78.
- Maseland, R. (2014), Does Germany Have an East–West Problem? Regional Growth Patterns in Germany Since Reunification. *Regional Studies* 48 (7): 1161–1175.
- McKinnon, R.I. (1963). Optimum Currency Areas. *The American Economic Review* 53 (4): 717–725.
- Montoya, L.A., J. de Haan (2008). Regional Business Cycle Synchronization in Europe? *International Economics and Economic Policy* 5 (1): 123–137.
- Mundell, R.A. (1961). A Theory of Optimum Currency Areas. *American Economic Review* 51 (4): 657–665.
- Pfeifer, C., W. Smolny, J. Wagner (2016), 25 Years of German Reunification. *Journal of Economics and Statistics* 236 (Special Issue): 153–322.
- Schirwitz, B. (2009), A Comprehensive German Business Cycle Chronology. *Empirical Economics* 37 (2): 287–301.
- Schirwitz, B., C. Seiler, K. Wohlrabe (2009a). Regionale Konjunkturzyklen in Deutschland - Teil I: Die Datenlage. *ifo Schnelldienst* 62 (27/28): 18–24.
- Schirwitz, B., C. Seiler, K. Wohlrabe (2009b). Regionale Konjunkturzyklen in Deutschland - Teil II: Die Zyklendatierung. *ifo Schnelldienst* 62 (14): 24–31.
- Schirwitz, B., C. Seiler, K. Wohlrabe (2009c). Regionale Konjunkturzyklen in Deutschland - Teil III: Konvergenz. *ifo Schnelldienst* 62 (32/33): 23–32.
- Siedschlag, I., G. Tondl (2011). Regional Output Growth Synchronisation with the Euro Area. *Empirica* 38 (2): 203–221.
- Stock, J.H., M.W. Watson (2002), Forecasting Using Principal Components from a Large Number of Predictors. *Journal of the American Statistical Association* 97 (460): 1167–1179.
- Stock, J.H., M.W. Watson (2014), Estimating Turning Points Using Large Data Sets. *Journal of Econometrics* 178: 368–381.

# Appendix A

**Table 5:** Business cycle statistics.

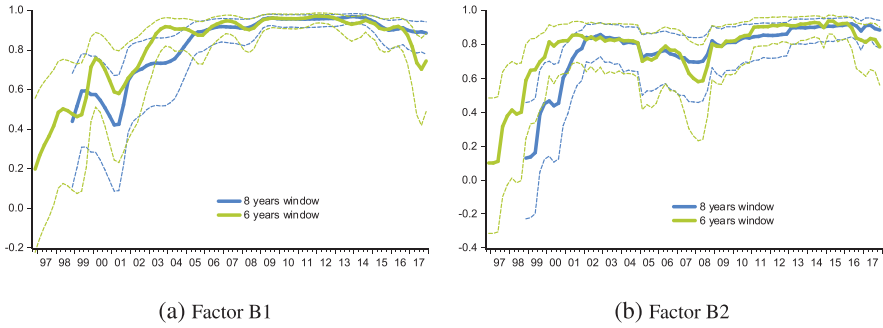
		average	average of levels	volatility	persistence
GDP qoq growth	East	0.531		1.362	-0.104
	West	0.318		0.887	0.273
output gap	East	-0.087		1.538	0.930
	West	0.003		1.487	0.922
1st diff unemployment rate	East	-0.002	14.170	0.270	0.156
	West	-0.002	7.315	0.103	0.427
cyclical component of unemployment rate	East	0.050		0.877	0.983
	West	-0.014		0.430	0.992
1st diff ifo situation	East	0.234	102.267	1.734	-0.153
	West	0.699	104.138	3.540	0.017
1st diff ifo expectation	East	0.072	103.758	1.638	-0.090
	West	0.102	103.863	2.826	0.345

Note: Sample 1991–2017. Averages for unemployment rate and ifo indicators are given for seasonally-adjusted data and the first differences. Volatility and persistence are calculated with standard-deviation and autocorrelations coefficients, respectively.



**Figure 8:** Common factors in East and West Germany.

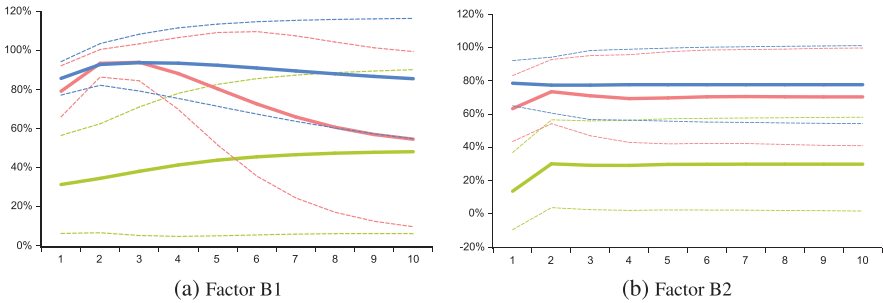
Note: Common factor based on three indicators. Factor 3 is based on coincident index, Factor 4 is based on a dynamic factor model.



**Figure 9:** Rolling correlation for factors.

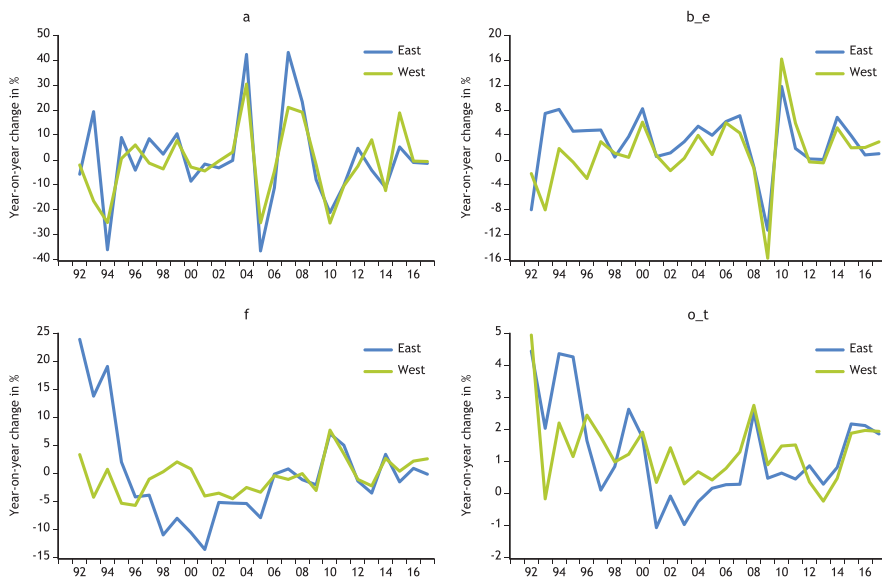
Note: Blue-solid line – rolling correlation of the 8 year rolling window; green-solid line – rolling correlation of the 6 year rolling window; dashed lines – corresponding confidence bands based on a 5 % significance level.

Sources: German Federal Statistical Office and own calculations.



**Figure 10:** Variance decompositions.

Note: Forecast error variance decomposition (FEVD) share of the variance in East German indicators that can be attributed to national shocks: Green-solid line – FEVD for 1991 – 1999; red-solid line – FEVD for 2000 – 2008; blue-solid line – FEVD for 2009 – 2017; dashed lines – corresponding confidence bands based on a 5 % significance level.



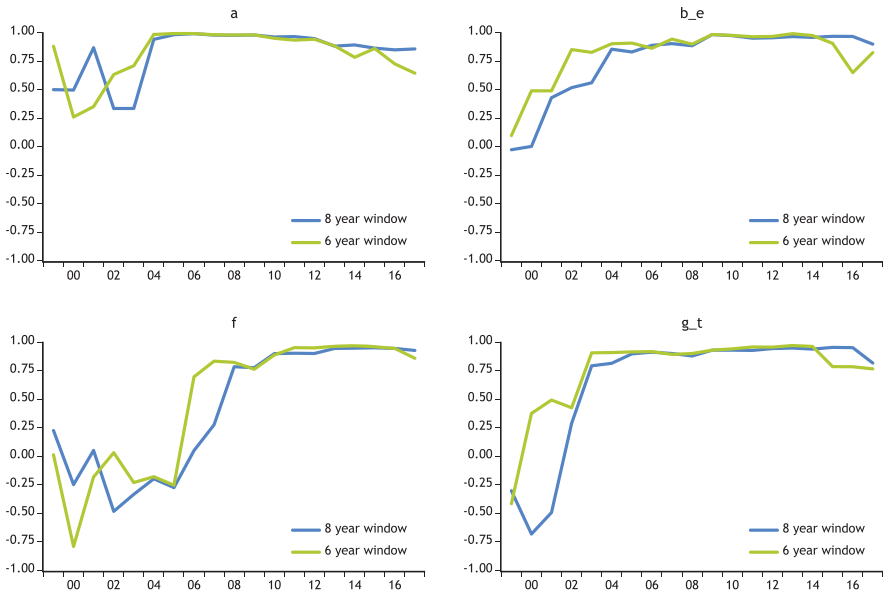
**Figure 11:** Sectoral growth rates. Note: Year-on-year percentage changes for growth in economic activity in NACE sectors are provided: agriculture, forestry and fishing (A); producing industries (B–E); construction (F), services (G–T).

Sources: German Federal Statistical Office, IWH and own calculations.

**Table 6:** Sectoral correlation.

Variables	1991–2017	1991–2004	2005–2017	2010–2017
A	0.81	0.73	0.88	0.86
B–E	0.68	0.20	0.94	0.90
F	0.36	0.28	0.88	0.93
G–T	0.44	0.26	0.91	0.82
GVA	0.25	–0.41	0.97	0.87
GDP	0.21	–0.34	0.96	0.87

Note: Correlations for economic activity in NACE sectors are provided between East and West Germany: agriculture, forestry and fishing (A); producing industries (B–E); construction (F), services (G–T), for total gross value added (GVA) and GDP at annual frequency.



**Figure 12:** Correlation between East and West sectoral growth rates.

Note: Blue-solid line – rolling correlation of the 8 year rolling window; green-solid line – rolling correlation of the 6 year rolling window between East and West.

Sources: German Federal Statistical Office and own calculations.

**Table 7:** Amplitudes of business cycles.

Variables	1991–2017	1991–2004	2005–2017	2010–2017
GDP growth				
East	1.37	1.77	0.79	0.55
West	0.89	0.83	0.95	0.53
output gap				
East	1.54	1.77	1.29	0.64
West	1.49	0.86	1.94	0.97
differences of unemployment rate				
East	0.27	0.35	0.12	0.07
West	0.10	0.10	0.11	0.05
cyclical component of unemployment rate				
East	0.88	1.18	0.40	0.13
West	0.43	0.37	0.48	0.19

Note: Amplitudes are measured by the standard deviation.