IWH
Halle Institute for Economic Research
Member of the Leibniz Association

Discussion Papers

No. 7
March 2019

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

Stefan Gießler, Katja Heinisch, Oliver Holtemöller

Authors

Stefan Gießler
Halle Institute for Economic Research (IWH) – Member of the Leibniz Association,
Department of Macroeconomics
E-mail: stefan.giessler@iwh-halle.de
Tel +49 345 7753 782

Katja Heinisch
Corresponding author
Halle Institute for Economic Research (IWH) – Member of the Leibniz Association,
Department of Macroeconomics
E-mail: katja.heinisch@iwh-halle.de
Tel +49 345 7753 836

Oliver Holtemöller
Martin Luther University Halle-Wittenberg and Halle Institute for Economic Research (IWH) – Member of the Leibniz Association,
Department of Macroeconomics
E-mail: oliver.holtemoeller@iwh-halle.de
Tel +49 345 7753 800

Editor

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

Address: Kleine Maerkerstrasse 8
D-06108 Halle (Saale), Germany
Postal Address: P.O. Box 11 03 61
D-06017 Halle (Saale), Germany

Tel +49 345 7753 60
Fax +49 345 7753 820

www.iwh-halle.de

ISSN 2194-2188

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

Abstract

This paper analyses 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 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, recently synchronisation among East and West German business cycles seems to become weaker, in line with international evidence.

Keywords: business cycles, synchronisation, East Germany

JEL classification: C32, E32, R11

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

1 Introduction

Almost 30 years after German reunification, there is substantial evidence that the East German economy is still structurally different from the West German economy in terms of GDP per capita, productivity and unemployment (see, e.g., Maseland, 2014). For instance, GDP per capita in East Germany is still, on average, 20% lower compared to total Germany. From 2014-16, the East German economy has largely benefited from the current expansion of the German economy with annual GDP growth being higher compared to growth rates in West Germany. However, this special situation was mainly driven by the "Berlin-effect" with a rapidly rising services sector. Currently, the East German growth rates are again below their West German counterparts. Based on the existence of a common monetary policy and labor mobility between East and West Germany, it is an open question whether and to what degree regional business cycles are synchronized.[1]

Analyses of European business cycles synchronization grew, particularly in the light of the EU enlargement and with regard to the question whether the new EU member states are eligible to join the monetary union (see, e.g. Artis and Zhang, 1997; Fidrmuc and Korhonen, 2006; Darvas and Szapáry, 2008; Belke *et al.*, 2017). Recently, the synchronization literature analyzes in more detail the effects of trade and financial integration on business cycle synchronization (e.g. Gong and Kim, 2018) and the role of *Animal Spirits* (De Grauwe and Ji, 2017). Recently, studies show evidence that after the Great Recession synchronization, has weakened, both within Europe and between Europe and the US, although synchronization among business cycles was high prior to 2008 (Grigoraş and Stanciu, 2016; Belke *et al.*, 2017). The European business cycle was constantly enforced by formal or informal cohesion between EU member states prior to the Great Recession.

All these studies focus on synchronization at the national level — besides European Monetary Union (EMU) as a whole, Germany is often used as benchmark. However, business cycle analyses at a regional level are rare. Some studies analyze synchronization across European NUTS regions (Montoya and de Haan, 2008; Bierbaumer-Polly *et al.*, 2016; Gomez-Loscos *et al.*, 2018) or German states (Schirwitz *et al.*, 2009a,b,c).[2] For Germany, Inklaar *et al.* (2008) and Ferreira-Lopes and Sequeira (2011) had analyzed synchronization of business cycles across German Laender and find stronger synchronization inside West German Laender and East German Laender, respectively.[3]

[1] The traditional theory of optimum currency areas (OCA) states that a high degree of business cycle synchronization is an important criterion for participation in a monetary union (Mundell, 1961).

[2] 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).

[3] Focusing on the long-run perspective, Funke and Strulik (2000) are using a calibrated model to apply different fiscal policy rules causing convergence of regional output per capita.

It is important to get deeper insights into the different regional business cycle developments which provide the basis for (regional) fiscal policy decisions and related federal subsidies. Regional analyses are also highly relevant at the European level with regard to regional policies dealing with diminishing interregional differences ("Cohesion Policy"). Therefore, it is of the utmost importance for policy makers to know the extent to which business cycles between East and West Germany become similar — given that the German states have their own responsibility for federal fiscal policy. In addition, this is essential because policy decisions at the national level could affect the East and West differently. Therefore, we analyze whether the cyclical economic development in East Germany is similar to that in West Germany, and, hence, whether Germany exhibits a single synchronized business cycle or if separate regional business cycles exist. Our analysis builds on a variety of business cycle indicators and makes use of a new data set provided by the Halle Institute for Economic Research for quarterly GDP data at the regional level. In addition to static analyses of business cycle co-movements, we allow for time-varying analyses.

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

2 Business cycles indicators in East and West Germany

2.1 Data

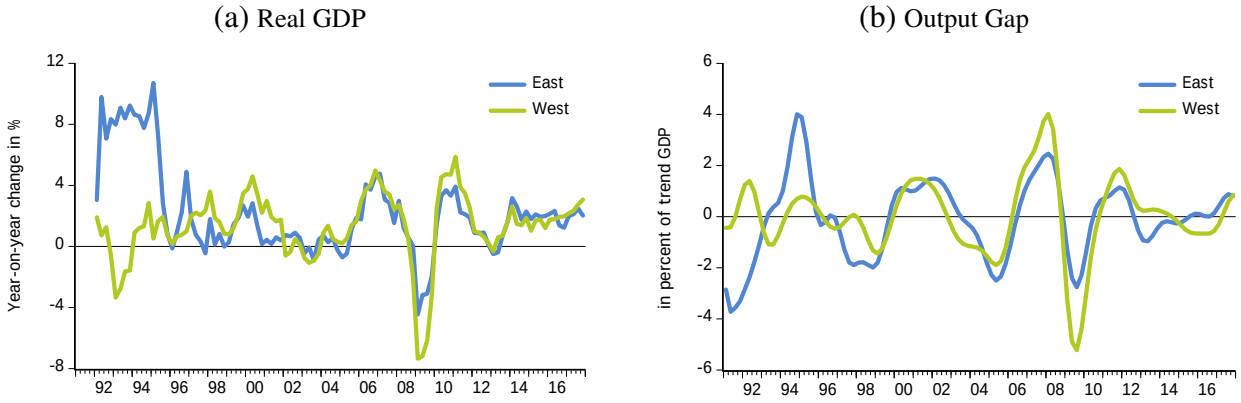
Instead of focusing on individual German states, we distinguish between two regions — East Germany and West Germany. The former consists of Brandenburg, Saxony, Saxony-Anhalt, Thuringia, Mecklenburg-West Pomerania and Berlin. The remaining states cover West Germany. We refer to common business cycle indicators, such as GDP and (un)employment rate. Since quarterly GDP data for East Germany is not provided by the German Federal Statistical Office, we make use of a new data set on quarterly regional GDP series provided by the Halle Institute for Economic Research (IWH).[4] We assess quarterly, seasonally adjusted GDP growth for the period 1991 to 2017.[5] 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 (frequency) filter by Christiano and Fitzgerald (2003)

[4] See Claudio *et al.* (2018) for description of the data. Data is available at `http://www.iwh-halle.de/en/research/data-and-analysis/macroeconomic-reports/macro-data-download/`

[5] In contrast to Ferreira-Lopes and Sequeira (2011) we do not consider the per capita indicators.

that eliminates both high and low frequency fluctuations.[6] Figure 1 shows the year-on-year GDP growth rates in East and West Germany and the corresponding output gap.

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 and Fitzgerald, 2003).
Sources: German Federal Statistical Office and own calculations.

Data for 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 of Christiano and Fitzgerald (2003). Unemployment rates and cyclical component of unemployment rates are shown in Figure 2.

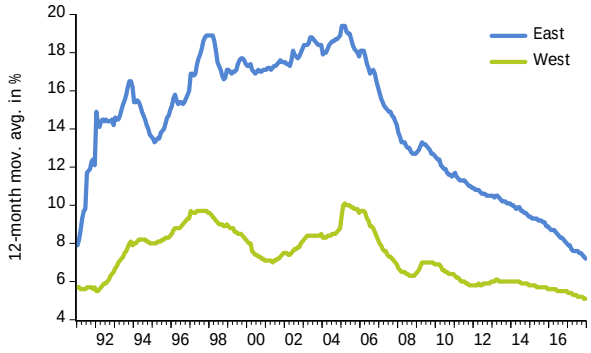
Both figures indicate that the pattern between East and West data become more similar. While annualized GDP growth was substantially higher in East Germany than in West Germany at the beginning of the 1990's, the year-on-year growth rate is currently about 2.2%, which is in line with the corresponding rates in West Germany.[7] During the financial crisis, the East German economy was less affected in terms of economic slump. However, also the subsequent recovery was lower than in West Germany. In 2017, the regional actual growth rates exceeded the corresponding trends and, hence, result in a positive output gap. The unemployment rate in East Germany is much higher over the whole sample, with peak values in 2006 above 19%. In the subsequent years, both the

[6] Although the Hodrick-Prescott (HP) filter is heavily criticized in the literature (Hamilton, 2017), e.g. for spurious dynamic relations and spurious dynamics, we apply this filter for robustness. However, the results for the empirical analysis are relatively similar.

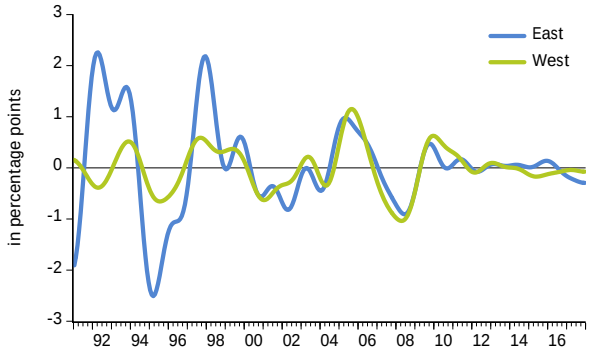
[7] Negative growth rates in West Germany in 1993 were mainly caused by a recession with high unemployment, high inflation rate and weak exports.

Figure 2: Unemployment in East and West Germany

(a) Unemployment Rate



(b) Unemployment Rate Cyclical Component

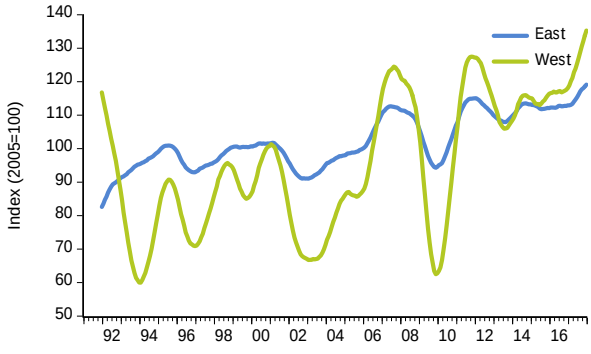


Note: 12 months moving averages for unemployment. The cyclical component of the unemployment rate is calculated with asymmetric band-pass filter (Christiano and Fitzgerald, 2003).
Sources: Federal Employment Agency and own calculations.

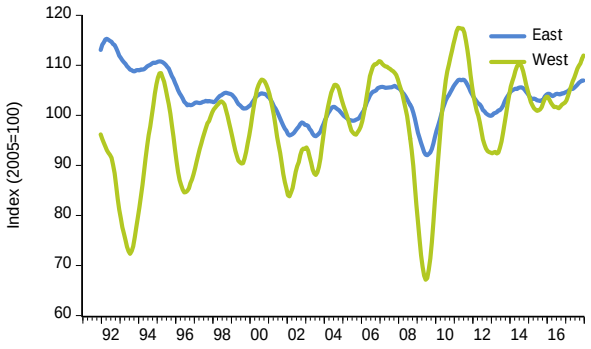
implemented labor market reforms and a huge migration from East to West Germany contributed to an ongoing decrease of the East German unemployment rate. In recent years, the unemployment rate in West Germany has stabilized at around 5%. Although there was a huge decline in East German rates to around 7% at the end of 2017, there is still a gap between East and West German unemployment rates of about two percentage points. Also, with regard to the cyclical component, there are still huge differences among East and West German rates.

Figure 3: Business surveys in Germany

(a) ifo Business Situation



(b) ifo Business Expectation



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

In addition to the hard indicators presented above, we make use of the ifo business survey indicators for business situation and business expectations in trade and industry (Figure 3) published

by the ifo institute in Munich. A shortcoming of this indicator is that the ifo business surveys for East Germany do not include data for Berlin. Seasonally adjusted values are considered at a monthly frequency. In the 1990's, the survey results were different in East Germany compared to West Germany; however, in recent years, both the business situation and business expectations for East and West Germany have become aligned with each other with regard to direction, not amplitude. This development is even more prominent for business expectations. Moreover, both indicators are less pronounced at their turning points for East Germany.

In addition to the visual analysis, Table 5 in the Appendix summarizes the business cycle statistics. In line with Figure 1, average GDP growth in East Germany is slightly higher. However, the average unemployment rate in East Germany is almost twice as much as in West Germany (Figure 2). The ifo business situation indicator is, on average, higher in West Germany, the expectation indicator is higher in East Germany. The latter is mainly distorted by high expectations in the 1990's. Standard–deviations (volatility) figures show that data for East Germany is much more volatile, with the exception of ifo business situation. Persistence — measured by autocorrelations coefficients — is not very high, and is slightly higher in West Germany.[8]

2.2 Factor analysis of business cycle indicators

The literature has shown that is ambiguous to rely on a single indicator to determine the dating of the business cycle and to assess synchronization. For instance, the NBER's Business Cycle Dating Committee uses various measures of broad economic activity, such as real GDP — both on the production and income side —, economy-wide employment, real income and also indicators that do not cover the entire economy, such as real sales and industrial production. To incorporate all 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 and Watson, 2014):

$$\text{FactorA1}_t = exp\left[\sum_{i=1}^{4} \alpha_i ln\left(X_{it}\right)\right], \tag{1}$$

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

[8] Only output gap and cyclical component of unemployment show high persistence for both regions.

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

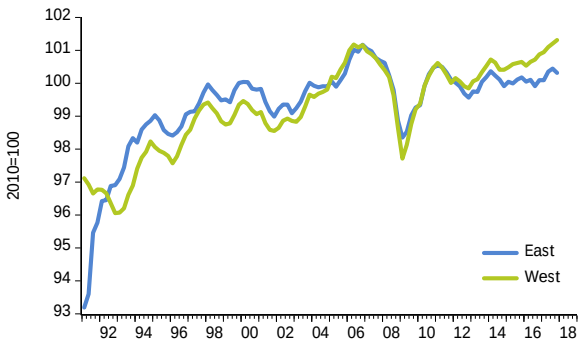
$$\mathrm{X}_t = \Lambda F_t + \epsilon_t, \tag{2}$$

where $X_t = [x_{1t}, ..., x_{4t}]$ is a vector of stationary time series with zero mean, Λ is the loading matrix such that $[\lambda_1, ..., \lambda_4]'$, the common components $\chi_t = \Lambda F_t$ are driven by a small number of factors common to all variables. 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) are highly synchronized, only in the early 1990's and since 2013 does the West German common factor deviate from the East German one. Based on the principal component analysis (Factor A2) the relationship among East and West German common factors is less obvious, as both factors are very volatile.

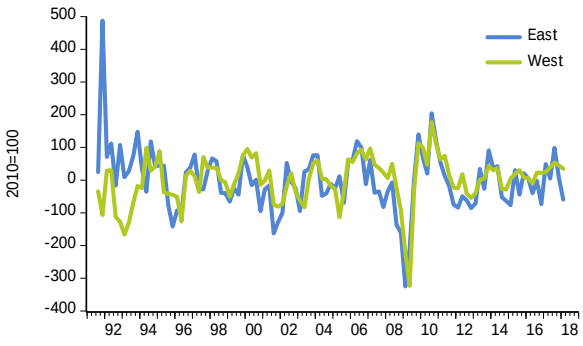
For robustness, we additionally check whether synchronization increases if only three indicators (ifo expectations, ifo situation, unemployment) are considered.[9] In general, the results are relatively similar to those of Factor A1 and A2. However, the coincident indicator is more volatile than Factor A1. The East-West-factors based on the factor model are much closer compared to Factor A2.

Figure 4: Common Factors in East and West Germany

(a) Factor A1



(b) Factor A2



Note: Common factor based on four indicators. Factor 1 based on coincident index, Factor 2 based on a factor model.

[9] Results for Factor B1 (coincident index) and Factor B2 (DFM) are provided in the appendix (Figure 7).

3 Econometric analysis

For assessing synchronization between business cycles, various methods have been applied in the literature, e.g. correlations, synchronization indices and historical decompositions. Using these techniques, we conduct the analysis for the East and West German cycle.

3.1 Correlations

Starting with a benchmark analysis, we are determining the degree of synchronization of the East and West German business cycle 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 between the indicators are considered. Synchronized cycles are existent if the coefficients are positive and statistically significant. The higher the coefficient of correlation, the higher the degree of correlation. 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 synchronization. Correlation among business situation surveys did not differ from those among business expectations surveys (0.47). Correlation of GDP growth in East and West Germany is weak. However, this result is heavily biased to huge growth rates of East German GDP in the beginning of the 1990's.

In the second and third column in panel A, the results for 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 (ρ_1 and ρ_2) for all considered variables. This implies that the correlation and, hence, synchronization 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 on how the great recession and the subsequent recovery has affected the correlation pattern in recent years. The coefficients of the last 8-years window (ρ_3) are smaller compared to the second sub-sample (ρ_2) for

Table 1: Correlation coefficients

Variables	A Correlation Coefficients				B Correlation Coefficients Test of Difference	
	1991Q1–2017Q4 ρ	1991Q1–2004Q2 ρ_1	2004Q3–2017Q4 ρ_2	2010Q1–2017Q4 ρ_3	$H_0 : \rho_1 = \rho_2$ Prob. 2-tailed	$H_0 : \rho_1 \geq \rho_2$ Prob. 1-tailed
GDP growth	0.05	-0.30	0.77	0.59	0.00***	0.00***
Output gap	0.59	0.34	0.89	0.65	0.00***	0.00***
	1991M1–2017M12 ρ	1991M1–2004M6 ρ_1	2004M7–2017M12 ρ_2	2010M1–2017M12 ρ_3	$H_0 : \rho_1 = \rho_2$ Prob. 2-tailed	$H_0 : \rho_1 \geq \rho_2$ Prob. 1-tailed
Unemployment rate (first diff.)	0.32	0.19	0.68	0.29	0.00***	0.00***
Unemployment rate (cyclical component)	0.55	0.56	0.91	0.42	0.00***	0.00***
	1991M1–2017M12 ρ	1991M1–2004M6 ρ_1	2004M7–2017M12 ρ_2	2010M1–2017M12 ρ_3	$H_0 : \rho_1 = \rho_2$ Prob. 2-tailed	$H_0 : \rho_1 \geq \rho_2$ Prob. 1-tailed
Business situation (first diff.)	0.47	0.29	0.60	0.57	0.00***	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.

all the considered variables. The synchronization among the East and West German business cycle has abated after the Great Recession, a finding that also was identified by Grigoraş and Stanciu (2016) for the Euro Area.[10]

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, where H_0: $\rho_1 = \rho_2$ and second, where 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 from those of the first sub-sample. This implies that the correlation of all indicators has increased over the considered time period and thus indicates that the business cycle of East and West Germany has become more synchronized.

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 analyze whether the correlation coefficient increases (Artis and Zhang, 1997). Table 2a shows that the correlation pattern did not improve if a particular lead or lag of the respective indicator is considered for the full sample. However, it might be that a non-contemporaneous

[10] Belke *et al.* (2017) find that peripheral countries decreased synchronization with regards to the core, non-EMU countries and among themselves.

relationship between the two cycles exists, if various leads/lags are taken into account. We follow the approach of multiple correlation suggested by Ferreira-Lopes and Sequeira (2011),

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

where the East indicator y_t^{East} is explained by various lead and lags of the West German counterpart, 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.[11] Interestingly, for all indicators, correlation is higher if West German data is explained by East German data. Overall, both non-contemporaneous analyses indicate that we cannot improve the relationship if lags or leads are considered. Hence, the level of synchronization is determined by the maximum correlation at period 0.

Table 2: Correlation Coefficients

	GDP qoq growth		output gap		unemployment rate first diff.		unemployment rate cyclical component		Business situation first diff.		Business expectation first diff.	
(a) cross correlation	lag	lead	lag	lead	lag	lead	lag	lead	lag	lead	lag	lead
0	0.05	0.05	0.59	0.59	0.32	0.32	0.55	0.55	0.47	0.47	0.47	0.47
1	0.08	0.17	0.55	0.53	0.25	0.22	0.54	0.56	0.08	0.08	0.27	0.19
2	0.09	0.11	0.44	0.40	0.09	0.19	0.52	0.56	0.07	0.08	0.17	0.10
3	−0.08	−0.13	0.27	0.23	0.08	0.13	0.50	0.55	0.20	0.24	0.20	0.10
4	−0.17	−0.15	0.09	0.05	0.11	0.12	0.47	0.53	0.04	0.08	0.08	0.05
5	−0.09	0.05	−0.07	−0.11	0.12	0.17	0.43	0.51	0.09	0.12	0.03	−0.02
6	−0.04	−0.11	−0.18	−0.24	0.11	0.03	0.39	0.48	0.10	0.05	0.01	−0.01
7	−0.18	−0.08	−0.24	−0.35	0.06	0.11	0.34	0.45	−0.04	0.01	−0.05	−0.08
8	−0.18	−0.09	−0.26	−0.43	0.06	0.16	0.29	0.41	0.09	0.10	−0.04	−0.10
(b) multiple correlation												
East / West($\pm t$)	0.29[a]		0.60		0.36		0.58		0.49		0.50	
West / East($\pm t$)	0.37[a]		0.70		0.41		0.59		0.57		0.69	

Note: Correlation coefficients for seasonally adjusted series are shown for 1991–2017. [a]Given negative R^2-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.

Analyzing 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 biasing the results. Therefore, we conduct a rolling window correlation analysis which allows us to analyze the evolution of the correlation coefficients for each point in time for the full sample. 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 robustness check.

[11] The correlation coefficient for GDP growth in 1993-2017 is 0.30.

Figure 5 shows the variation of the correlation coefficient for different indicators between East and West Germany with an 8-year (6-year) rolling window. The correlation analysis reveals that the business cycle between East and West Germany has synchronized over the considered sample, whereas GDP variables show a higher degree of synchronization compared to the variables referring to the unemployment rate. The highest synchronization among the East and West German business cycle is given if common factors are considered, with coefficients above 0.9. However, all indicators display that the relationship between the East and West German business cycle is ambiguous since 2014, i.e. correlation is declining.

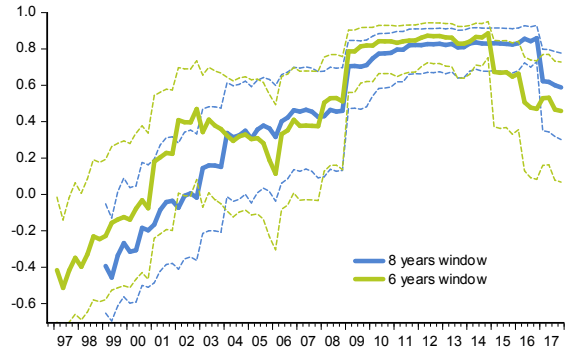
Analyzing the indicators in more detail, we find that in the 1990's, the correlation between East and West German GDP growth was negative and about -0.45 (-0.45) due to high growth rates in East Germany (reunification boom) and even negative growth rates in West Germany (Figure 5a). During the 2000's, 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 1990's 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 indicating that the regional GDP growth rates are relatively similar. However, from 2014 onwards, the cycles seem to deviate from each other.

For the East and West German output gap (Figure 5b), we find that in the 1990's, the correlation was about 0.15 (0.05) and rose up to 0.90 (0.95) thereafter, and remained at this level until 2013 which indicates a strong link in the development of both output gaps. Recently, the GDP trend rate in East Germany is somewhat higher and, hence, correlation of output gaps decreases. Furthermore, correlations of the 8-year rolling window differ from the correlations of the 6-year window from the late 1990's through to nearly 2005 and confidence bands have a wide range around the correlation coefficients. 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 indicating 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.

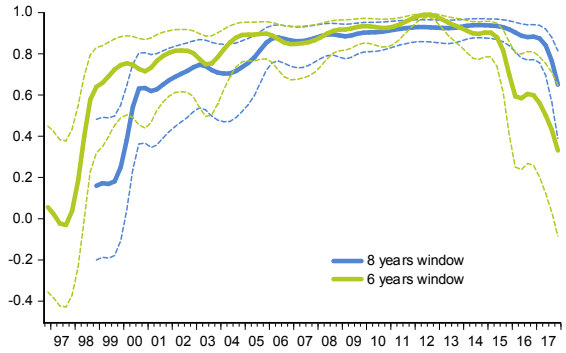
For first difference of the unemployment rate of East and West Germany (Figure 5c) correlation coefficients are between 0.10 and about 0.50 (0.05 and about 0.60) in the 1990's, and increase

Figure 5: Rolling correlations

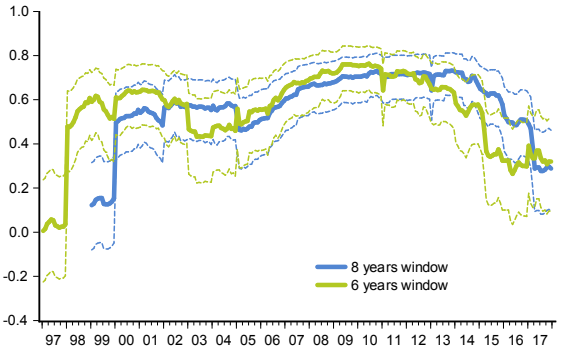
(a) GDP



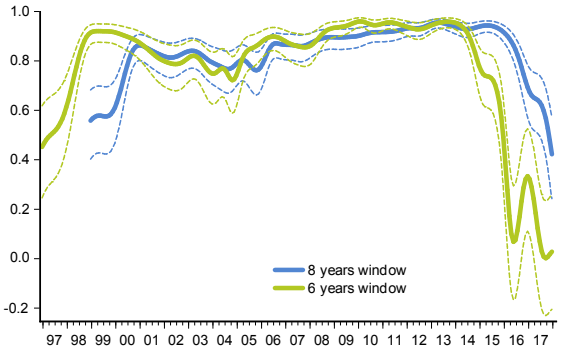
(b) Output Gap



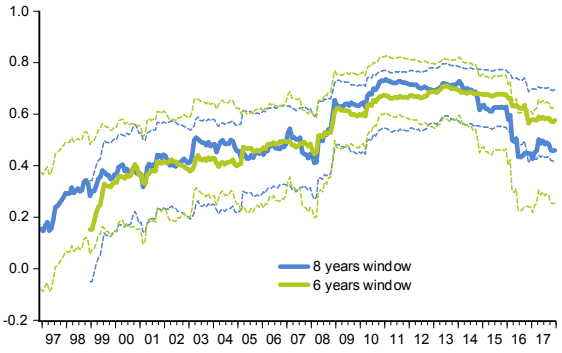
(c) first difference of unemployment rate



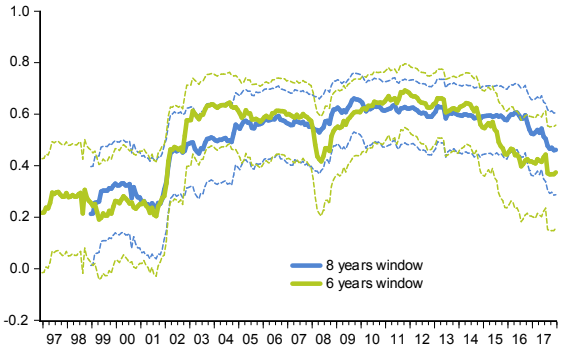
(d) cyclical component of unemployment rate



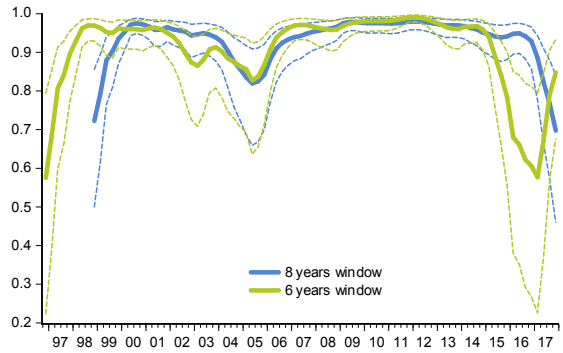
(e) first difference of ifo business situation indicator



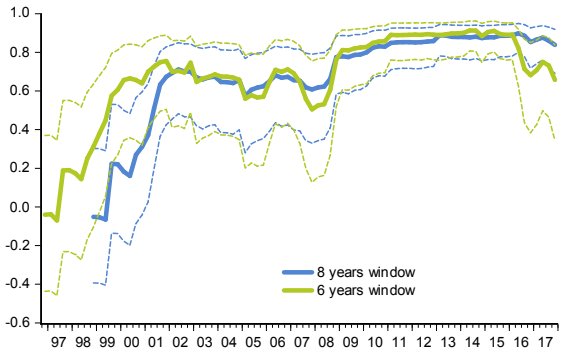
(f) first difference of the ifo business expectation indicator



(g) Factor A1



(h) Factor A2



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.

slightly above 0.70 (0.75) thereafter and remain at this level until 2013/14. From 2014 onwards, correlation coefficients decrease gradually to values above 0.35 (0.35) which is certainly caused by a more severe decline of the East German unemployment rate compared to the West German unemployment rate since 2012. The correlation coefficients of the 8-years and 6-years rolling window differ slightly from each other in the late 90's and align to each other in the early 2000's. Moreover, the range of the confidence bands does not vary much over time as 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.

Correlation between the cyclical component of the unemployment rate of East and West Germany (Figure 5d) was comparatively high in the 1990's, with coefficients between 0.50 and 0.85 (0.40 and 0.90). But in the 2000's, the correlation coefficient 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 certainly caused by a sharper decline of the unemployment rate in East Germany compared to West Germany. Furthermore, the correlation coefficients of the 8-year and 6-year rolling windows slightly differ from each other for the entire considered time period and the range of the confidence bands does not vary much over this time period.

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 correlation

analysis for the factors (Figures 4g and 4h) support the results of the correlation analysis of the previous indicators.

Overall, our results indicate that the synchronization 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 synchronization is more pronounced for GDP variables and less for indicators based on unemployment rates and business confidence indicators. However, all indicators indicate that synchronization has weakened since 2014.

3.2 Coincidence of booms and recessions

3.2.1 Cycle synchronization index

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

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

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

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 synchronization between the East and West German business cycle. The higher the sign concordance the stronger is the degree of business cycle synchronization.

Table 3 illustrates the results of the cycle synchronization index (CSI). For this analysis, we choose the same sub-samples as for the correlation analysis. In column A, results for the entire sample from 1991 to 2017 are presented for all variables. Column 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.[12]

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 test of difference show insignificant results, which implies that the synchronization has not increased significantly from the first to the second sub-sample. Nevertheless, the degree of synchronization is already high for these indicators in both sub-samples. The CSI results for the common factors clearly confirm a high synchronization among business cycles phases.

Table 3: Cycle synchronization 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.

Overall, our results indicate that the synchronization 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 synchronization is more pronounced for GDP variables and less for indicators based on unemployment rates and business confidence indicators.

[12] While the k_t-variable follows a binomial distribution, the test statistic (difference of the CSIs) follows a normal distribution.

3.2.2 Classifying booms and recessions

Official dating of business cycle turning points does not exist either for Germany as a whole or the German states. Therefore, several authors have proposed a business cycle chronology for the German economy (Fritsche and Kuzin, 2005; Schirwitz, 2009) and the German states (Schirwitz *et al.*, 2009b). But none of them has distinguished between East and West Germany as aggregate. 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. 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: GDP growth & recession

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

Figure 6 shows the quarterly GDP growth rates for the period 1991 to 2017, where the blue shaded areas indicate the recession periods for East Germany and West Germany, respectively. The non-shaded areas of the figure represent the economic boom periods. The comparison of both figures indicates that the economic expansion and recession periods differ in the 90's and early 2000's in terms of their occurrence and their time length. From 2004 onwards, periods of economic expansion and recession gradually aligned in East and West Germany in terms of occurrence and time length. Synchronization appears to be large over the entire sample and differences in the degree of synchronization of the two consecutive sub-samples are hard to detect. Hence, we provide further analysis 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 synchronization 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 as compared to the calculations in the previous section, i.e. the concordance of boom and recession periods for each of the considered business cycle indicators are investigated.[13] 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 synchronization 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 synchronization 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 the test of difference shows significant results at the 1% level which shows that the degree of synchronization of booms and recessions has significantly increased for GDP over the considered time period. For the unemployment rate and the ifo business situation indicator, the test of difference is insignificant but the degree of synchronization is high for both consecutive sub-samples. That the test of difference is significant for the ifo business expectations implies that the degree of synchronization has increased over time at the 10% significance level. The results for the factors show similar results as the ifo survey indicators, since synchronization is on a high level in both sub-samples and the test of difference indicates that there is no significant increase of the degree of synchronization from the first to the second sub-sample.

We conclude from these results that the degree of synchronization of the business cycle with regard to common booms and recession has increased in terms GDP and unemployment rate. For ifo business confidence indicators and the factors, the degree of synchronization is already high for

[13] The binary variable k_t is one if both the East and West German indicator is in a boom or recession simultaneously; k_t is zero otherwise.

Table 4: Cycle synchronization 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.

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 analyze how the contribution of the total German business cycle on the variability of the East German business cycle has changed. For this analysis, we conduct a forecast error variance decomposition, which measures the contribution of each type of shock on the forecast error variance. The analysis is based on a structural vector-autoregressive model (SVAR) with shocks which are identified by means of long-run restrictions where shocks of East German variables have no long-run effect on total German variables (Chow and Kim, 2003). This analysis allows us to measure the contribution of the specific total German business cycle indicator on the variability of the corresponding East German business cycle indicator. Moreover, we split the entire sample into three sub-samples of equal length which allows us to pursue this variance decomposition for three consecutive sample periods (1991–1999, 2000–2008, 2009–2017). The results of the forecast error variance decomposition analysis are illustrated in Figure 7, whereas the corresponding confidence bands are calculated by means of Monte Carlo simulations. For all indicators the explained variance increases considerably from the first to the second subperiod. After the Great Recession, the impact of the total German indicators on the variance of the East Germany indicators decreases compared to pre-crisis levels. For production and unemployment, the share that is explained is above 50%. For survey data German data explains about 30% of East German survey 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.

To provide more details, we conducted forecast error variance decomposition for GDP growth in East Germany and for all of Germany and measured the size of the variability in GDP growth of East Germany which is explained by the variability of GDP growth of total Germany (Figure 7a). From 1991 to 1999, the contribution of entire German GDP growth to the variability of East German GDP growth is about 4% from the first quarter to the 10th quarter. From 2000 to 2008, the contribution of the entire German GDP growth to the variability of East German GDP growth is almost 50% in the first quarter and rises to about 80%, in the 10th quarter. Finally, from 2009 to 2017, the contribution of the entire German GDP growth to the variability of East German GDP growth is about 50% in the first quarter and drops slightly in the 10 quarters ahead. Hence, for GDP growth, we can conclude that the contribution of total German GDP growth to the variability of East German GDP growth has increased from the first to the third sample period, which indicates a higher impact of the total German business cycle on the East German business cycle.

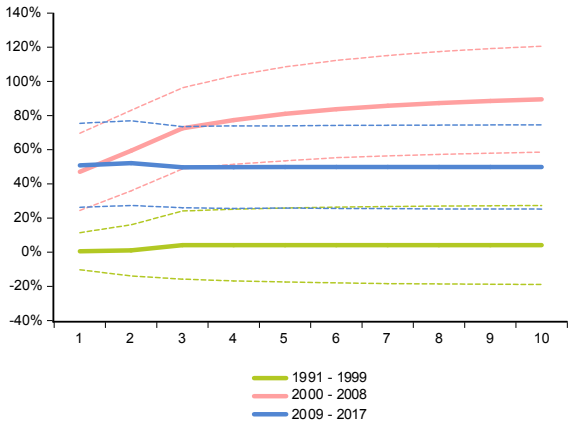
The contribution of total German output gap to the variability of East German output gap from 1991 to 1999 is close to 10% (Figure 7b). In the second period, the contribution increases up to 80%. Finally, from 2009 to 2017, the contribution of total German output gap to the variability of East German output gap is almost 60%. Thus, for the output gap, we obtain nearly the same results as for GDP growth, since the contribution of total German output gap to the variability of East German output gap has increased over time, which suggests a higher impact of the total German business cycle on the East German business cycle.

Figure 7c illustrates the results of the forecast error variance decomposition for the first difference of the unemployment rate. The contribution of total German first difference of unemployment rate to the variability of East German first difference of unemployment rate declines from the first sample to the third sample. In the first quarter, the contribution is slightly above 60% from 1991 to 1999 and remains at this level thereafter. From 2009 to 2017, the contribution is about 27% over the entire time horizon. The contribution of the total German first difference of unemployment rate to the variability of the East German first difference of unemployment rate has significantly decreased over time, which suggests a reduced impact of the total German unemployment rate on the East German unemployment rate over time.

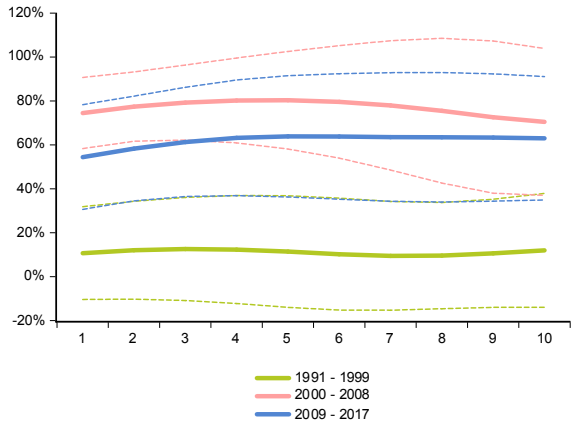
The contribution of total German cyclical component of unemployment rate to the variability of East German cyclical component of unemployment rate declines from the second to the third time period (Figure 7d). Nevertheless, for all three time periods, this contribution remains on a

Figure 7: Share of East German variables associated with shocks to the aggregate economic activity

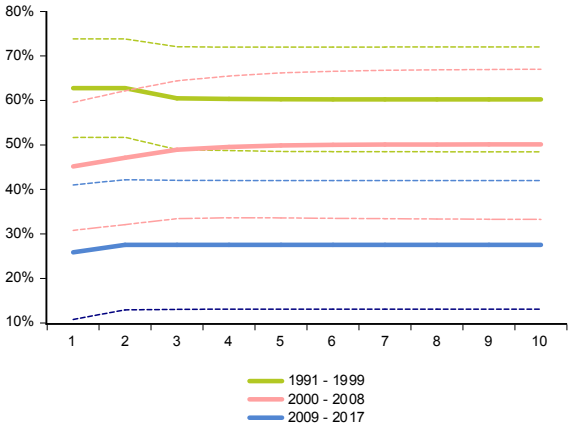
(a) GDP growth



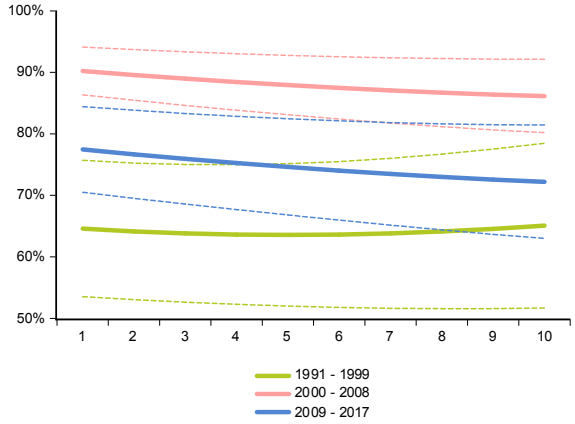
(b) Output Gap



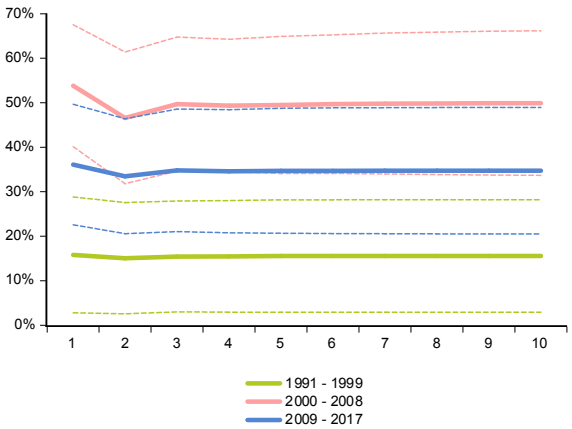
(c) First difference of unemployment rate



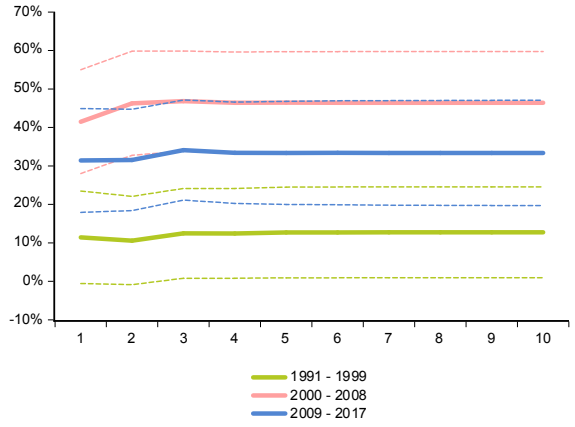
(d) Cyclical component of unemployment rate



(e) ifo business situation indicator

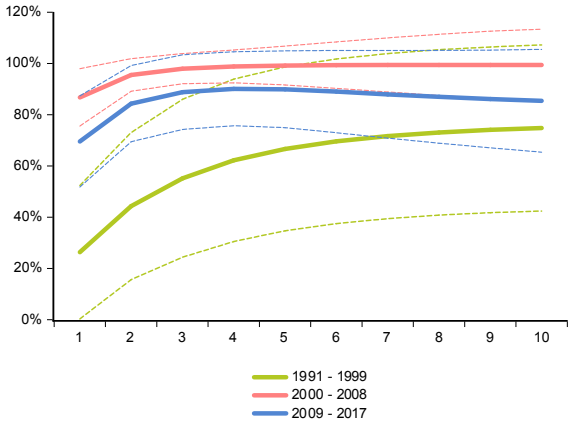


(f) ifo business expectation indicator

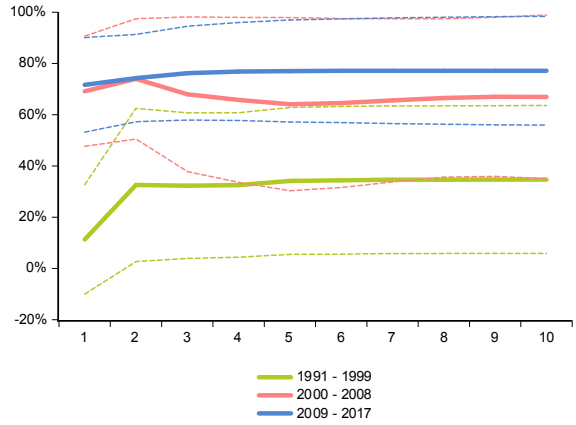


Note: Forecast error variance decomposition (FEVD) measures the impact of total German indicator on the variability of East German indicator for three consecutive sample periods: Green solid line – FEVD for 1991 – 1999; red solid line – FEVD for 2000 – 2008; blue solid line – FEVD for 2009 – 2017; dashed lines – corresponding confidence bands based on a 5% significance level.

(g) Factor A1



(h) Factor A2



Note: Forecast error variance decomposition (FEVD) measures the impact of total German GDP indicator on the variability of East German indicator for three consecutive sample periods: 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.

high level, even though this contribution reduces from close to 90% for the second time period to close to 75% in the third time period. These results suggest an ongoing high impact of the total German cyclical component of unemployment rate on its East German counterpart.

Figures 7e and 7f show the results of the forecast error variance decomposition of the first difference of the ifo business confidence indicators for total Germany and East Germany, respectively. The contribution of the total German ifo business situation indicator to the variability of East German ifo business situation indicator increases from below 15% in the first time period to about 50% in the second time period and declines to about 35% in the third time period. Except for the second time period, the contribution of total German ifo business confidence indicator on East German ifo business confidence indicator remains at a modest level in the third and most recent time period. For the business expectation indicator, we obtain comparable results and the contribution of the total German ifo business expectation indicator to the variability of the East German ifo business expectation indicator increases from about 10% in the first time period to about 30% in the third time period. Moreover, this contribution has not changed significantly from the first to the third time period and is at a modest level in the third and most recent time period.

The contribution of total German factor to the variability of East German factor has considerably increased for Factor A2 over time and amounts to about 77%. A similar result emerges for the Factor A1, where the variability of the total German factor to the variability of the East German

factor increased over time and accounts for 99% in the period from 2000 to 2008, but slightly decreases thereafter to values between 85% to 90%.

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 synchronization from the first to the second and third time period, whereas the change in the synchronization from the second to the third time period is insignificant. For the business cycle indicators based on unemployment rates, the analysis of business cycle synchronization lead to reverse conclusions compared to the results of the output-based indicators. From the first to the third time period, the business cycle synchronization substantially and significantly declined, at least for the cyclical component of unemployment rate. However, the synchronization is still on a high level. For the two ifo business confidence indicators, business cycle synchronization increases from the first to the third time period, but this increase is modest and insignificant.

4 Conclusions

In this paper we analyze the question of whether East and West German business cycles have become more synchronized over time. The results from the correlation analysis, synchronization indices, the variance decomposition and the analysis of business cycle turning points are robust and fit accurately with each other. We observe an increase in regional business cycle synchronization until 2014, although there are differences depending on the indicators considered. The business cycle indicator based on production data show larger evidence for business cycle synchronization as compared to the indicators based on unemployment rates and ifo indicators. However, the finding for the ifo surveys might be distorted by the fact that Berlin is not included in the East German survey data. Our findings also support that dissimilitudes decreased over time and in particular from the mid 2000's, synchronization has been relatively stable. However, labor market indicators still indicate differences, which arise mainly from different demographic structure and employment creation; the share of West German population to total population is 80.5%, while it it 19.5% in East Germany. In recent years, the degree of business cycle conformity between East and West seems to have abated, which is in line with international evidence after the Great Recession. In contrast to Ferreira-Lopes and Sequeira (2011), our analysis is not based on per capita indicators, but given the similar development of GDP growth rates results might be relatively similar (Figure

10). Furthermore, it might be the case that the synchronization pattern is different when sectoral-level data or state-level data is analyzed.

References

AGUIAR-CONRARIA, L., BRINCA, P., GUDJONSSON, H. V. and SOARES, M. J. (2017). Business cycle synchronization across US states. *The BE Journal of Macroeconomics*, **17** (1), online available.

ARTIS, M. J. and ZHANG, W. (1997). International business cycles and the ERM: Is there a European business cycle? *International Journal of Finance & Economics*, **2** (1), 1–16.

BELKE, A., DOMNICK, C. and GROS, D. (2017). Business cycle synchronization in the EMU: Core vs.periphery. *Open Economies Review*, **28** (5), 863–892.

BIERBAUMER-POLLY, J., HUBER, P. and ROZMAHEL, P. (2016). Regional business-cycle synchronization, sector specialization and EU accession. *Journal of Common Market Studies*, **54** (3), 544–568.

BRY, G. and BOSCHAN, C. (1971). *Cyclical analysis of time series: Selected procedures and computer programs*. National Bureau of Economic Research, New York.

CHOW, H. K. and KIM, Y. (2003). A common currency peg in East Asia? Perspectives from Western Europe. *Journal of Macroeconomics*, **25**, 331 – 350.

CHRISTIANO, L. J. and FITZGERALD, T. J. (2003). The band pass filter. *International Economic Review*, **44** (2), 435–465.

CLAUDIO, J. C., HEINISCH, K. and HOLTEMÖLLER, O. (2018). *Nowcasting East German GDP growth: A MIDAS approach*. IWH Discussion Paper forthcoming, IWH.

DARVAS, Z. and SZAPÁRY, G. (2008). Business cycle synchronization in the enlarged EU. *Open Economies Review*, **19** (1), 1–19.

DE GRAUWE, P. and JI, Y. (2017). The international synchronisation of business cycles: The role of animal spirits. *Open Economies Review*, **28** (3), 383–412.

DIXON, R. and SHEPHERD, D. (2013). Regional dimensions of the Australian business cycle. *Regional Studies*, **47** (2), 264–281.

FERREIRA-LOPES, A. and SEQUEIRA, T. N. (2011). Business cycles in reunified Germany: Closer together or further apart? *Review of Urban & Regional Development Studies*, **23** (2-3), 94–113.

FIDRMUC, J. and KORHONEN, I. (2006). Meta-analysis of the business cycle correlation between the euro area and the CEECs. *Journal of Comparative Economics*, **34** (3), 518 – 537.

FRITSCHE, U. and KUZIN, V. (2005). Prediction of business cycle turning points in Germany. *Jahrbücher für Nationalökonomie und Statistik*, **225** (1), 22–43.

FUNKE, M. and STRULIK, H. (2000). Growth and convergence in a two-region model of unified Germany. *German Economic Review*, **1** (3), 363–384.

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.

GOMEZ-LOSCOS, A., GADEA, M. D. and BANDRES, E. (2018). *Business cycle patterns in European regions*. MPRA Paper 83964.

GONG, C. and KIM, S. (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. and STANCIU, I. E. (2016). New evidence on the (de)synchronisation of business cycles: Reshaping the European business cycle. *International Economics*, **147**, 27 – 52.

HAMILTON, J. D. (2017). Why you should never use the Hodrick-Prescott filter. *Review of Economics and Statistics*, p. available online.

HARDING, D. and PAGAN, A. (2002). Dissecting the cycle: a methodological investigation. *Journal of Monetary Economics*, **49** (2), 365–381.

INKLAAR, R., JONG-A-PIN, R. and DE HAAN, J. (2008). Trade and business cycle synchronization in OECD countries – A re-examination. *European Economic Review*, **52** (4), 646–666.

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 EastWest problem? Regional growth patterns in Germany since Reunification. *Regional Studies*, **48** (7), 1161–1175.

MONTOYA, L. A. and DE HAAN, J. (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.

SCHIRWITZ, B. (2009). A comprehensive German business cycle chronology. *Empirical Economics*, **37** (2), 287–301.

—, SEILER, C. and WOHLRABE, K. (2009a). Regionale Konjunkturzyklen in Deutschland - Teil I: Die Datenlage. *ifo Schnelldienst*, **62** (27/28), 18–24.

—, — and — (2009b). Regionale Konjunkturzyklen in Deutschland - Teil II: Die Zyklendatierung. *ifo Schnelldienst*, **62** (14), 24–31.

—, — and — (2009c). Regionale Konjunkturzyklen in Deutschland - Teil III: Konvergenz. *ifo Schnelldienst*, **62** (32/33), 23–32.

STOCK, J. H. and WATSON, M. W. (2002). Forecasting using principal components from a large number of predictors. *Journal of the American Statistical Association*, **97** (460), 1167–1179.

— and — (2014). Estimating turning points using large data sets. *Journal of Econometrics*, **178**, 368–381.

Appendix

Table 5: Business Cycle Statistics

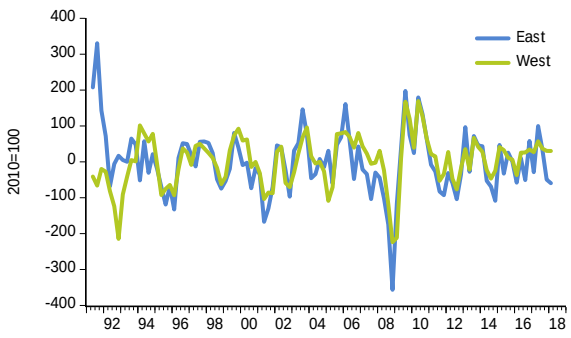
		average	average of levels	volatility	persistence
GDP qoq growth	East	0.531		1.362	-0.104
	West	0.318		0.887	0.273
output gap	East	-0.087		1.538	0.930
	West	0.003		1.487	0.922
1st diff unemployment rate	East	-0.002	14.170	0.270	0.156
	West	-0.002	7.315	0.103	0.427
cyclical component of unemployment rate	East	0.050		0.877	0.983
	West	-0.014		0.430	0.992
1st diff ifo situation	East	0.004	102.267	9.139	-0.167
	West	0.001	104.138	10.469	0.278
1st diff ifo expectation	East	0.000	103.651	5.068	-0.058
	West	0.001	100.627	5.503	0.349

Note: 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

(a) Factor B1

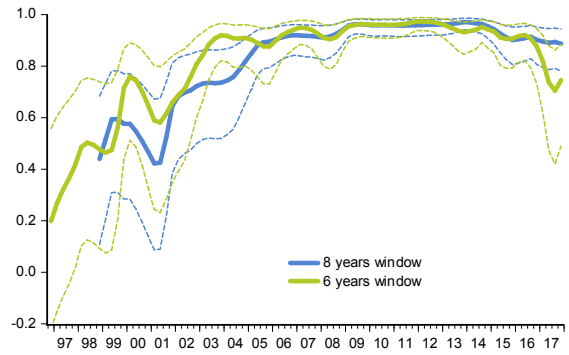
(b) Factor B2



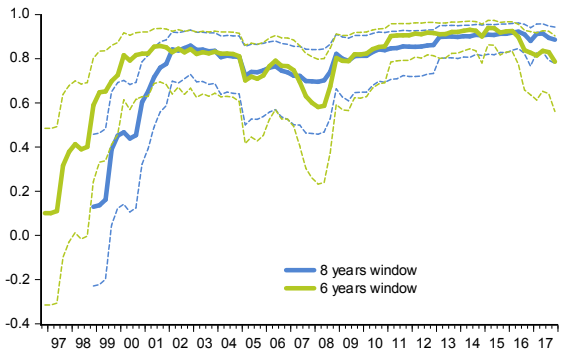
Note: Common factor based on three indicators. Factor 3 based on coincident index, Factor 4 based on a dynamic factor model.

Figure 9: Rolling correlation for Factors

(a) Factor B1



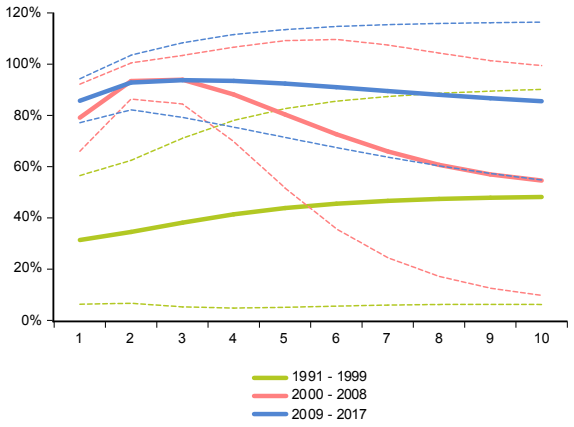
(b) Factor B2



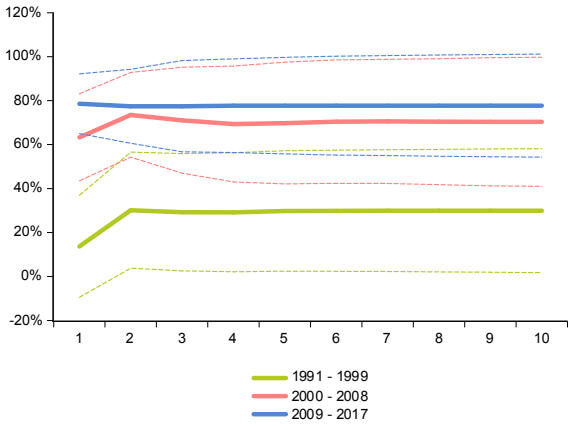
Note: Blue solid line – rolling correlation of the 8 year rolling window; green solid line – rolling correlation of the 6 year rolling window; dashed lines – corresponding confidence bands based on a 5% significance level.
Sources: German Federal Statistical Office and own calculations.

Figure 10: Variance decompositions

(a) Factor B1



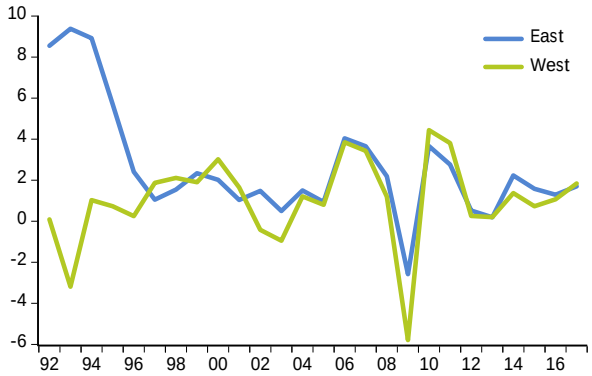
(b) Factor B2



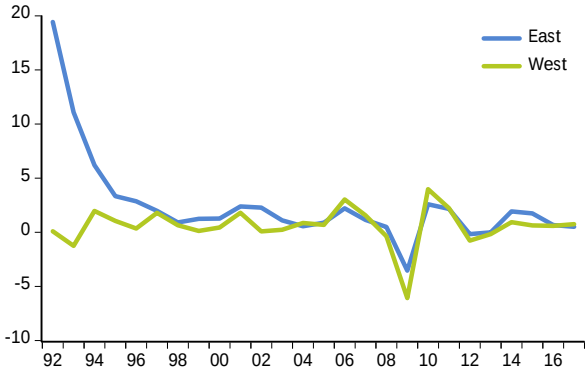
Note: Forecast error variance decomposition (FEVD) measures the impact of total German GDP indicator on the variability of East German indicator for three consecutive sample periods: Green solid line – FEVD for 1991 – 1999; red solid line – FEVD for 2000 – 2008; blue solid line – FEVD for 2009 – 2017; dashed lines – corresponding confidence bands based on a 5% significance level.

Figure 11: Production per capita

(a) GDP per capita



(b) GDP per employee



Note: Annual GDP per capita growth rates and GDP per employee growth rates.
Sources: German Federal Statistical Office.

Halle Institute for Economic Research –
Member of the Leibniz Association

Kleine Maerkerstrasse 8

D-06108 Halle (Saale), Germany

Postal Adress: P.O. Box 11 03 61

D-06017 Halle (Saale), Germany

Tel +49 345 7753 60

Fax +49 345 7753 820

www.iwh-halle.de

ISSN 2194-2188

Leibniz
Association