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Fiscal Sustainability of the German Laender
Time Series Evidence

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Abstract

We analyze the sustainability of public finances in the 16 states (Laender) of the Federal Republic of Germany using an unprecedentedly comprehensive fiscal dataset covering the period from 1950 to 2011 for West German Laender and from 1991 to 2011 for East German Laender. As we apply unit root and stationarity tests not only on debt but also on expenditure and revenue and explore their long-run relation in cointegration analyses for each Land we extend the existing literature. The results provide evidence against strict fiscal sustainability in a majority of German Laender. A notable exception to this finding is Bavaria.

JEL Classification: H62, H77, H72

Keywords: Fiscal Sustainability, Federalism, Unit Root, Cointegration, Public Debt

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1. Introduction

The fiscal framework of Germany comprised of the 16 federal states (Laender) and the federal level is likely to erode sub-federal finances. On the one hand, tax autonomy of the Laender is limited and expenditure are largely federally determined. On the other hand, the constitution requires that all states have the financial means to ensure "equivalent living standards". As a result, Germany has an extensive system of revenue sharing and equalization. Thus, the Laender have incentives to be considered as fiscally weak and rely on fiscal transfers and debt. The bias towards public debt is exacerbated by the explicit bailout granted twice to the Saarland and Bremen in 1992. As the sub-federal level could, thus, seriously endanger general fiscal sustainability and nullify federal consolidation efforts, it is essential to study the sustainability of public finances within the German Laender.[1]

Today the Laender are responsible for around one quarter of total spending and account for more than 30% of total debt. While the Laender share a common political, cultural and constitutional framework, regional disparities exist. A poor economy and a low population density are commonly found in the East German Laender that were part of the German Democratic Republic until reunification in 1990. Among the West German Laender the southern Laender tend to be richer and grow more dynamically than most northern ones. In fact, the southern West German states of Bavaria, Baden-Wuerttemberg and Hesse have been the only three Laender that have not benefited from the horizontal fiscal equalization scheme in 2013 but have actually funded it. While Baden-Wuerttemberg and Hesse have never received transfers from the horizontal fiscal equalization scheme, Rhineland-Palatinate and Lower Saxony have never contributed to it. Besides geographical patterns (east and west), the German Laender can be classified in non-city-states and city-states. The latter group comprises Berlin, Bremen and Hamburg, which are characterized by large commuting inflows and high population density. While the fiscal equalization scheme compensates the city-states for potentially higher costs due to their special status, their debt per capita is large. However, Hamburg frequently has the highest fiscal capacity of all Laender.

[1] For a broad overview of Germany's fiscal federalism refer to Burret and Feld (2013).

Despite the relevance of sub-federal finances for fiscal sustainability in Germany, most studies focus on the public finances of general government (Afonso 2005, Bravo and Silvestre 2002, Greiner et al. 2006, Greiner and Kauermann 2007, 2008, Grilli 1988, Payne 1997, Polito and Wickens 2011, Burret et al. 2013). Fiscal sustainability of the German Laender has been studied by Kitterer (2007), Claeys et al. (2008), Herzog (2010), Fincke and Greiner (2011), Burret et al. (2014) and Potrafke and Reischmann (2014). Most studies reject fiscal sustainability under certain (restrictive) assumptions (Table A.20). For example, Claeys et al. (2008) find sustainable policies in most Laender when the time-period under consideration is shortened to 1991-2005. However, Claeys et al. (2008) as well as Kitterer (2007), Fincke and Greiner (2001) include municipal finances, focusing on multiple levels of government and various policymakers. While most studies conduct univariate unit root and Model-Based Sustainability (MBS) tests, Potrafke and Reischmann (2014) and Burret et al. (2014) test Laender panels. Interestingly, Potrafke and Reischmann (2014), who use the MBS-test on a panel of the West German Laender conclude that sustainability cannot be rejected once fiscal transfers are taken into account. On the contrary Burret et al. (2014), who also include fiscal transfers, find that public finances are not sustainable in one panel (Hamburg, Saarland, Rhineland-Palatinate) and at best weakly sustainable in another panel of Laender (Baden-Wuerttemberg, Hesse, Lower Saxony, North-Rhine Westphalia, Schleswig-Holstein).

Previous time series studies show notable shortcomings: first, the validity of univariate tests remain limited since the covered time-period is relatively short (between 13 and 36 years). Second, most univariate analyses do not control for structural breaks, even though trends and other time series characteristics are important for fiscal data. Third, most studies analyze only a subset of the German Laender. Fourth, the years of the Great Recession and the period of the "German economic miracle" are only covered by Burret et al. (2014). In our companion paper, we focus however on Laender panels rather than on single Laender. Thus, this paper contributes to the current literature by providing an in-depth analysis of fiscal sustainability separately for each German Land using a newly compiled dataset that covers up to 62 years increasing validity for West German Laender. In fact, we are the first to explore the long-run relation between expenditure and revenue in each German Land in a cointegration analyses.

The remainder of the paper is organized as follows: Section 2 briefly describes the dataset and the test strategy. In Section 3 the results are presented. Conclusions are offered in Section 4.

2. Data and Methodology

2.1. Data

The empirical analysis is based on annual data covering public expenditure, revenue and explicit public debt of the 16 German Laender excluding their municipalities. While the three city-states (Berlin, Bremen, Hamburg) are special, the findings for the city and non-city-states refer to only one level of government with only one responsible executive. Moreover, the data takes fiscal transfers into account since the fiscal equalization scheme is an immanent part of the German fiscal constitution. Due to the former division of Germany the sample comprises the years 1950-2011 for the ten West German Laender (Bavaria, Baden-Wuerttemberg, Bremen, Hamburg, Hesse, Lower Saxony, North-Rhine Westphalia, Rhineland-Palatinate, Saarland, Schleswig-Holstein) but only the years 1992-2011 for the five East German Laender (Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt and Thuringia) and Berlin.[2]

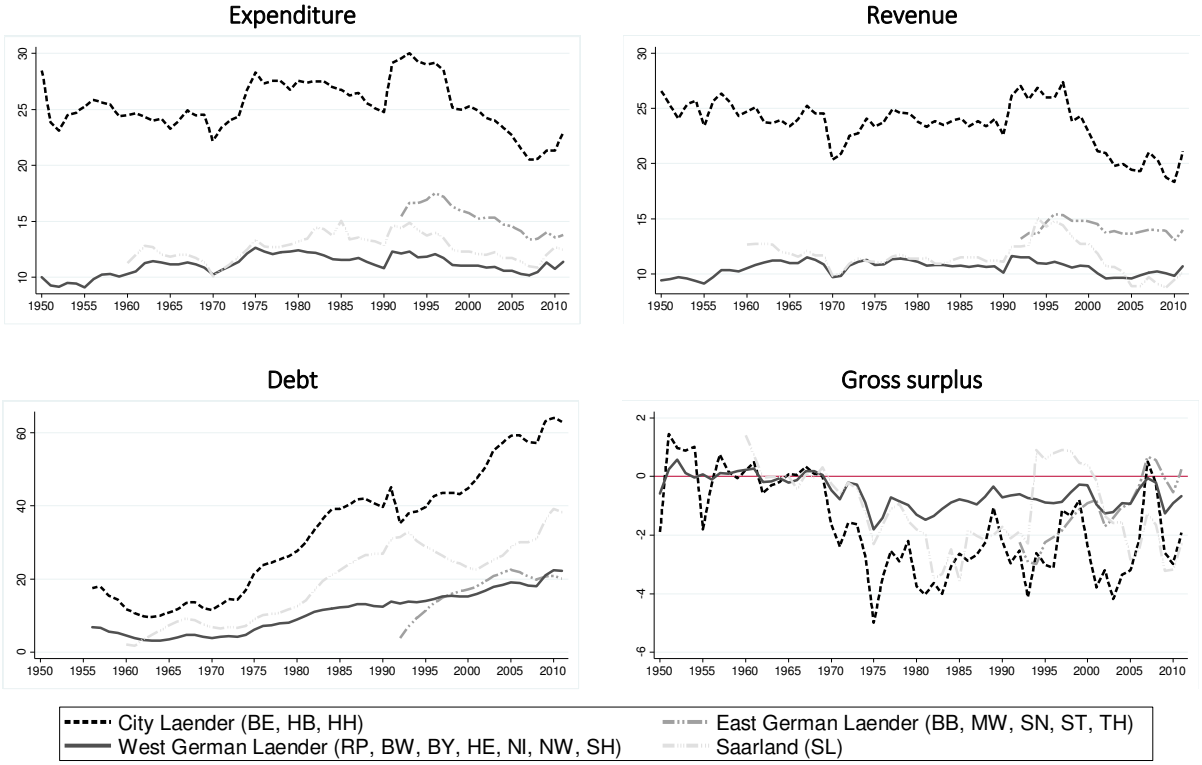
To get a clearer definition of fiscal sustainability (Kirchgässner and Prohl 2008) and to achieve similarly scaled series that offer more credible information (Bohn 2008), fiscal variables are commonly measured in relation to the country's fiscal strength, which is usually approximated by GDP. Such an approach is problematic in our case as the quality of regional GDP data is questionable.[3] To cope with the benchmarking problem we follow the German Council of Economic Experts (2011) and measure our variables in relation to imputed GDP. This benchmark is derived by multiplying national GDP per capita in year t by the population of the respective Land in year t. Unlike simple per capita measurement, imputed GDP has the advantage of mapping the increase in the Laender's financial capacity over time. At the same time it is equivalent to per capita data in the cross-section.

[2] Data on public debt is not available before 1955. The time series for Saarland starts in 1960. The Saarland was not part of the Federal Republic of Germany until 1957. Further information on the data and descriptive statistics are provided in Table A.7 and A.8. Figure 3 shows a map of the German states.

[3] These GDP data could either be calculated from the production side. In this case, commuters between Laender provide difficulties for the calculation. Or, they could be calculated from the expenditure side; then the proper assignment of imports and exports is problematic. These difficulties do not only arise for city-states, but also for Laender the borders of which cut directly through agglomeration areas, e.g., Rhineland-Palatinate and Hesse. It is thus common knowledge of specialists of German fiscal federalism, that these GDP data are unreliable.

Figure 1 shows the development of public finances in different groups of the Laender. As expected, many Laender regularly achieved a fiscal surplus during the "German economic miracle" of the 1950s and 1960s. However, fiscal deficits have occurred frequently in subsequent years. While expenditure and revenue do not show a clear pattern, public debt reveals an increasing trend, particularly since the oil crises of the 1970s. Due to their special status it is not surprising that the three city-states (Berlin, Bremen, Hamburg) exhibit outstandingly large expenditure, revenue and debt. The public finances of the other West German Laender seem to be in a better state. The fiscal differences between the city and non-city-states are not worrisome for our econometrics as the tests are predominantly applied to first-differenced data.[4]

Figure 1 Development of Public Finances by Laender Groups, in % of imputed GDP



Note: City-states include Berlin (BE), Bremen (HB) and Hamburg (HH). East German Laender include Brandenburg (BB), Mecklenburg-Western Pomerania (MW), Sachsen (SN), Sachsen-Anhalt (ST) and Thuringia (TH). West German Laender include Rhineland-Palatinate (RP), Baden-Wuerttemberg (BW), Bavaria (BY), Hesse (HE), Lower Saxony (NI), North-Rhine Westphalia (NW) and Schleswig-Holstein (SH), while the Saarland (SL) is depicted separately since its time series does not start before 1960.

[4] For anecdotal evidence on the development of public finances in Germany refer to Burret et al. (2013).

2.2. Methodology

We investigate fiscal sustainability separately for each Land by testing a sustainability condition derived from the present value budget constraint. The sustainability condition requires the discounted present value of public debt to converge to zero in infinity and initial debt to equal the expected present value of future primary surpluses. This condition is assumed to be met:

- if public debt follows a stationary process I(0), i.e., its variance and mean are stable across time, or
- in the case of a non-stationary public debt series, i.e., I(1), if total revenue and expenditure are cointegrated with a vector of [1,-1], whereas the individual time series need not be stationary (Bohn 2008, Burret et al. 2013, Larin and Süßmuth 2014).

Sustainability tests based on unit root and cointegration tests have been put forward by e.g., Hamilton and Flavin (1986), Trehan and Walsh (1988, 1991), Elliot and Kearney (1988), Hakkio and Rush (1991), Ahmed and Rogers (1995), Haug (1995). Besides, a second approach is often pursued in the econometric evaluation of fiscal policy. Bohn (1995, 1998, 2008) challenges the unit root and cointegration tests and suggests testing whether the reaction of primary surplus is sufficient to offset an increase in the public debt.

We follow the first approach and assess fiscal sustainability in the Laender in three consecutive steps (Figure 2). In a *first step* we analyze the stationarity properties of the time series on public debt, expenditure and revenue in each Land using the Augmented Dickey Fuller (ADF), the Philipps-Perron (PP) and the Kwiatkowski (KPSS) test. While the ADF and PP tests examine the null hypothesis of a unit root in time series analysis, the KPSS test has the null of a trend stationary time series. The tests are applied in levels and in first differences. However, structural breaks in the time series might be present due to multiple business cycles and fiscal reforms since 1950. These structural breaks can decrease the power of a standard unit root test by, for example, making the ADF-test biased towards a non-rejection of the null hypothesis. To overcome this shortcoming and to control for structural breaks, we follow a twofold approach: first, we conduct the unit root and stationarity tests on each Land allowing for different trend and intercept assumptions; second we allow for structural breaks in the time series by additionally applying a test suggested by Zivot and Andrews (ZA). This test

examines the null hypothesis of a unit root against the break-stationarity alternative and chooses the break date where the t-statistics from the ADF test is most negative, i.e., the evidence is "least favorable for the unit root null" (Glynn et al. 2007: 68). The ZA test is applied in levels allowing for a structural break in both the intercept and the intercept and trend.[5]

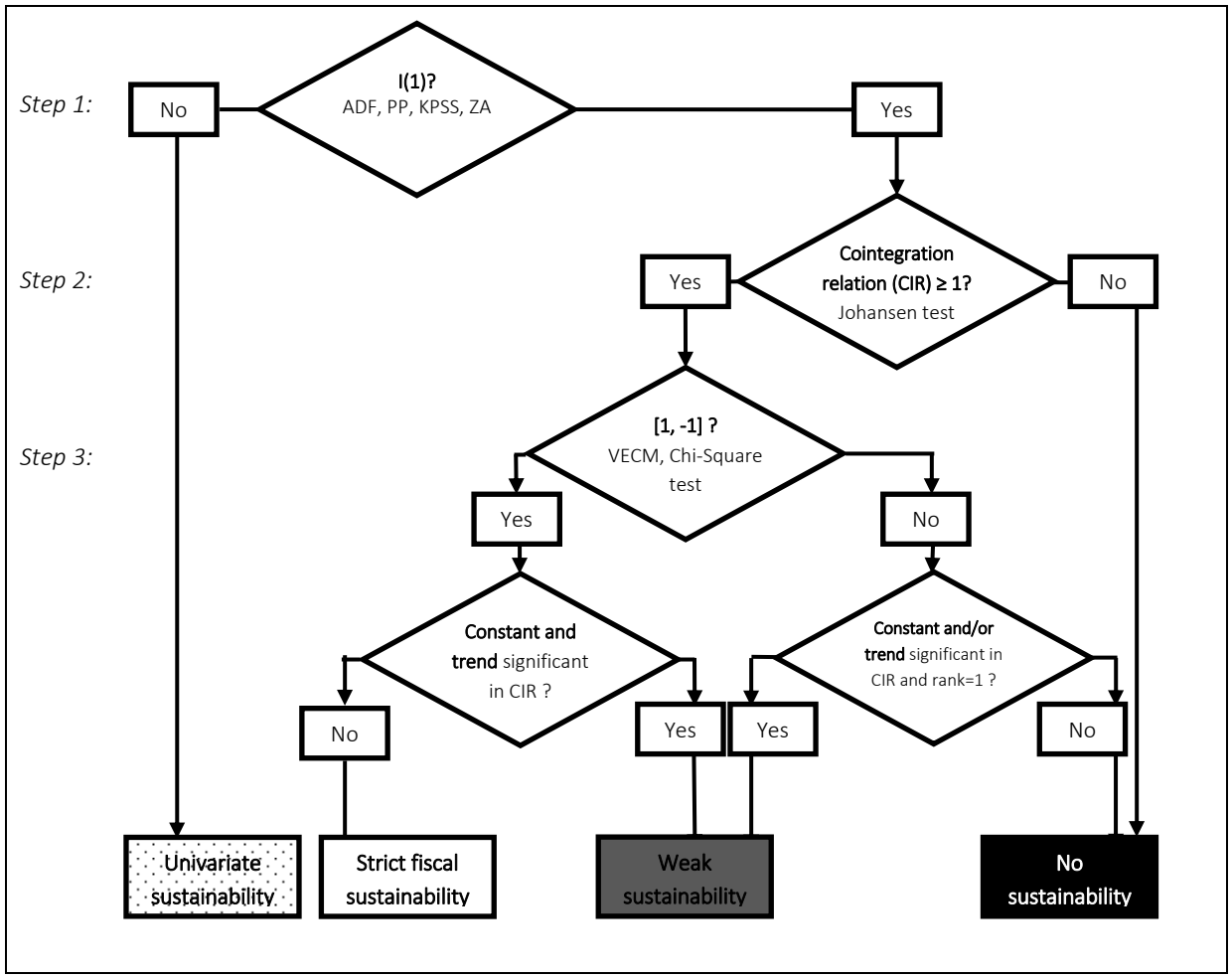
If we find conclusive evidence that public debt is stationary, then we have an indication for strict fiscal sustainability. Otherwise, we proceed with Johansen tests on cointegration between expenditure and revenue in a *second step*. The application of the Johansen cointegration test requires subtracting one lag length since it is estimated in first differences. The lag lengths are selected in accordance with the results of Laender specific Vector Autoregression (VAR) models. This is followed by the estimation of Vector Error Correction Models (VECM) allowing for multiple assumptions such as a trend in the data, a constant in the error correction term and a trend in the cointegration relation.

If no significant cointegration relation between revenue and expenditure is found, we conclude that public finances are not sustainable in the corresponding Land. In case of a significant cointegration relation we follow recent contributions and conduct Chi-Square tests on the "normality vector" in the cointegration relation in a *third step* (e.g., Kirchgässner and Prohl 2008). According to Afonso (2005) fiscal policy is sustainable, if the time series of expenditure and revenue are cointegrated and the hypothesis of a "normality vector" of [1,-1] holds, i.e., a one-percentage point increase in revenue leads to a one percentage point increase in expenditure (and vice versa). However, Koester and Priesmeier (2013) show that a significant element in the error correction term can be associated with fiscal unsustainability because the significant constant (trend) implies a (increasing) wedge between revenue and expenditure. This contributes to increasing deficits across time.

[5] The ADF test determines the number of lags using the Hannan-Quinn criterion, the PP test selects the bandwidth automatically in accordance to the Newey-West procedure using Bartlett kernel (Newey and West 1994), and the KPSS test with equivalent bandwidth selection procedures (Hamilton 1994). The Akaike Information Criterion (AIC) is used to determine the optimal number of lags regarding the ZA test. We allow for a maximum of four lags which corresponds to the VAR lag length criteria on each variable in any Land under consideration. See also Campbell and Perron (1991) and Cheung and Lai (1995) for the application of unit-root tests on (fiscal) macro data.

Thus, a cointegration vector of [1,-1] indicates strict sustainability if and only if a significant constant and trend in the error correction term is rejected. If both elements are significant we conclude that public finances are weakly sustainable. A rejection of the "normality vector" is taken as evidence for weak sustainability as long as at least one element (constant and/or trend) in the long-run relation is significant. Otherwise we conclude that public finances are not sustainable. To determine whether at least one element in the long-run relation is significant, we conduct Chi-Square tests allowing for multiple assumptions, including a constant, a trend and a deterministic trend in the cointegration relation.

Figure 2 Three-step Time Series Test Procedure for Expenditure and Revenue of each Land



Own illustration.

3. Empirical Results

In the interest of clarity and comprehensibility, the discussion of our findings is primarily focused on Baden-Wuerttemberg, Bavaria, Hesse, North Rhine-Westphalia and Rhineland-Palatinate. These five Laender are chosen due to their economic significance, population size,

status within the fiscal equalization scheme and fiscal stance. We try to group the remaining eleven Laender to one of these five examples if the time series characteristics are similar. Finally, the main results are briefly summarized for each Land in a last step. The detailed test results for the remaining Laender are provided in the Appendix.

3.1. Baden-Wuerttemberg (BW)

Step 1: Unit root and stationarity tests, BW (Table 1, upper panel)

The ADF and PP tests jointly suggest that *public debt* has a unit root in levels and no unit root in first differences. The KPSS confirms the findings in levels but not in first differences. Similarly, the ZA test cannot reject the null hypothesis of a unit root in the time series with a structural break in the intercept. In line with Herzog (2010), we conclude that public debt in Baden-Wuerttemberg is not stationary and, thus not sustainable across time.

Regarding *revenue* the results are trend-sensitive: unit roots in levels are not rejected at a significance level below 10% by any test result if trend assumptions are respected. However, if we only assume a constant, stationarity is indicated by all tests. For *expenditure,* the results are inconclusive: The ADF and PP tests jointly suggest that the time series is non-stationary in levels. While the KPSS test confirms the finding if a trend is included, the null hypothesis of no unit root cannot be rejected otherwise. Moreover, both ZA breakpoint tests reject stationarity of the time series at the 5% level.

Step 2: Cointegration of revenue and expenditure, BW (Table 1, middle panel)

In order to determine the number of cointegration relations in the system, we perform Johansen tests on cointegration between revenue and expenditure. To do so, we retrieve the lag length criteria from a VAR, whereas the Akaike Information Criterion (AIC) suggests a lag length of 1. If we assume no trend in the series, the Trace and Maximum Eigenvalue tests jointly reject the null of no cointegration at the 5% significance level and imply one cointegration vector at the same significance level. While the Maximum Eigenvalue test confirms this finding if we assume a trend in the data and allow for intercept and trend in the cointegration relation, the null of no cointegration is retained by the Trace test. Cheung and Lai (1995) show that the Trace test is more robust than the Maximum Eigenvalue test regarding skewness and excess kurtosis of residuals. Thus, we conclude that no cointegration exists if a trend in the cointegration relation is assumed.

Table 1 Baden-Wuerttemberg

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	0.979	-2.540	-3.310**
		Constant and trend	-2.422	-2.560	-3.280*
	1st differences	Constant	-7.610***	-8.970***	-8.832***
PP	Level	Constant	0.998	-2.473	-3.250**
		Constant and trend	-2.370	-2.542	-3.228*
	1st differences	Constant	-6.980**	-9.219***	-13.373***
KPSS	Level	Constant	0.805***	0.265	0.197
		Constant and trend	0.156**	0.222***	0.197**
	1st differences	Constant	0.463**	0.067	0.315
ZA	Level	Constant	-2.823 (1968)	-4.072** (1997)	-4.509* (1997)
		Constant and trend	n.s.m.	-5.329** (1974)	-4.557 (1976)
Verdict			*non-stationary*	*inconclusive*	*inconclusive*

Note: We report the estimated t-statistics for the unit root and stationary tests. While the KPSS has the null of no unit root, the ADF, PP and ZA test have the null of a unit root. ADF lag length selection from a maximum of 10 lags. `n.s.m.´ indicates that estimation was not retrievable due to near singular matrix error. `***´, `**´ and `*´ indicate that the corresponding null hypothesis can be rejected at the 1%, 5%, and 10% significance level, respectively.

Step 2: Johansen test on cointegration between expenditure and revenue

Constant

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.256	23.297**	20.262
At most1	0.089	5.562	9.165
		Max. Eigenvalue statistic	
0	0.256	17.735**	15.892
1	0.089	5.562	9.165

Constant and trend

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.279	25.154	25.872
At most 1	0.088	5.553	12.518
		Max. Eigenvalue statistic	
0	0.279	19.601**	19.387
1	0.088	5.553	12.518

Note: The Johansen test examines the hypothesized number of cointegration relations, i.e., the rank of the matrix (r). The number of cointegration relations is smaller than 1, i.e., "None", following Trace test's null hypothesis. If the statistic is higher than the critical value, the null hypothesis is rejected. Eigenvalue test examines the null that the number of cointegration relations (r) is "0". The critical values for both tests are derived from the Trace and Maximum Eigenvalue of the stochastic matrix. `***´, `**´ and `*´ indicate that the corresponding null hypothesis can be rejected at the 1%, 5%, and 10% significance level, respectively.

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant

Chi-Square	Prob.	Rev.	Exp.	Constant
6.767***	0.010	1.000	-1.000	0.004
				(0.001)
				[2.711]

Constant and trend

Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
7.370***	0.006	1.000	-1.000	0.001	0.056
					(0.047)
					[1.183]

Note: The Chi-Square test has the null that the cointegration vector is [1,-1]. The estimated variance is indicated in parentheses and the t-statistic is indicated in square brackets. `***´, `**´ and `*´ indicate that the corresponding null hypothesis can be rejected at the 1%, 5%, and 10% significance level, respectively.

Step 3: Test on cointegration vector [1,-1] and statistical inference, BW (Table 1, lower panel)

To test whether one percentage point increase in revenue leads to a one percentage point increase in expenditure (and vice versa) we analyze whether the cointegrating vector of rank 1 is [1, -1] by estimating VECM models. The VAR suggests a lag length of 0 for the VECM of the cointegrated time series. The Chi-Square test rejects the null hypothesis that the cointegrating vector is [1, -1] at the 1% significance level. This finding is robust to the inclusion of a trend in the cointegration relation. The significant intercept in the error correction indicates that a constant wedge between revenue and expenditure exists which might contribute to deficits across time (Koester and Priesmeier, 2013). Although revenue and

expenditure are cointegrated, public finances in Baden-Wuerttemberg do not meet the conditions for strict fiscal sustainability, i.e., a cointegrating vector of [1, -1]. However, the significant cointegration indicates signs of weak fiscal sustainability. Due to similar time series properties, a comparable conclusion is drawn for Brandenburg (Table A.10), Hesse (Table 3), Lower-Saxony (Table A.13), North-Rhine Westphalia (Table 4) and Schleswig-Holstein (Table A.18). However, it has to be noted that we do not have clear indication that public debt follows a non-stationary process in Hesse, Lower Saxony and Brandenburg.

3.2. Bavaria (BY)

Step 1: Unit root and stationarity tests, BY (Table 2, upper panel)

Since *public debt* in Bavaria is low compared to other Laender we expect Bavaria to show relatively sound finances. While the ADF, PP and KPSS tests jointly reject a unit root in the time series if we allow for an exogenous trend, it is retained otherwise. The ZA test indicates a structural break in the intercept in 1978 – shortly after a near-continuous debt decrease lasting almost two decades came to an end. Regarding *revenue and expenditure*, unit roots in levels is not rejected at a significance level below 10% by any test results except for expenditures in the ZA test with a break in the intercept and trend. In sum, public debt in Bavaria is stationary once we allow for a trend, while expenditure and revenue are I(1).

Step 2: Cointegration of revenue and expenditure, BY (Table 2, middle panel)

The hypothesis of no cointegration is conclusively rejected by the Trace and the Maximum Eigenvalue test at the 1% significance level. This holds for both specifications: with a constant in the error correction and with a constant and trend in the cointegration relation. All four tests indicate one cointegration relation.

Step 3: Test on cointegration vector [1,-1] and statistical inference, BY (Table 2, lower panel)

The VAR suggests a lag length of zero for the VECM of the cointegrated time series. While the null hypothesis of a cointegrating vector [1, -1] is retained by the Chi-Square test if we allow for a constant in the cointegration relation, it is rejected at the 1% significance level once a trend is added. Thus, sustainability of fiscal policy could be doubted if we allowed for a trend in the cointegration relation. However, the trend does not reach statistical significance in the error correction model, which indicates that the wedge between expenditure and revenue is at least not increasing across time. Given the significant cointegration of revenue and

expenditure and the cointegration vector of [1,-1] without a trend, we have at least some evidence for strict sustainability in Bavaria. Due to similar time series properties, a similar conclusion is drawn for Hamburg (Table A.12) despite the fact that public debt in Hamburg does not follow a stationary process (with or without a trend). Moreover, Hamburg has a significant trend in the cointegration relation. Therefore the indication for strict sustainability is more pronounced in the case of Bavaria.

Table 2 Bavaria

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	2.029	-2.286	-2.247
		Constant and trend	-3.754**	-3.013	-3.283*
	1st differences	Constant	-4.496***	-7.692***	-7.066***
PP	Level	Constant	-2.258	-2.094	-1.905
		Constant and trend	-3.710**	-3.077	-3.245*
	1st differences	Constant	-4.488***	-11.632***	-18.937***
KPSS	Level	Constant	0.360*	0.606**	0.673**
		Constant and trend	0.119	0.207**	0.198**
	1st differences	Constant	0.396*	0.152	0.297
ZA	Level	Constant	-4.494 (1978)	-4.165 (1962)	-4.652* (1963)
		Constant and trend	n.s.m.	-5.366** (1983)	-5.064* (1972)
Verdict			*inconclusive*	*non-stationary*	*non-stationary*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.397	34.738***	20.261
At most1	0.071	4.412	9.165
		Max. Eigenvalue statistic	
0	0.397	30.326***	15.892
1	0.071	4.412	9.165

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.402	38.188***	25.872
At most 1	0.115	7.344	12.518
		Max. Eigenvalue statistic	
0	0.402	30.844***	19.387
1	0.115	7.344	12.518

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant				
Chi-Square	Prob.	Rev.	Exp.	Constant
2.928	0.087	1.000	-1.000	0.002

Constant and trend					
Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
5.203***	0.021	1.000	-1.000	0.000	0.050
					(0.034)
					[1.461]

For notes see Table 1.

3.3. Hesse (HE)

Step 1: Unit root and stationarity tests, HE (Table 3, upper panel)

The unit root and stationarity test results for *public debt* are trend-sensitive: ADF, PP and KPSS jointly indicate non-stationarity in debt levels if we do not allow for a trend and stationarity otherwise. The ZA test rejects the hypothesis that debt has a unit root with a structural break in the intercept in the year 1978 – shortly after the sharp debt increase of the mid-1970s came to an end. Regarding *expenditure* in levels all tests indicate I(1) except for the ZA test

with a trend. The results for *revenue* are ambiguous. While the ADF, PP and KPSS test jointly indicate stationarity if we allow for an exogenous trend, the ZA test, again allowing for a trend, strongly rejects a unit root. If the trend assumption is not applied, we have an indication of non-stationarity.

Step 2: Cointegration of revenue and expenditure, HE (Table 3, middle panel)

We can reject the hypothesis of no cointegration relation between expenditure and revenue at least at the 5% significance level according to both the Trace and the Maximum Eigenvalue test with and without a trend in the series. The tests jointly indicate one cointegration relation.

Step 3: Test on cointegration vector [1,-1] and statistical inference, HE (Table 3, lower panel)

The VAR suggests a lag length of zero for the VECM of the cointegrated time series. Allowing for a constant in the cointegration relation, the null hypothesis that the cointegrating vector is [1, -1] is rejected at the 1% level by the Chi-Square test. Similar results obtain if we allow for a trend in the cointegration relation. The significant trend in the error correction term indicates that the wedge between expenditure and revenue is increasing across time. Therefore, we conclude that revenue and expenditure in Hesse are cointegrated, but do not follow a sustainable path since 1950, i.e., the cointegration vector of [1,-1] is rejected. This means that there is some evidence that Hesse is only weakly sustainable. Due to similar time series properties, this conclusion can be drawn for Baden-Wuerttemberg (Table 1), Lower Saxony (Table A.13), North Rhine-Westphalia (Table 4), Schleswig-Holstein (Table A.18) and Brandenburg (Table A.10). Nevertheless it should be noted that stationarity of public debt is only indicated for Hesse (once a trend is included).

Table 3 Hesse

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	1.040	-2.129	-3.040**
		Constant and trend	-4.588***	-2.155	-2.988
	1st differences	Constant	-4.533***	-8.008***	-7.065***
PP	Level	Constant	0.700	-2.053	-2.771*
		Constant and trend	-3.863**	-2.133	-2.781
	1st differences	Constant	-4.727***	-8.068***	-10.161***
KPSS	Level	Constant	0.864***	0.392**	0.191
		Constant and trend	0.095	0.194**	0.134*
	1st differences	Constant	0.325*	0.104	0.500**
ZA	Level	Constant	-5.361*** (1975)	-4.165 (1960)	n.s.m.
		Constant and trend	n.s.m.	-5.117** (1961)	-6.456*** (1972)
Verdict			*inconclusive*	*non-stationary*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.270	25.403***	20.261
At most1	0.097	6.191	9.165
		Max. Eigenvalue statistic	
0	0.270	19.212***	15.892
1	0.097	6.191	9.165

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.292	28.717***	25.872
At most 1	0.118	7.652	12.518
		Max. Eigenvalue statistic	
0	0.292	21.065***	19.387
1	0.118	7.652	12.518

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant				
Chi-Square	Prob.	Rev.	Exp.	Constant
7.755***	0.005	1.000	-1.000	0.005
				(0.002)
				[3.516]

Constant and trend					
Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
4.523**	0.033	1.000	-1.000	-0.0267	0.000
					(0.044)
					[2.710]

For notes see Table 1.

3.4. North Rhine-Westphalia (NW)

Step 1: Unit root and stationarity tests, NW (Table 4, upper panel)

The unit root and stationarity tests clearly indicate that *public debt* in North Rhine-Westphalia is I(1). Thus, we have conclusive evidence that public debt is not sustainable. For expenditure and revenue the results are inconclusive: *expenditure* is I(1) according to any trend adjusted test. However, the ADF and PP tests reject non-stationarity if no trend is assumed. Regarding *revenue* the ADF and ZA tests indicate I(1), while the PP tests rejects a unit root in the time series. Furthermore, the KPSS test suggests stationarity if a trend is included and non-stationarity otherwise. The time series properties of revenue and expenditure are further analyzed in the next step.

Step 2: Cointegration of revenue and expenditure, NW (Table 4, middle panel)

The Trace and Maximum Eigenvalue test both reject the null of no cointegration between revenue and expenditure at the 5% significance level with or without a trend in the cointegration relation. The test results indicate one cointegration relationship in both cases.

Step 3: Test on cointegration vector [1,-1] and statistical inference, NW (Table 4, lower panel)

The VAR suggests a lag length of zero for the VECM of the cointegrated time series. Allowing for a constant and a constant and trend in the cointegration relation the null hypothesis of a cointegrating vector of [1, -1] is rejected at the 1% significance level. Furthermore, the constant and the trend are both significant in the error correction term. This implies a constant wedge between expenditure and revenue, leading to increasing debt levels.

In sum, we find a significant cointegration of revenue and expenditure in North Rhine-Westphalia but reject a cointegration vector of [1,-1]. Thus, fiscal policy in North Rhine-Westphalia is at best associated with weak sustainability. Due to similar time series properties, a comparable conclusion can be drawn for Baden-Wuerttemberg (Table 1), Brandenburg (Table A.10), Hesse (Table 3), Lower Saxony (Table A.13) and Schleswig-Holstein (Table A.18). Stationarity of public debt is only conclusively rejected in North Rhine-Westphalia, Baden-Wuerttemberg and Schleswig-Holstein.

Table 4 North Rhine-Westphalia

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	1.981	-2.771*	-1.981
		Constant and trend	-2.090	-2.710	-3.479*
	1st differences	Constant	-4.428***	-7.338***	-7.681***
PP	Level	Constant	1.749	-3.003**	-3.003**
		Constant and trend	-1.712	-3.529**	-3.529**
	1st differences	Constant	-5.428***	-7.583***	-7.583***
KPSS	Level	Constant	0.856***	0.679**	0.679**
		Constant and trend	0.137*	0.047	0.047
	1st differences	Constant	0.326*	0.157	0.157
ZA	Level	Constant	-2.341 (1980)	-4.099 (1973)	-3.729 (2001)
		Constant and trend	n.s.m.	-4.105 (1973)	-3.997 (1972)
Verdict			*non-stationary*	*inconclusive*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.242	23.032**	20.261
At most1	0.094	6.001	9.165
		Max. Eigenvalue statistic	
0	0.242	17.031**	15.892
1	0.094	6.001	9.165

Constant and trend

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.318	32.155***	25.872
At most 1	0.134	8.793	12.518
		Max. Eigenvalue statistic	
0	0.318	23.362***	19.387
1	0.134	8.793	12.518

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant

Chi-Square	Prob.	Rev.	Exp.	Constant
10.785***	0.001	1.000	-1.000	0.006
				(0.002)
				[2.335]

Constant and trend

Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
13.508***	0.000	1.000	-1.000	-0.001	0.000
					(0.066)
					[2.381]

For notes see Table 1.

3.5. Rhineland-Palatinate (RP)

Step 1: Unit root and stationarity tests, RP (Table 5, upper panel)

The ADF and PP tests retain non-stationarity of *public debt* in Rhineland-Palatinate without a trend and reject non-stationarity with a trend (however only at the 10% level). The KPSS tests support these results. The ZA test results reject a random walk in public debt if no trend is assumed and reveals a break point in 1989, one of the few years in which the debt-to-GDP

ratio decreased. In sum, we have evidence that public debt in Rhineland-Palatinate is I(1). Regarding public *expenditure* the tests clearly indicate I(1). Similarly, the results for *revenue* indicate non-stationarity of the time series. The ADF, PP and ZA tests do not reject the presence of a unit root. The findings of the KPSS test are, however, trend sensitive. Thus, the time series properties for revenue and expenditure are further analyzed in a cointegration analysis.

Step 2: Cointegration of revenue and expenditure, RP (Table 5, middle panel)

We have estimated five cointegration tests with the following specifications. The first two tests assume no trend in the data and differ with respect to the assumption of an intercept in the cointegration relation: both reject cointegration between revenue and expenditure. The second pair of tests assumes a linear trend in the data and an intercept in the cointegration relation. It also differs with respect to the inclusion of a trend component in the cointegration relation. This second pair of tests also rejects cointegration over the same lag interval. The fifth test assumes a quadratic trend in the data, an intercept and trend in the cointegration relationship. This cointegration test identifies one cointegration vector. To confirm these results, we directly test for a cointegration with 0 lags (and employ SC and HQ lag length criteria). As shown in Table 5, the null hypothesis of no cointegration of expenditure and revenue is rejected by the Trace test and retained by the Maximum Eigenvalue test. Despite this ambiguity, Cheung and Lai (1995) argue that the Trace test is more robust than the Maximum Eigenvalue test regarding type II errors, skewness and excess kurtosis of residuals. Accordingly, we have a weak indication of cointegration, but no significant evidence. Note that similar results obtain for Bremen.

Step 3: Test on cointegration vector [1,-1] and statistical inference, RP (Table 5, lower panel)

Since at least one out of the five Johansen tests identified a cointegration vector, we assess whether revenue and expenditure are cointegrated with a [1,-1] vector. First, the Chi-Square tests reject such a vector at the 10% level. Second, public debt is I(1) and third, only one out of five Johansen tests indicates a cointegration relation between expenditure and revenue. This is evidence against a significant cointegration of rank one. Thus, fiscal policy in Rhineland-Palatinate is not sustainable. Due to similar time series properties, comparable conclusions are drawn for Bremen (Table A.11), Mecklenburg-Western Pomerania (Table A.14), Saarland (Table A.15), Saxony-Anhalt (Table A.17) and Thuringia (Table A.19). However, non-

stationarity of public debt is only indicated for Rhineland-Palatinate, Mecklenburg-Western Pomerania and Saarland.

Table 5 Rhineland-Palatinate

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	1.621	-2.064	-2.561
		Constant and trend	-3.253*	-1.739	-2.161
	1st differences	Constant	-4.410***	-7.939***	-7.152***
PP	Level	Constant	1.362	-2.070**	-2.549
		Constant and trend	-3.358*	-1.755	-2.585
	1st differences	Constant	-5.144***	-7.940***	-7.136***
KPSS	Level	Constant	0.869***	0.431*	0.226
		Constant and trend	0.148**	0.220***	0.200**
	1st differences	Constant	0.435*	0.203	0.329
ZA	Level	Constant	-4.488 (1989)	n.s.m.	-2.644 (1997)
		Constant and trend	n.s.m.	-3.909 (1963)	-4.209 (1963)
Verdict			*non-stationary*	*non-stationary*	*non-stationary*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.231	19.384**	18.398
At most1	0.053	3.334	3.841
		Max. Eigenvalue statistic	
0	0.231	16.046	17.148
1	0.053	3.340	3.841

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant and trend					
Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
3.559*	0.063	1.000	-1.000	-0.032	0.000

Note: The ECM was estimated with a quadratic trend in the data. For further notes see Table 1.

3.6. Summary

Table 6 briefly summarizes the main results of our test procedure for each Land. In line with the general observation that public debt has been increasing across time in the German Laender, we find no convincing evidence that public debt is stationary in any Land (column A). In around half of all Laender the unit root and stationarity tests indicate that public debt is not sustainable. While stationarity characteristics are inconclusive in other cases, we have some indication of stationary debt series in Bavaria and Hesse once a trend is included.

To further explore fiscal sustainability by means of cointegration between revenue and expenditure, the two variables need not be stationary. In fact, we have no conclusive evidence of a stationary time series regarding revenue and expenditure in any Land (column B and C).

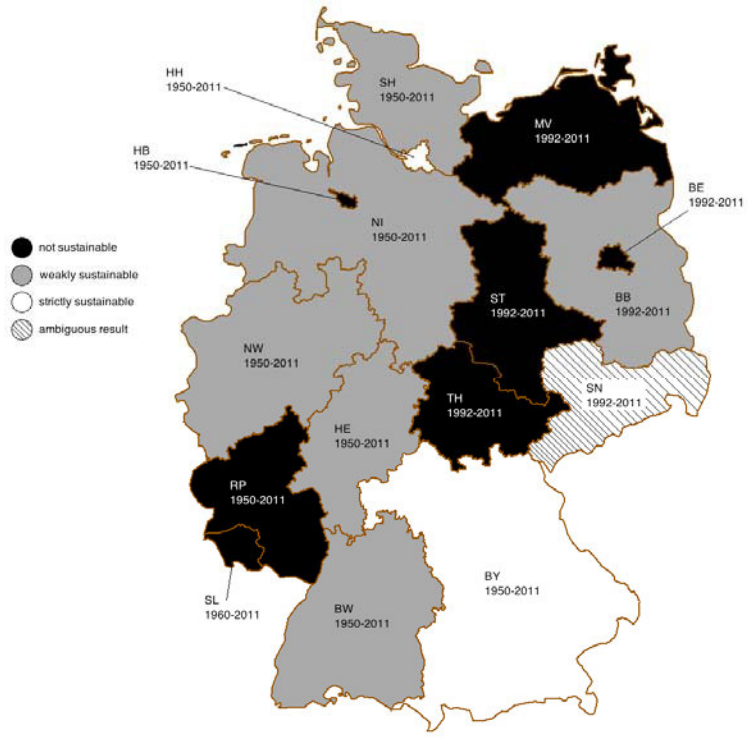
While a significant cointegration relation between revenue and expenditure is revealed in eight Laender (column D), a cointegration vector of [1,-1] is rejected in all eight Laender but Bavaria and Hamburg (column E). Thus, these two Laender are assumed to be strictly sustainable as a one percentage point increase in revenue leads to a one percentage point increase in expenditure (and vice versa). The other six Laender are assumed to be weakly sustainable since their revenue and expenditure are cointegrated but not with a vector that is commonly associated with strict fiscal sustainability. Unlike Hamburg, Bavaria has no significant trend in its cointegration relation and is therefore assumed to be the most fiscally responsible Land (column F). In several Laender, the tests indicate that public debt is non-stationary and that revenue and expenditure are not cointegrated. These Laender are assumed to be fiscally unsustainable. Note, however, that the findings for East German Laender have to be considered with caution since time series are rather short and the power of the tests is, thus, limited. With regard to fiscal sustainability, our findings suggest that East and West German Laender are considerably different (Figure 3).

Table 6 Summary of Main Empirical Findings

	Stationarity of			Cointegration of expenditure and revenue			Verdict
	debt	expenditure	revenue	Cointegration relation	Cointegration vector [1,-1]	Significant trend	Sustainability
	A	*B*	*C*	*D*	*E*	*F*	*G*
West German Laender							
Baden-Wuerttemberg	No	~	~	✓	No	No	Weak
Bavaria	~	No	No	✓	✓	No	Strict
Bremen	~	No	~	No	n.a.	n.a.	No
Hamburg	~	No	~	✓	✓	✓	Weak
Hesse	~	No	~	✓	No	✓	Weak
Lower Saxony	~	No	No	✓	No	✓	Weak
North Rhine-Westphalia	No	~	~	✓	No	✓	Weak
Rhine-Palatinate	No	No	No	No	No	n.a.	No
Saarland	No	No	~	No	n.a.	n.a.	No
Schleswig-Holstein	No	No	~	✓	No	✓	Weak
East German Laender							
Brandenburg	~	~	No	✓	No	✓	Weak
Mecklenburg-Western Pomerania	No	~	~	No	n.a.	n.a.	No
Saxony	No	~	~	n.a.	n.a.	n.a.	~
Saxony-Anhalt	~	~	~	No	n.a.	n.a.	No
Thuringia	~	~	~	No	n.a.	n.a.	No
Berlin	No	~	No	n.a.	n.a.	n.a.	No

Note: In columns A, B and C 'No' means that empirical evidence is in favour of non-stationarity and '~' indicates ambiguous tests results. In columns D, E and F '✓' ('No') means that at least one (no) test result suggest a cointegration relationship, a cointegration vector of [1,-1] and a significant trend in the cointegration relation. 'n.a.' indicates that the test was not preformed due to previous test results. The last column indicates whether the findings suggest strict, weak or no fiscal sustainability. If '~' results are not without ambiguity. Further details are provided in the Appendix.

Figure 3 Fiscal Sustainability in German Laender



Note: The years indicate the start and end dates of the time series. For abbreviation of the Laender, see Figure 1.

4. Conclusion

We extend the existing literature on fiscal sustainability in the German Laender as we apply unit root and stationarity tests not only on debt but also on expenditure and revenue and explore their long-run relation in cointegration analyses. Moreover, our newly compiled dataset covers all 16 Laender and, at least for West Germany, a much longer time-period than previous studies. Broadly in line with the existing literature, our findings suggest that public debt is not sustainable in the majority of the German Laender. However, a notable exception is Bavaria. Public finances in Baden-Wuerttemberg, Hesse, Hamburg, North Rhine-Westphalia, Lower Saxony, Schleswig-Holstein and Brandenburg are weakly sustainable at least. All other Laender, i.e., Berlin, Bremen, Saarland, Rhineland-Palatinate, Mecklenburg-Western Pomerania, Saxony-Anhalt and Thuringia, have unsustainable public finances. While the East German Laender recorded high levels of debt, Saxony has a unique debt record as it has successfully managed to reduce initial debt levels in the course of the last decade. We are, however, reluctant to overstate evidence from the East German Laender including Berlin since the time series is relatively short.

The unsustainability of public finances in most German Laender is likely to be related to the lack of tax autonomy in conjunction with federally determined expenditure on the one hand and the extensive fiscal equalization scheme and explicit bailout rule on the other. While fiscal sustainability need not to be satisfied if other levels of government stand ready for rescue, Germany seems to handle bailout requests rather restrictively. So far a bailout has only been granted to Bremen and Saarland in 1992. As expected, our results suggest that these two Laender have unsustainable finances. Since Burret et al. (2013) show that general government finances in Germany, including all levels of governments, are not sustainable anymore, neither the federal level nor the fiscally sustainable Laender (such as Bavaria) seem to have the capability to compensate the fiscal deficits of all Laender. Thus, the consolidation of Laender public finances becomes more and more important.

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Appendix

Table A.7 Data

Variable	Level	Period	Definition	Source
Expenditure and revenue	Laender (without local level)	1950-1969 1970-2011	Total revenue and total expenditure (post fiscal equalization data) Total revenue and total expenditure adjusted for payments from the same level (post fiscal equalization data). Data in accordance with cash statistics for 2011 and in accordance with final annual accounting otherwise.	Federal Statistical Office
Debt	Laender (without local level)	1955-2011	Since 2006 it includes most, and since 2010 all public funds, institutions and companies. Data in accordance with cash statistics for 2011 and in accordance with final annual accounting otherwise.	Federal Statistical Office
Population	Laender	1950-2011	End of each year	Federal Statistical Office
GDP per capita	Federal	1950-2011	GDP in current prices	Federal Statistical Office

Note: Data for Saarland is not available before 1960. Data for East German Laender and whole of Berlin starts in 1992. Since 1960 is a short fiscal year (April – December), the 1960 values for expenditure and revenue have been derived by interpolation for all West German Laender except for Saarland. In the case of Saarland the 1960 data was derived by extrapolation. Data is partly derived by a search request at the Federal Statistical Office.

Table A.8 Descriptive Statistics in General and by Laender Group

Variable	Obs	Mean	Std. Dev.	Min	Max
Expenditure					
All Laender	730	0.1458	0.0574	0.0680	0.3226
City-states	144	0.2528	0.0289	0.1987	0.3226
East non-city- states	100	0.1528	0.1497	0.1245	0.1973
West non-city- states	486	0.1127	0.0122	0.0680	0.1506
Revenue					
All Laender	730	0.1367	0.0524	0.0705	0.3144
City-states	144	0.2344	0.0295	0.1654	0.3144
East non-city- states	100	0.1413	0.0079	0.1265	0.1684
West non-city- states	486	0.1067	0.0104	0.0705	0.1511
Debt					
All Laender	685	0.1703	0.1437	0.0149	0.9009
City-states	134	0.3508	0.1978	0.0799	0.9009
East non-city- states	100	0.1682	0.0751	0.0226	0.2899
West non-city- states	451	0.1172	0.0779	0.0149	0.3921

Note: City-states include Bremen and Hamburg and since 1992 Berlin. East non-city-states include Brandenburg, Mecklenburg-Western Pomerania, Saxony-Anhalt, Saxony and Thuringia. West non-city-states include Bavaria, Baden-Wuerttemberg, Hesse, Lower Saxony, North-Rhine Westphalia, Rhineland-Palatinate, Schleswig-Holstein, and since 1960 Saarland.

Table A.9 Time Series Test Results for Berlin

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	-2.876*	-3.996***	-2.232
		Constant and trend	-0.188	-1.910	-2.700
	1st differences	Constant	-2.225	-1.965	-5.994***
PP	Level	Constant	-2.876	-0.726	-2.232
		Constant and trend	-0.303	-2.456	-2.640
	1st differences	Constant	-2.138	-4.832***	-6.165***
KPSS	Level	Constant	0.547**	0.570**	0.472**
		Constant and trend	0.156**	0.118	0.120*
	1st differences	Constant	0.452*	0.094	0.170
ZA	Level	Constant	-2.408 (2007)	-3.048 (2002)	-4.588* (2007)
		Constant and trend	-3.094 (2003)	n.s.m.	-4.640 (2007)
Verdict			*non-stationary*	*inconclusive*	*non-stationary*

For notes see Table 1.

Table A.10 Time Series Test Results for Brandenburg

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	-3.731**	-0.441	-2.014
		Constant and trend	-2.038	-4.963***	-2.732
	1st differences	Constant	-2.075	-4.883***	-3.712**
PP	Level	Constant	-5.890***	-0.283	-2.072
		Constant and trend	-3.776**	-4.963***	-2.731
	1st differences	Constant	-2.858*	-13.006***	-3.705**
KPSS	Level	Constant	0.555**	0.567**	0.260
		Constant and trend	0.183**	0.120*	0.121*
	1st differences	Constant	0.503**	0.237	0.187
ZA	Level	Constant	-3.427 (2006)	-6.923*** (2000)	-4.355 (2002)
		Constant and trend	-4.483 (2006)	-5.820*** (2007)	n.s.m.
Verdict			*inconclusive*	*inconclusive*	*non-stationary*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.628	27.635**	25.872
At most 1	0.371	8.804	12.518
		Max. Eigenvalue statistic	
0	0.628	18.831*	19.387
1	0.371	8.804	12.518

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant and trend					
Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
9.147***	0.002	1.000	-1.000	0.004	-0.002
					(0.000)
					[-5.521]

For notes see Table 1.

Table A.11 Time Series Test Results for Bremen

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	0.555	-2.385	-3.348**
		Constant and trend	2.670	-2.670	-3.340*
	1st differences	Constant	-3.979***	-7.379***	-3.129**
PP	Level	Constant	0.928	-2.560	-2.807*
		Constant and trend	-2.026	-2.835	-2.734
	1st differences	Constant	-3.932***	-7.379***	-8.789***
KPSS	Level	Constant	0.850***	0.215	0.104
		Constant and trend	0.085	0.128*	0.103
	1st differences	Constant	0.283	0.138	0.120
ZA	Level	Constant	-3.625 (1994)	-4.456 (1973)	-3.304 (2002)
		Constant and trend	n.s.m.	-4.257 (1991)	-4.183 (1991)
Verdict			*inconclusive*	*non-stationary*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.138	14.950	15.459
At most1	0.092	5.865**	3.841
		Max. Eigenvalue statistic	
0	0.138	9.087	14.265
1	0.092	5.862**	3.841

For notes see Table 1.

Table A.12 Time Series Test Results for Hamburg

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	0.020	-2.097	-2.425
		Constant and trend	-3.941**	-2.523	-4.192**
	1st differences	Constant	-5.889***	-8.148***	-9.181***
PP	Level	Constant	-0.076	-2.097	-2.329
		Constant and trend	-3.637**	-2.613	-4.175***
	1st differences	Constant	-5.797***	-8.505***	-12.282***
KPSS	Level	Constant	0.857***	0.504**	0.814***
		Constant and trend	0.154**	0.231***	0.179**
	1st differences	Constant	0.181	0.080	0.162
ZA	Level	Constant	-4.511 (1993)	-4.992** (1998)	-5.669*** (1998)
		Constant and trend	n.s.m.	-4.469(1998)	-5.309** (1998)
Verdict			*inconclusive*	*non-stationary*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.241	21.025**	20.261
At most1	0.066	4.176	9.165
		Max. Eigenvalue statistic	
0	0.241	16.849**	15.892
1	0.066	4.176	9.165

Constant and trend

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.438	41.667***	25.872
At most 1	0.100	6.484	12.518
		Max. Eigenvalue statistic	
0	0.438	35.183***	19.387
1	0.100	6.484	12.518

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant

Chi-Square	Prob.	Rev.	Exp.	Constant
0.069	0.790	1.000	-1.000	0.011
				(0.003)
				[3.394]

Constant and trend

Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
12.434***	0.000	1.000	-1.000	0.018	0.000
					(0.000)
					[2.762]

For notes see Table 1.

Table A.13 Time Series Test Results for Lower Saxony

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	0.110	-2.208	-2.773*
		Constant and trend	-4.158***	-1.708	-2.686
	1st differences	Constant	-4.483***	-5.583***	-8.541***
PP	Level	Constant	-0.617	-1.957	-2.655*
		Constant and trend	-3.701**	-1.737	-2.531
	1st differences	Constant	-4.183***	-7.665***	-9.501***
KPSS	Level	Constant	0.865***	0.338	0.241
		Constant and trend	0.149**	0.226***	0.236**
	1st differences	Constant	0.326	0.175	0.302
ZA	Level	Constant	-4.437 (1968)	-3.364 (1972)	-5.669 (1997)
		Constant and trend	n.s.m.	-3.938 (1974)	-4.022 (1977)
Verdict			*inconclusive*	*non-stationary*	*non-stationary*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.262	23.817**	20.261
At most1	0.083	5.293	9.165
		Max. Eigenvalue statistic	
0	0.261	18.524**	15.892
1	0.083	5.293	9.165

Constant and trend

Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.327	29.881**	25.872
At most 1	0.087	5.578	12.518
		Max. Eigenvalue statistic	
0	0.327	24.303**	19.387
1	0.087	5.578	12.518

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant					Constant and trend					
Chi-Square	Prob.	Rev.	Exp.	Constant	Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
10.250***	0.001	1.000	-1.000	0.007	11.889***	0.000	1.000	-1.000	-0.0002	0.000
				(0.002)						(0.051)
				[3.291]						[2.534]

For notes see Table 1.

Table A.14 Time Series Test Results for Mecklenburg-Western Pomerania

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	-2.465	-0.891	-2.085
		Constant and trend	0.548	-3.955**	-2.621
	1st differences	Constant	-1.501	-3.554**	-4.460***
PP	Level	Constant	-4.461***	-0.961	-2.085
		Constant and trend	-1.002	-4.016**	-2.540
	1st differences	Constant	-1.131	-4.611***	-4.469***
KPSS	Level	Constant	0.513**	0.447**	0.270
		Constant and trend	0.168**	0.100	0.009
	1st differences	Constant	0.610**	0.227	0.144
ZA	Level	Constant	-2.088 (2006)	-4.132 (1999)	n.s.m.
		Constant and trend	n.s.m.	-3.815 (2007)	n.s.m.
Verdict			*non-stationary*	*inconclusive*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.553	22.245***	18.398
At most 1	0.307	6.966***	3.841
		Max. Eigenvalue statistic	
0	0.553	15.278	17.148
1	0.307	3.340***	3.841

For notes see Table 1.

Table A.15 Time Series Test Results for Saarland

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	-0.949	-2.251	-1.701
		Constant and trend	-3.078	-2.169	-1.748
	1st differences	Constant	-4.257***	-7.609***	-6.866***
PP	Level	Constant	-0.483	-2.301	-1.944
		Constant and trend	-1.849	-2.226	-1.997
	1st differences	Constant	-4.277***	-7.619***	-8.789***
KPSS	Level	Constant	0.898***	0.206	0.139
		Constant and trend	0.096	0.185**	0.112
	1st differences	Constant	0.077	0.102	0.083
ZA	Level	Constant	-4.094 (1994)	-3.610 (1997)	-3.317 (2001)
		Constant and trend	-3.384 (1981)	-3.621 (1973)	-3.922 (1991)
Verdict			*non-stationary*	*non-stationary*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.203	16.092**	15.495
At most1	0.094	4.492**	3.841
		Max. Eigenvalue statistic	
0	0.242	11.600	14.264
1	0.094	4.492	3.841

For notes see Table 1.

Table A.16 Time Series Test Results for Saxony

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	-0.575	-0.248	-2.627
		Constant and trend	0.630	-4.576**	-3.260
	1st differences	Constant	-2.341	-4.330***	-3.735**
PP	Level	Constant	-1.845	-0.509	-2.619
		Constant and trend	-1.219	-4.099**	-4.930***
	1st differences	Constant	-2.344	-5.541***	-4.169***
KPSS	Level	Constant	0.165	0.532**	0.160
		Constant and trend	0.165**	0.077	0.122*
	1st differences	Constant	0.507**	0.500**	0.229
ZA	Level	Constant	-0.335 (2002)	-5.787*** (2006)	-3.737 (2004)
		Constant and trend	n.s.m.	-5.194** (2001)	n.s.m.
Verdict			*non-stationary*	*inconclusive*	*inconclusive*

For notes see Table 1.

Table A.17 Time Series Test Results for Saxony-Anhalt

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	-5.706***	-1.251	-3.121**
		Constant and trend	0.320	-2.969	-3.118
	1st differences	Constant	-1.907	-5.283***	-3.290**
PP	Level	Constant	-5.367***	-1.324	-3.096**
		Constant and trend	-0.678	-3.439*	-3.220
	1st differences	Constant	-1.907	-4.668***	-4.735***
KPSS	Level	Constant	0.582**	0.457*	0.120
		Constant and trend	0.168**	0.101	0.123*
	1st differences	Constant	0.636**	0.183	0.172
ZA	Level	Constant	-0.691 (2002)	-3.353 (2007)	n.s.m
		Constant and trend	-4.385 (2005)	-3.425 (2007)	-4.767 (1998)
Verdict			*inconclusive*	*inconclusive*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.445	20.213***	18.398
At most 1	0.378	9.016***	3.841
		Max. Eigenvalue statistic	
0	0.445	11.196	17.148
1	0.378	9.016***	3.841

For notes see Table 1.

Table A.18 Time Series Test Results for Schleswig-Holstein

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	1.486	-2.589	-3.016**
		Constant and trend	-3.459*	-2.592	-4.484***
	1st differences	Constant	-4.595***	-6.621***	-7.488***
PP	Level	Constant	1.363	-2.598*	-3.140**
		Constant and trend	-3.875**	-2.385	-4.485***
	1st differences	Constant	-6.517***	-8.864***	-13.006***
KPSS	Level	Constant	0.888***	0.232	0.455*
		Constant and trend	0.137*	0.232***	0.150**
	1st differences	Constant	0.392*	0.361*	0.269
ZA	Level	Constant	-3.837 (1977)	-3.893 (1998)	-5.800*** (1998)
		Constant and trend	n.s.m.	-3.313 (1974)	-5.503** (1991)

Verdict			*non-stationary*	*non-stationary*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.354	34.677**	25.872
At most 1	0.123	7.984	12.518
		Max. Eigenvalue statistic	
0	0.354	26.693**	19.387
1	0.123	7.984	12.518

Step 3: Test on sustainability vector [1,-1] in cointegration relation between expenditure and revenue

Constant and trend					
Chi-Square	Prob.	Rev.	Exp.	Constant	Trend
11.403***	0.000	1.000	-1.000	-0.0005	0.000
					(0.057)
					[3.265]

For notes see Table 1.

Table A.19 Time Series Test Results for Thuringia

Step 1: Unit root and stationary tests

			Debt	Expenditure	Revenue
ADF	Level	Constant	-5.517***	-0.377	-2.035
		Constant and trend	-0.490	-4.442**	-3.517*
	1st differences	Constant	-1.941	-5.264***	-4.502***
PP	Level	Constant	-5.023***	-0.377	-1.549
		Constant and trend	-1.196	-4.368**	-2.681
	1st differences	Constant	-1.171	-5.616***	-4.481***
KPSS	Level	Constant	0.554**	0.510**	0.307
		Constant and trend	0.168**	0.126*	0.112
	1st differences	Constant	0.625**	0.290	0.227
ZA	Level	Constant	-2.820 (2007)	-5.089* (2002)	-3.967 (2002)
		Constant and trend	-3.191 (2004)	-4.626 (2006)	n.s.m.
Verdict			*inconclusive*	*inconclusive*	*inconclusive*

Step 2: Johansen test on cointegration between expenditure and revenue

Constant and trend			
Null hypothesis	Eigenvalue	Trace statistic	5% critical value
None	0.593	22.621**	18.397
At most 1	0.252	5.524***	3.841
		Max. Eigenvalue statistic	
0	0.593	17.097*	17.148
1	0.252	5.520**	3.841

For notes see Table 1.

Table A.20 Studies on the Sustainability of German Laender Finances

	Panel	Econometrics	Empirical tests and variables	Key findings	Fiscal sustainability?*
Kitterer (2007)	West Laender 1971-2004 East Laender 1992-2004	Time series (Univariate)	Unit root tests (debt)	Fiscal sustainability not met in most Laender.	YES [HE, NW, SN] NO [all other Laender]
Claeys et al. (2008)	West Laender 1970-2005 East Laender 1991-2005	Time series (Univariate), Panel analysis	MBS-tests (debt and surplus)	Laender governments do not react appropriately to increasing debt levels and curb consolidation requirements.	Rather NO [depends on time period under consideration]
Herzog (2010)	BE and BW 1970-2005	Time series (Univariate)	Unit root tests, MBS-tests (debt and surplus)	For BE sustainability is rejected by both tests. For BW sustainability is rejected by unit root tests but not by MBS-tests.	NO [BE] Mixed [BW]
Fincke and Greiner (2011)	West Laender 1975-2006	Time series (Univariate)	Unit root tests, MBS-tests (debt and surplus)	All but Bavaria account for rising "debt to GDP ratios which is not compatible with sustainability in the long run" (p. 248) .	YES [BW, BY, HH] Rather YES [HE, RP, NI, NW, SH] NO [SL, HB, BE]
Burret et al. (2014)	West Laender 1950-2011 East Laender 1992-2011	Panel time series analysis	Panel unit root tests, cointegration tests	Laender finances are hardly sustainable.	NO [HB, SL, RP] Rather YES [BW, BY, HE, HH, NI, NW, SH]
Potrafke and Reischmann (2014)	West Laender 1980-2010	Panel analysis (Multivariate)	MBS-tests applied to panel using OLS (debt and surplus)	Including/excluding fiscal equalization transfers in the primary surplus changes the results.	YES [if transfers are included] NO [if transfers are excluded]

* "YES" indicates that the empirical results suggest that fiscal sustainability is detected. East German Laender include Brandenburg (BB), Berlin (BE), Saxony (SN), Saxony-Anhalt (ST), Thuringia (TH), Mecklenburg Western-Pomerania (MW) and West German Laender include Baden-Wuerttemberg (BW), Bavaria (BY), Bremen (HB), Hesse (HE), Hamburg (HH), North Rhine-Westphalia (NW), Lower Saxony (NI), Rhineland-Palatinate (RP), Schleswig Holstein (SH) and Saarland (SL).

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