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Does Wagner's law ruin the sustainability of German public finances?

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Abstract:
The empirical and theoretical literature on long-term relationships in public finance is dominated by two approaches: Fiscal sustainability and Wagner's law of an increasing state activity. In this paper, we argue that these two relationships should be analyzed simultaneously and not separately. We show how Wagner's law might influence fiscal sustainability and how the interaction of the two can be modelled using vector error correction models that include public expenditures, revenues and GDP. For Germany, we find strong evidence for Wagner's law throughout the whole period analyzed (1960-2007), while our results indicate sustainability of public finances only until 1973. We show that, for the period after 1973, it is the interaction of permanent expenditure increases and revenue reductions resulting from fiscal policy reactions to the oil crisis and Wagner's law that ruins the sustainability of public finances in Germany. Our findings underline the importance of the German debt brake for re-establishing sustainable public finances even under Wagner's law.

Keywords:
Fiscal sustainability; Wagner's law; Structural breaks; Cointegration; Vector error correction models.

JEL-Classification:
H63, H19, H50, E62.

Non-technical summary

The empirical and theoretical literature on long-term relationships in public finance is dominated by two approaches: Fiscal sustainability and Wagner's law of an increasing state activity. Fiscal sustainability - conceptionalized in the intertemporal budget constraint of the government - can be tested empirically based on ex-post data of government revenues and expenditures. Wagner's law postulates a long-term relationship between GDP and government expenditures.

In this paper, we argue that these two relationships should be analyzed not separately, but simultaneously: expenditure developments are the hinge between the dynamic long-term relationships of Wagner's law and fiscal sustainability. Furthermore structural breaks need to be taken into account. Therefore we estimate three-dimensional vector error correction models, which allow us not only to test the two dynamic long-term relationships simultaneously, but as well to analyze their interaction and to take structural breaks into account.

For a long dataset for Germany we find strong evidence for Wagner's law throughout the whole period analyzed (1960-2007), while our results indicate sustainability of public finances only until 1973. We show that, for the period after 1973, it is the interaction of permanent expenditure increases and revenue reductions related to the oil crisis with Wagner's law that ruins the sustainability of public finances in Germany. Thus, we conclude that Wagner's law has been decisive in ruining the sustainability, but not solely responsible. From a policy-perspective our findings underline the importance of the German debt brake for re-establishing sustainable public finances in particular under Wagner's law.

Nicht-technische Zusammenfassung

Die Literatur zur Analyse von Langfristbeziehungen in den öffentlichen Finanzen wird von zwei Ansätzen dominiert, fiskalische Tragfähigkeit und Wagner's Gesetz einer zunehmenden Staatstätigkeit. Fiskalische Tragfähigkeit - konzeptionalisiert auf Grundlage der intertemporalen Budgetbedingung - kann empirisch mittels der Beziehung zwischen Staatseinnahmen und -ausgabenentwicklungen untersucht werden. Wagner's Gesetz postuliert einen langfristigen Zusammenhang zwischen dem Wirtschaftswachstum und der relativen Größe des Staatssektors.

In diesem Papier versuchen wir, diese beiden Ansätze, die meist separat betrachtet werden, zusammenzuführen: Ausgabenentwicklungen stellen dabei das Scharnier zwischen den beiden dynamischen Langfristbeziehungen dar. Außerdem ist es entscheidend, mögliche Strukturbrüche zu berücksichtigen. Daher analysieren wir die Zusammenhänge in dreidimensionalen Vektor-Fehler-Korrekturmodellen mit den Variablen Staatsausgaben, Staatseinnahmen und Bruttoinlandsprodukt. Dies ermöglicht uns nicht nur das simultane Testen der beiden Beziehungen, sondern auch die Untersuchung ihrer Interaktion unter der Berücksichtigung von Strukturbrüchen.

Unsere Schätzungen liefern - basierend auf einem langen Datensatz für Deutschland (1960-2007) - umfangreiche Evidenz für das Vorliegen von Wagner's Gesetz in der gesamten betrachteten Periode, während fiskalische Tragfähigkeit nur bis 1973 gewährleistet war. Wir zeigen, wie nach 1973 das Zusammenspiel von mit der Ölkrise in Zusammenhang stehenden permanenten Ausgabenerhöhungen und Einnahmensenkungen auf der einen Seite und Wagner's Gesetz auf der anderen Seite, zu nicht-tragfähigen Staatsfinanzen in Deutschland geführt hat. Somit war Wagner's Gesetz entscheidend für den Verlust der Tragfähigkeit, aber nicht allein verantwortlich. Angewandt auf die Finanzpolitik betonen unsere Ergebnisse die Bedeutung der deutschen Schuldenbremse für die Wiederherstellung der fiskalischen Tragfähigkeit der öffentlichen Finanzen - vor allem bei Gültigkeit von Wagner's Gesetz.

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Does Wagner's Law Ruin the Sustainability of German Public Finances?[1]

1 Introduction

The European sovereign debt crisis - which left Greece, Ireland and Portugal in need of fiscal support - has reemphasized the importance of sustainable public finances. But when can public finances be characterized as sustainable? Large parts of the economic literature define fiscal sustainability on the basis of the intertemporal budget constraint of the government, which states that the present value of the outstanding sovereign debt needs - in any period - to equal the present value of all future primary surpluses.[2] This conception allows for empirical testing of the sustainability of public finances in sophisticated and convincing ways.

Hamilton and Flavin (1986) were the first to propose an empirical framework for testing the present value budget constraint by evaluating the stationarity properties of (undiscounted) public debt and primary deficits. In another approach, Trehan and Walsh (1991) investigate the cointegration relationship of public debt levels and primary deficits as an indicator for sustainability. Trehan and Walsh (1988) and Hakkio and Rush (1991) develop an alternative empirical framework which focuses on the stationarity of the total deficit. According to Hakkio and Rush (1991), a necessary condition for sustainable fiscal policies is a long-run elasticity of 1 between public expenditures, including interest payments and revenues, implying that increases (decreases) in government expenditures need to be matched in the long-run by identical revenue increases (decreases). Tests of this long-run relationship are based on cointegration analyses. Quintos (1995) modifies the approach of Hakkio and Rush and distinguishes between "'weak" and "strong" sustainability: A cointegration coefficient of 1 indicates strong sustainability, whereas a cointegration

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[2]Other approaches focus on the probability of a government becoming insolvent. See, for example, the value-at risk approach of Barnhill and Kopits (2004). Alternatively, Bohn (1998, 2007) investigates the government's primary surplus ratio response to changes in the debt ratio. Another, less frequently applied approach is presented in Caporale (1995), who transfers a specification test developed for speculative bubbles in financial markets to sustainability analyses.

coefficient between 0 and 1 implies only weakly sustainable public finances. Hakkio and Rush-type approaches have been frequently applied in recent multi-country studies (see Baharumshah and Lau (2007) or Afonso (2005)) or in comprehensive country-specific approaches (see Kirchgässner and Prohl (2008) or Gurbuz, Jobert and Tuncer (2007)).[3]

Testing fiscal sustainability based on cointegration has been criticized for not taking economic growth into account. The utmost importance of economic growth in sustainability analyses was already stressed by the very early contributions of Hansen and Greer (1942) or Domar (1944) and was reemphasized by Quintos (1995). If, for example, revenue increases fall short of expenditure increases in the long-run, this does not, in any case, necessarily indicate unsustainable public finances: Whenever the resulting absolute deficits grow more slowly than the economy, the public debt ratio would nonetheless converge to a debt level that can still reflect sustainability. Hakkio and Rush (1991) recognized this as well, stating that instead of using levels of fiscal variables "per capita spending and revenue, and spending and revenue as a fraction of GNP deem as more pertinent for a growing economy" (p. 430). Based on this argument, other authors, such as Afonso (2005) and Kirchgässner and Prohl (2008), refer only to GDP ratios of fiscal variables in bivariate frameworks to study the sustainability of public finances in a growing economy along the lines of Hakkio and Rush (1991).

In this paper we propose a new and more comprehensive approach to analyzing fiscal sustainability as we use GDP as a third separate variable in an endogenous cointegrated model.[4] This approach has especially three important advantages over the existing literature. First, it can incorporate the two dominating relationships in the public finance literature on economic long-run relationships simultaneously: fiscal sustainability and Wagner's law. Wagner's law postulates a specific long–run relationship between the size of the public sector and economic development: in the long-run, GDP increases lead to even higher increases in public spending. Obviously, expenditure developments play a crucial role in fiscal sustainability as well as in Wagner's law and could therefore work as the hinge between the two. Second, an analysis of ratios is not even adequate: if revenues, expenditures and GDP are the decisive variables for fiscal sustainability analyses based on the intertemporal budget constraint of the government in a growing economy and more than one cointegration relation exist (i.e. so–called pairwise cointegration), modelling the two long-run restrictions would be more adequate than eliminating one

[3]For a general critique of this type of testing, see Bohn (1998, 2007).

[4]The need to take the three variables in levels and two long-run relationships into account when evaluating fiscal policy is also emphasized by Afonso et al. (2009). Another multicointegration approach for fiscal sustainability analysis was introduced by Leachman et al. (2005).

available statistical restriction by using ratios. Third, the degree of economic structure that can potentially be captured by the econometric model is significantly reduced ex ante by a reliance on ratios, because there can be more economic long–run restrictions between the three variables than just a fiscal sustainability relationship between expenditures and revenues. Our approach therefore enhances fiscal sustainability analysis by taking the interactions of the budgetary relationship (between expenditures and revenues) and Wagner's law relation into account at the same time.

The paper proceeds as follows: In section 2, we introduce and discuss the general hypotheses of fiscal sustainability and Wagner's law and their potential interactions in a growing economy. Based on this, an empirical framework to test the two hypotheses and their interactions simultaneously is developed. In section 3, we briefly review the data, introduce the most adequate model specifications and finally report the estimation results. Section 4 concludes and discusses the implications of our analyses for the sustainability of German public finances as well as for the role of the German debt brake.

2 Fiscal sustainability and Wagner's law

2.1 Fiscal sustainability: general approach and testable hypothesis

Based on the intertemporal budget constraint of the government, the concept of fiscal sustainability can be operationalized in technical terms. The constraint states that the present value of the outstanding sovereign debt needs - in any period - to equal the present value of all future primary surpluses in order to be sustainable, or formally:

$$B_t = \sum_{s=1}^{\infty} \prod_{j=1}^{s} \frac{1}{(1+i_{t+j})} \left(R_{t+s} - G_{t+s}^{ni}\right) + \lim_{s\to\infty} \prod_{j=1}^{s} \frac{1}{(1+i_{t+j})} B_{t+s} \ , \tag{1}$$

with B_t as the nominal funds raised by issuing new debt, R_t as the nominal government's total revenues, i_t the nominal (one-period) interest rate, G_t^{ni} the national accounts value of nominal public consumption, investment and transfers - excluding the interest payments on debt. The limit of the second term on the right-hand side of the equation must equal zero for s to infinity to rule out the possibility that the government finances its deficits by simply issuing new debt. Although this is a rather general conception, one of its advantages is that it allows us to derive empirically testable hypotheses on fiscal sustainability.[5] In this paper, we follow the widely applied approach of Hakkio and

[5]See, for example, the discussions in Hakkio and Rush (1991) or Afonso (2005) for details.

Rush (1991) to derive such testable empirical hypotheses. Under the assumption that the government cannot use a *Ponzi*-type scheme to finance its expenditures and that the long-term interest rate is constant,[6] Hakkio and Rush (p. 431) derive the following cointegration regression from the intertemporal budget constraint:

$$R_t = a^{FS} + b_1 G_t + e_t^R \ , \tag{2}$$

with R_t as nominal government's total revenues, G_t as the national accounts value of nominal public consumption, investment, transfers including the interest payments on debt, a^{FS} including deterministic terms and e_t^R as some zero-mean residuals. Hakkio and Rush (1991) argue that, based on the public budget constraint, cointegration of R_t and G_t with $b_1 = 1$ is a necessary condition for fiscal sustainability.[7] To model this long-run relationship within a dynamic and endogenous framework, we rewrite the cointegration relation in terms of an equivalent error correction term normalized on government revenues with all variables measured in logarithms levels,[8]

$$ec_{1,t}^r = r_t + \beta_1 g_t + d^{FS} \ . \tag{3}$$

What are the direct implications of this condition for fiscal deficits? And are there any other "sufficient conditions", which need to be fulfilled to ensure fiscal sustainability when the economy is growing? For such an investigation based on log levels, the deterministic terms included in the error correction relationship $\left(d^{FS}\right)$ and their simultaneous inter-

[6]For the US case, Hakkio and Rush state that "the assumption that the interest rate is stationary rules out nominal magnitudes, since nominal magnitudes are not stationary" (p.435). However, it should be noted that the non-stationarity of long-run nominal interest rates may hold for the employed US data from 1950:2 to 1988:4. But even for the US, recent empirical studies report strong evidence for the null of (break) stationarity for a wide range of nominal interest rates between 1985 and 2004 (Cerrato, Kim and Macdonald, 2010). Furthermore, German nominal long-run interest rates show a different picture. Generally, there seems to be a sustained tendency to return to a stationary long-run equilibrium in the interest rate. This holds especially between 1960 and German reunification in 1991. After 1991, the rate seems to be shifted into another, stationary low-interest rate regime which lasts until today. Nevertheless, we also used real aggregates to check for the robustness of our results. Tests on the properties and the (restricted and unrestricted) coefficient estimates did not report strong differences compared with the estimates based on nominal data.

[7]A coefficient $b_1 > 1$ would imply that revenues increase more strongly than expenditures and thus that public finances are sustainable. The authors also show that in the case of level aggregates the No-Ponzi condition can even hold for a cointegrating coefficient between zero and 1 for some special cases. Therefore, they call the condition with a cointegrating coefficient equal to 1 "probably necessary" (p. 433). See Quintos (1995) for a distinction between strong and weak sustainability. We abstract from this reservation and focus on the "'strong"' case in which only a cointegration with a coefficient of 1 is a necessary condition.

[8]Written in this form, the necessary condition for fiscal sustainability would be a cointegration of r_t and g_t with a coefficient $\beta_1 = -1$ that cannot be rejected. A coefficient $\beta_1 < -1$ would imply that revenues increase more strongly than expenditures and thus indicate that public finances are sustainable.

action with other long-run relationships, such as Wagner's law in particular, will be of special importance. Generally, three cases have to be distinguished:

1. If *no deterministic terms* have to be included, the cointegrating relation with $\beta_1 = -1$ holds around a stationary zero-mean. No absolute deficits occur and no debt builds up in the long run. So the first possible sufficient condition for fiscal sustainability would be that the cointegration holds around a stationary zero-mean. In this paper, we call this the "'sufficient condition for zero debt in the long run" which would indicate fiscal sustainability in a very strict sense.[9]

2. If *a positive constant* has to be included in the error correction term, this would imply that - given a cointegration coefficient of $\beta_1 = -1$ – the expenditure over revenue ratio is larger than 1.[10] Such a ratio indicates the existence of a constant wedge between expenditures and revenues. This results in deficits, which lead to a continuous build-up of debt. While the ratio of these deficits to both expenditures and revenues, is necessarily constant in this case (following from the constant expenditure over revenue ratio), whether the ratio of these deficits with respect to GDP would be constant, decreasing or increasing depends on the development of expenditures relative to GDP. We therefore need to take the interactions with the second long-term relationship (Wagner's law) into account to discuss the sufficient conditions for sustainability in this case. We do this in section 2.3.

3. If we need to include *a positive trend* component in the error correction term, this would - based on a cointegrating coefficient of $\beta_1 = -1$- and variables in log levels - mean that the wedge between revenues and expenditures would grow permanently.[11] This would lead to a constant increase in the share of expenditure that needs to be deficit financed. Generally, this would make public finances clearly unsustainable in the long-term. The only exception would be the theoretical case in which the share of expenditures with respect to GDP decreases more strongly over time than the deficits increase.[12]

[9] As $r_t - g_t = \log(R_t/G_t)$, a positive non-zero constant in the equation normalized on log revenues would imply a revenue-expenditure ratio that is permanently smaller than 1, or respectively an expenditure-revenue ratio permanently larger than 1 and therefore imply structural deficits in absolute terms. In contrast, for negative non-zero constants, $0 < G_t/R_t < 1$ holds, resulting in permanent surpluses.

[10] In general, the deterministic could be negative as well but that would imply surpluses, which are exceptional for Germany and are therefore not in the focus of our analysis.

[11] The trend could be negative as well, but that would imply ever increasing surpluses.

[12] A decrease in the expenditure over GDP ratio would mean that Wagner's law does not hold (see section 2.2).

Sufficient conditions for fiscal sustainability in the event of the existence of Wagner's law as a second long-run restriction in a growing economy will be evaluated in detail in section 2.3 after a brief introduction to the theoretical and empirical conception of Wagner's law in the next section.

2.2 Wagner's law: general approach and testable hypothesis

Adolf Wagner's law of an increasing state activity" (Wagner (1883)) has a long tradition in the public finance literature and remains very influential. Peacock and Scott (2000), for example, classify Wagner's law as one of the most fundamental long-run relationships in public finances. However, they also point to the conceptional difficulties when testing the law. In his works, Wagner argued that industrial development is the decisive factor that drives up expenditure and leads to an increasing share of the public sector in the economy. Legrenzi and Milas (2002b, p. 437) distil three main causes of an upward influence of growing domestic income on government expenditure based on an evaluation of the full range of Wagner's works from 1883 to 1911. First, the increasing *complexity* of a growing economy leads to an increasing demand for government intervention. This complexity results from the growing importance of positive and negative externalities, general market failure and increasing inequality - all three leading to a substitution of private by public activity. Second, Wagner argues in favour of a *superior income elasticity* of public goods and services, which leads to a disproportionately large expansion in income-elastic cultural and welfare expenditures when domestic income grows. Third, economic development leads to an increasing need to finance *large-scale investments* and infrastructures *with public good characteristics*.

In contrast to the literature on fiscal sustainability, there is no established formal framework for Wagner's law from which an empirically testable expression can be directly derived (for an overview of methodological approaches, see Peacock and Scott (2000)). Instead, the theoretical considerations discussed above have to be translated - most adequately - into a testable empirical hypothesis. This leaves a considerable degree of freedom to the analyst. In this paper, we decided to follow the traditional and most frequently applied approach in public finance literature, which argues that Wagner's law can be tested most adequately by evaluating the relationship between total general government expenditures in current prices and gross domestic product (Peacock and Wiseman (1961)). This is the most frequently applied approach as it comes closest to what Adolph Wagner could have had in mind with respect to the three main arguments discussed above.[13]

[13]It should be noted that a broad variety of specifications that differ slightly from the traditional

To avoid potentially spurious and endogenously biased relationships between GDP and expenditures, an endogenous equilibrium model should be applied.[14] Legrenzi and Milas (2002a,b) show that, within such a framework, Wagner's law cannot be rejected if the long-run domestic income elasticity of total general expenditures in current prices is estimated to be higher than unity. Formally, this implies the following cointegration regression of public spending on economic development,

$$g_t = a^{WL} + b_2 gdp_t + e_t^g \ , \tag{4}$$

where g_t stands for the logarithmized national accounts value of nominal public consumption, investment, transfers including the interest payments on debt, gdp_t stands for log nominal output, a^{WL} for the deterministic terms and e_t^g is the equilibrium residual term. Wagner's law is rejected whenever the cointegrating coefficient β_2 is found to be significantly smaller or equal to 1. Equation 4 can be implemented as second error correction term - normalized, this time, on public spending and including the deterministic terms in d_t^{WL} into the dynamic and endogneous framework, where Wagner's law cannot be rejected for $\beta_2 < -1$,[15]

$$ec_{2,t}^g = g_t + \beta_2 gdp_t + d_t^{WL} \ . \tag{5}$$

In contrast to the fiscal sustainability analysis, the deterministic is less decisive here. The integration of a constant would not affect the conditions under which we would falsify Wagner's law. The same holds for the inclusion of a linear trend that could be implemented in a more general specification in order to control for factors other than GDP that might also have influenced the development of public spending in the long run.

2.3 Fiscal sustainability, Wagner's law and their interaction in a growing economy

Instead of testing fiscal sustainability and Wagner's law separately, an endogenous error correction model allows us to include and to estimate the two long-run equilibrium condi-

one can be found in the literature. For example, Legrenzi and Milas (2002b) additionally introduce five different versions of the law. Two additional versions are presented in Magazzino (2010). In some studies, unidirectional Granger-type causality based on error correction models is mentioned as an even stronger criterion for Wagner's law (see, for example, Ansari, 1997). An alternative and weaker version is presented, for example, by Yuk (2005), arguing that the law already holds if domestic income Granger-caused government expenditures and the response of expenditures to a shock in domestic income are significant and positive using an unrestricted VAR framework.

[14] See, for example, Henrekson (1993) and Gemmel (1990) for a discussion on spurious and endogenously biased estimations.

[15] In a pairwise cointegration approach with a budgetary relation as one long-run restriction, the Wagner's law hypothesis could also be tested based on a cointegrating relation between government revenues and economic development.

tions simultaneously (based on several estimation steps). We thus integrate the necessary condition for the sustainability of public finances (equation 3) as a first error correction term normalized on government revenues in the most general testable version with a constant and a linear trend.[16] In addition, the Wagner's law hypothesis is implemented as a second error correction term normalized on public spending (see equation 5), including a constant and a trend.[17] If the variables are included for each observation t in the vector y_t, no additional structural breaks in the cointegration deterministic, D_t^{CO} and the parameters of the long-run restrictions are captured in $[\beta' : \eta]$, where β has row dimension $K = 3$ and column dimension $r = 2$ and η is of dimension (2×2), the long-run part can be written as:

$$\begin{bmatrix} ec_{1,t}^{r} \\ ec_{2,t}^{g} \end{bmatrix} = \left[\beta' : \eta\right] \begin{bmatrix} y_t \\ D_t^{CO} \end{bmatrix} = \begin{bmatrix} 1 & \beta_1 & 0 & c_1 & trend_1 \\ 0 & 1 & \beta_2 & c_2 & trend_2 \end{bmatrix} \begin{bmatrix} r_t \\ g_t \\ gdp_t \\ 1 \\ t \end{bmatrix}. \tag{6}$$

The established necessary condition for fiscal sustainability (log levels)
Within this framework, the established necessary condition for the sustainability of public finances holds if there is a stationary linear combination of (difference-stationary) revenues and expenditures and the cointegrating vector is not significantly different from $\begin{bmatrix} 1 & -1 & 0 & c_1 \end{bmatrix}$ (if only a constant is restricted to the relation) and $\begin{bmatrix} 1 & -1 & 0 & c_1 & 0 \end{bmatrix}$ (for the more general version with a constant and a trend) with any value for c_1.

The established necessary condition for Wagner's law (log levels)
Wagner's law could not be rejected for the data if public spending and economic development are difference-stationary and cointegrated with a cointegrating vector $\begin{bmatrix} 0 & 1 & \beta_2 & c_2 \end{bmatrix}$ for the benchmark specification and $\begin{bmatrix} 0 & 1 & \beta_2 & c_2 & trend_2 \end{bmatrix}$ in the trend version, with $\beta_2 < -1$ and any value for the c_2 and the $trend_2$ coefficient.

A (modified) sufficient condition for fiscal sustainability in a growing economy (log levels)
We have already argued that the interaction between the deterministic specification and

[16] In the literature, a specification with only a constant restricted to the cointegration relation represents the benchmark.

[17] In fact, the intuition of the new theoretical approach to assessing Wagner's law by Florio and Colautti (2005) is closely related to ours. However, it focuses the interactions between fiscal sustainability and Wagner's law the other way around. The authors state that Pigou's conjecture of an excess burden from an ever increasing distortionary taxation under balanced budgets constrains the growth of public expenditures.

Wagner's law relationship becomes decisive, in the log-level based evaluation of fiscal sustainability in a growing economy. This is carried out below and is illustrated in figure 1. If no additional deterministic needs to be included given a coefficient of -1, the cointegrating relation holds around a stationary zero-mean, which would indicate zero debt in the long term and therefore very strict sustainability. If the $trend_1$ coefficient is found to be significantly larger than zero for a cointegration coefficient of -1, public finances can only be sustainable in exceptional cases.[18]

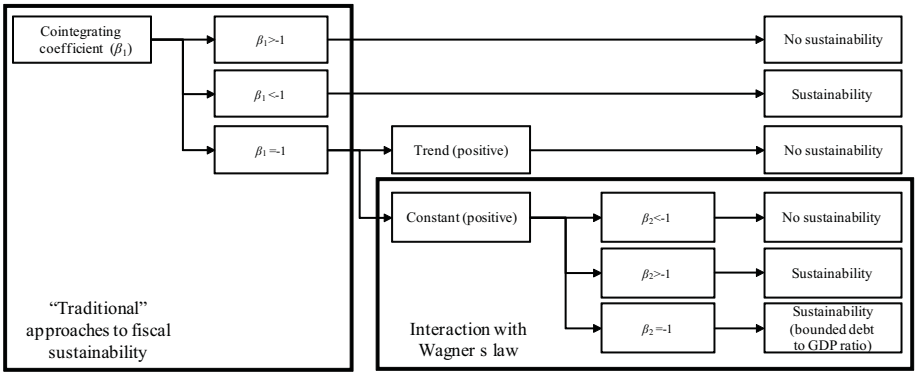

Figure 1: Integrating Wagner's law into the sustainability analysis of public finances

Thus, the most important case in a growing economy - for a cointegration coefficient of -1 - occurs if a significant constant needs to be included. If only a significant constant c_1 larger than zero has to be included, this would imply permanent deficits. *Two cases* have to be distinguished:

First, if Wagner's law does not hold (i.e. $\beta_2 \geq -1$), government deficits as a share of expenditures and of GDP are decreasing or at least constant in the long-run. In this case, the debt over GDP ratio would not grow indefinitely but would converge to a certain limit. For $\beta_2 > -1$, the limit equals zero and for $\beta_2 = -1$ the limit depends on the relationship of the nominal growth rate of the economy and the initial deficit over GDP ratio.[19]

In contrast, if Wagner's law holds (i.e. $\beta_2 < -1$), the deficits - which are constant as a share of expenditures - increase as a share of GDP. This directly follows from the

[18]The only exception would be the theoretical case in which the share of expenditures with respect to GDP decreases more strongly over time than the deficits increase. A decrease in the expenditure over GDP ratio would also mean that Wagner's law does not hold (see part 2.2).

[19]For example, given a nominal growth rate of 5% and a deficit to GDP ratio of 3%, the nominal debt would converge to around 60% of GDP, the debt threshold defined under the Maastricht criteria. The level up to which such a debt level is considered sustainable would have to be decided more or less arbitrarily.

increasing share of expenditures in GDP. In such a case, the interaction of a wedge between expenditures and revenues with Wagner's law results in permanently growing deficit and debt ratios in the long run. Thus, public finances need to be classified as unsustainable. We can therefore say that the dynamics resulting from Wagner's law ruin the sustainability of public finances. However, these dynamics can only have such negative consequences on sustainability if an initial wedge between public expenditures and revenues has occurred. These relationships between the fiscal sustainability relationship and Wagner's law are mapped in figure 1 (ordering of the relations is not decisive).

2.4 Fiscal sustainability and Wagner's law in German data

In the empirical literature on the sustainability of public finances in Germany, the four studies of Afonso (2005), Bravo and Silvestre (2002), Garcia and Hénin (1999) and Payne (1997) come closest to our approach, as they test the cointegration relationship between expenditures and revenues for different periods of German data (see table 1).[20] Two of these studies turn down the hypothesis of fiscal sustainability, while two find support for it.

Study	**Afonso (2005)**	**Bravo and Silvestre (2002)**	**Garcia and Hénin (1999)**	**Payne (1997)**
Data set	Annual data EU countries 1970-2003	Annual data Austria, France, Germany, Netherlands 1960-2000	Semi-annual data G7 countries (Germany 1961:2 – 1996:2)	Annual data G7 countries (Germany 1951-1993)
Empirical method	Stationarity analyses of public debt [B] Cointegration analyses [R/GDP, G/GDP]	Cointegration analyses [R/GDP, G/GDP]	Cointegration analyses impulse response functions [R/GDP, G/GDP]	Cointegration analyses [R, G; R/GDP, G/GDP; R p.c, G p.c.]
Evidence for FS (Germany)	No	Yes	No	Yes
Long-run coefficient	-0.521 (Engle-Granger); -0.629 (Johansen)	-0.689* (Engle-Granger, *not significantly larger than -1)	-0.727 (Johansen)	-1.002; -0.988; -1.002 (Engle-Granger)

Table 1: Fiscal sustainability in Germany

Although Wagner's law is very prominent in the literature, the number of empirical studies that focus on Germany is rather limited and the tested specifications of the law frequently differ from the traditional conception to which we refer. Six studies of German data seem

[20] Additional empirical evidence is presented in appendix A.

particularly relevant in this context (see Table 2).[21] The authors do as well study different time periods of German data and four of the studies find some support for Wagner's law.

Study	**Magazzino (2010)**	**Karagianni et al. (2002)**	**Thornton (1999)**	**Hayo (1996)**	**Payne and Ewing (1996)**	**Bohl (1996)**
Data set	Annual data EU-27 countries 1970-2009	Annual data EU-15 countries 1949-1998	Annual data 6 European countries 1750 - 1975	Quarterly data Germany 1960:1 - 1993:4	Annual data 22 countries 1952 – 1989	Annual data G7 countries (Germany: 1850 - 1913; 1960 - 1995)
Empirical method	Cointegration tests Granger-type causality tests (6 versions of WL, traditional and augmented)	Cointegration tests Granger-type causality tests (6 versions of WL)	Cointegration tests VECM estimation Granger-type causality tests (G and GDP)	Cointegration tests ADL and VECM estimation (G/GNP and GNP p.c.)	Cointegration tests ECM estimation Granger-type causality tests (G/GDP and GDP p.c.)	Cointegration tests ECM estimation Granger-type causality tests (G/GDP and GDP p.c.)
Evidence for WL (based on cointe-gration, Germany)	No (for standard version)	No (Engle-Granger) Yes (Johansen)	Yes	Yes	Yes	No
Long-run coefficient	-	-	-	-1.13	Between -0.679 and -0.992	-

Table 2: Wagner's law in Germany

3 Empirical analyses: An application for German data

Our analysis focuses on the long-run relationships between expenditures, revenues and GDP. The main variables employed are nominal total government expenditures, including interest spending, total government revenues and nominal aggregated output from 1960 to 2008 in a quarterly frequency (see figure 2).[22] We include only data up to 2007:4 as we are interested in long-term relationships and want to avoid possible distortions which could result from integrating the heavy economic downturn in 2008/09. Nonetheless, the horizon provides a long time-series data set - which is essential for a sophisticated analysis

[21] See Magazzino (2010) for an international survey.

[22] Logarithms of the level variables are used in the econometric analyses.

of long-run developments in public finances. In our view, the chosen variables are the most adequate measures for the relationships and interactions investigated in this paper.[23]

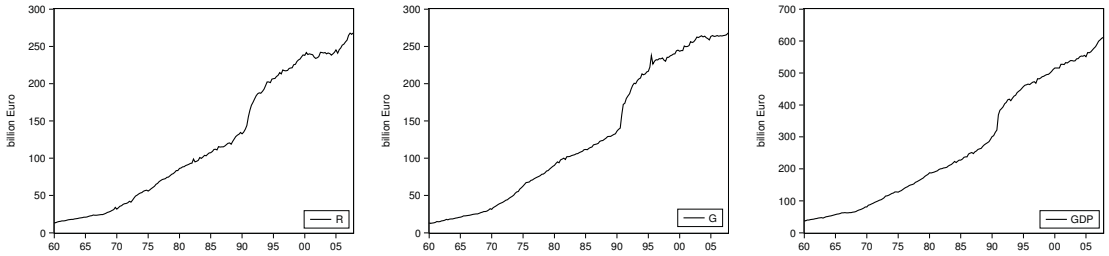

Figure 2: Total government revenues, total government expenditures and gross domestic product in bn Euro (all seasonally adjusted), 1960:1-2007:4.

3.1 Structural changes in fiscal regimes

Structural changes in fiscal regimes are not implausible in our rather long post-war data set, especially as the data includes periods of heavy economic distortions, such as German reunification and the first oil crisis in the early 1970s. An adequate empirical model needs to incorporate the effects of such exogenous events, via, for example, a correct specification of deterministic terms. In this way, in particular regime changes represented by shifts in the mean of a process can have direct implications on the analysis of fiscal sustainability. This is the case for the comprehensive sustainability approach that additionally involves the impact of other economic long-run relationships (see 2.3).

We apply a broad range of empirical instruments (equilibrium error analysis, recursive coefficient estimations, Cusum tests, Chow break-point and sample-split tests) to check for significant regime changes and their statistical properties.[24] These tests show strong evidence of a first structural break in the equilibrium relationships in the early 1970s,

[23]The data is based on the national accounts database of the Deutsche Bundesbank. Nominal data is seasonally adjusted using the Census-X-12-ARIMA procedure. In addition, the national accounts data is corrected for two statistical outliers resulting from the spending hike following from the liquidation of the German Treuhandanstalt in 1995:1 and the revenue windfall caused by the auction of UMTS licenses in 2000:3.

[24]The tests are based on two unrestricted log level models with a constant or a constant and a trend, and two first differences specifications taking account of the two potential long-run restrictions required under fiscal sustainability and Wagner's law around a constant or around a constant and a trend. The lag order is set based on information criteria with the highest level order, 4, recommended by the Akaike criterion (AIC) which is also reasonable due to the quarterly frequency of the data.

which can be related to the effects of the first oil crisis on the economy and the fiscal equilibriums. In the empirical literature on German public finances, this regime change has been frequently modelled as a level shift in 1973:4 (see e.g. Hayo (1996) and the references therein). A second break is related to the economic effects of German reunification in 1990/1991.[25] Most generally, it can be modelled as a shift in the long-run relationships in 1991:1.[26] Additionally, this choice of regime changes in 1973:4 and 1991:1 is further supported by bootstrapped versions of Chow break-point and sample-split tests (see table 3) on the null of parameter stability in the periods identified.

Long-run restrictions	General deterministic	Break date	Test	Test statistic	DF	Bootstrapped p-value
0	constant	1973 Q4	BP	121.6	45	0.021
			SS	91.53	39	0.008
		1991Q1	BP	142.8	45	0.003
			SS	79.6	39	0.018
	constant, trend	1973 Q4	BP	139.31	48	0.011
			SS	105.52	42	0.007
		1991Q1	BP	161.05	48	0.002
			SS	96.6	42	0.015
2	constant	1973 Q4	BP	96.34	39	0.037
			SS	63.57	33	0.001
		1991Q1	BP	124.8	39	0.004
			SS	71.48	33	0.003
	constant, trend	1973 Q4	BP	92.85	39	0.035
			SS	63.27	33	0.024
		1991Q1	BP	121.96	39	0.004
			SS	70.65	33	0.005

Note: Chow break-point (BP) and sample split (SS) tests based on bootstrapped p-values with 2000 replications; sample range 1961Q1-2007Q4.

Table 3: Sample-split and break-point tests

3.2 Stationarity and cointegration analyses

A precondition for the existence of long-run relationships is that the endogenous variables are integrated of order one, I(1), and not trend-stationary. First, we perform augmented Dickey-Fuller (ADF) tests (which examine the null hypothesis of a unit root) and, as a robustness check, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests on the null hypothesis of stationarity or trend-stationarity. These tests provide strong evidence that the log

[25] A minor influence might also stem from the slight methodological change in statistical recording following the application of the new European System of Accounts (ESA 1995). For the period from 1991 onwards, we have employed national accounts data according to ESA 1995 methodology, while data for previous years are based on the ESA 1970 methodology.

[26] Alternatively, a level shift only in the short-run part of the error correction model seems adequate based on evidence from recursive coefficients.

levels of all variables are integrated of order one and are not driven by deterministic trends.[27] However, according to Perron (1989), standard unit root tests tend to misspecify trend-stationary processes as difference stationary and may have very low power, even asymptotically, if regime changes are simply ignored. Thus, in a second step, we include the identified structural breaks (modelled as level shifts in the constant of a trend function in levels and correspondingly as impulse dummies in first differences). To test for unit roots including one structural shift, we apply the approach developed by Lanne, Lütkepohl and Saikonnen (2002). For two shifts, we slightly modify the methodology proposed by Perron (1989) and refer to Perron's test statistics.[28] The tests provide strong evidence that the implementation of one or two level shifts does not change the results obtained by standard ADF tests: No variable is trend-stationary if one or two breaks are included at the data points 1991:1 and 1973:4 (see appendix B). Hence, the results from all unit root and stationarity tests (with and without regime changes) indicate that the variables are non-stationary in levels, driven by a stochastic trend, and stationary in first differences.

Based on these I(1)-properties, we apply the Johansen (1995) cointegration procedure to test whether the variables are cointegrated - which is a necessary condition for the existence of any long-run restrictions. This procedure strongly depends on the deterministic terms that are included in the underlying models, as these can have strong effects on the limiting distributions to be applied. Therefore, the tests are performed including not only a constant - as in the majority of existing empirical studies on fiscal sustainability - but also a linear trend as suggested under the more general hypotheses of fiscal sustainability and Wagner's law.[29] Additionally, the identified structural breaks are taken into account by adding dummy variables to the deterministic part of the processes. In a first step, we test without any structural regime changes, before including just one structural break, either in 1973:4 or in 1991:1 in a second step. Finally, both regime changes are included. The optimal lag order is determined by information criteria for the corresponding VAR processes (larger order by AIC, lower by SC). The results are presented in appendix B.

If only a constant is included, all specifications of the tests provide strong evidence

[27]The results are presented in the first table in appendix B. The results of the KPSS test for the first differences are less consistent than those for the levels. The stationarity null hypothesis cannot be accepted for the first differences of our variables on the 5 percent level.

[28]The results of the tests with two breaks have to be interpreted with great caution, because the limiting distribution of the test probably changes when two breaks are included.

[29]We also tested different general deterministic specifications against each other, using standard likelihood ratio procedures. Especially for higher lag orders of the short-run dynamic in the underlying VEC models, there is evidence that a model with only a constant (restricted to the cointegration relations) performs better than a model with a linear trend if no regime shift or only one regime shift is included in the long-run restriction. However, this evidence becomes weaker for the cases of two breaks, lower lag orders or if the linear trend is set to be orthogonal to the cointegrating relationship.

for two cointegrating relationships between the three variables. If, additionally, a linear trend is included, this evidence becomes slightly weaker for higher lag orders (in the specifications with no or only one structural break). However, this may also result from a slight misspecification of the underlying models. In fact, the results of the related estimation indicate that the trend component is significant in only one of the cointegration relationships. Therefore, a proper specification with a trend only restricted to one of the long-run restrictions would probably further strengthen the result of two cointegrating vectors in each tested version.

Taken together, the analyses provide strong evidence for $r = 2$ linear independent long-run relationships between revenues, expenditures and GDP. This supports the idea of basing the sustainability analysis on an endogenous three-dimensional system with two long-run restrictions, instead of analyzing only the relation between revenues and expenditures over GDP. As our test in the previous two sections showed, all conditions for testing the two long-run hypotheses and their interaction, based on a three-dimensional cointegrated VAR, are empirically fulfilled.

3.3 A (dynamic and endogenous) model set up

In part 2, we derived values for the coefficients of the long-term equilibrium relationships under the null hypothesis of fiscal sustainability and Wagner's law. Now, these coefficients are estimated in a multi-step procedure based on vector error correction models (VECM). Diagnostic checks indicate that the most adequate specifications of our model include either a constant, or a constant and a linear trend restricted to the cointegration equation. Moreover, the identified regime changes in 1973:4 and 1991:1 are taken into account. According to the notation of Saikkonen and Lütkepohl (2000), the corresponding models in log levels are the following for our case of $K = 3$ variables:

$$y_t = \mu_0 + \delta_{73} D_{t,T_{73}} + \delta_{91} D_{t,T_{91}} + x_t \ , \tag{7}$$

$$y_t = \mu_0 + \mu_1 t + \delta_{73} D_{t,T_{73}} + \delta_{91} D_{t,T_{91}} + x_t \ . \tag{8}$$

Where μ_0 represents the (3×1) – vector of constants, μ_1 the (3×1) – vector of trend slope parameters, δ_{73} and δ_{91} are unknown (3×1) dummy parameter vectors, x_t is a 3–dimensional $VAR(p)$ process assumed to have a $VECM(p-1)$ form, and the dummy variables are defined as,

$$D_{t,T_{73}} = \begin{cases} 0, & t < T_{73} \\ 1, & t \geq T_{73} \end{cases} \text{ and } D_{t,T_{91}} = \begin{cases} 0, & t < T_{91} \\ 1, & t \geq T_{91} \end{cases} .$$

The Akaike info criterion (AIC) indicates three as optimal lag order for the model in first differences, which we considered as reasonable due to the quarterly data.[30] Thus, the two three-dimensional models with cointegration rank two and three lags in first differences represented in the following equations (9) and (10) are estimated,

$$\begin{aligned} \Delta y_t = \Pi^{sb} &\begin{bmatrix} y_{t-1} & 1 & D_{t-1,T_{73}} & D_{t-1,T_{91}} \end{bmatrix}' \\ &+ \sum_{i=1}^{3} \Gamma_i \Delta y_{t-i} + \sum_{i=0}^{3} \left[\gamma_{73,i} \Delta D_{t-i,T_{73}} + \gamma_{91,i} \Delta D_{t-i,T_{91}}\right] + u_t \end{aligned} \tag{9}$$

$$\begin{aligned} \Delta y_t = \upsilon + \Pi^{sb,tr} &\begin{bmatrix} y_{t-1} & t-1 & D_{t-1,T_{73}} & D_{t-1,T_{91}} \end{bmatrix}' \\ &+ \sum_{i=1}^{3} \Gamma_i \Delta y_{t-i} + \sum_{i=0}^{3} \left[\gamma_{73,i} \Delta D_{t-i,T_{73}} + \gamma_{91,i} \Delta D_{t-i,T_{91}}\right] + u_t \end{aligned} \tag{10}$$

where the $(3 \times (3+3))$- matrix $\Pi^{sb} = \alpha \left[\beta' : \eta : \theta_{73} : \theta_{91}\right] = \alpha \left[\beta' : -\beta'\mu_0 : -\beta'\delta_{73} : -\beta'\delta_{91}\right]$ includes the cointegration relationships (with structural breaks) as well as their loading parameters for the model with just a restricted constant. This matrix is of rank $r = 2$. The $(3 \times (3+3))$- matrix $\Pi^{sb,tr} = \alpha \left[\beta' : \eta : \theta_{73} : \theta_{91}\right] = \alpha \left[\beta' : -\beta'\mu_1 : -\beta'\delta_{73} : -\beta'\delta_{91}\right]$ is also of rank $r = 2$ and includes the cointegration relationships and their loadings for the model with a constant and a linear trend. Now the constant term is defined as $\upsilon = -\Pi\mu_0 + (I_3 - \Gamma_1 - ... - \Gamma_3)\,\mu_1$, and can be written outside the long-run relationship. In both models, $\Delta \mathrm{D}_{\mathrm{t}-i,T_{\mathrm{B}}}$ are the impulse dummies (valued 1 at time $t = T_B + i$, which results from differencing the shifts). Thus, the impulse dummy coefficients are defined as

$$\gamma_{73,i} = \begin{cases} \delta_{73}, & i = 0 \\ -\Gamma_i \delta_{73}, & i = 1, ..., 3 \end{cases} \quad and \quad \gamma_{91,i} = \begin{cases} \delta_{91}, & i = 0 \\ -\Gamma_i \delta_{91}, & i = 1, ..., 3 \end{cases} .$$

[30] The Schwartz criterion (SC) frequently indicated zero lags, which we considered as too restrictive with respect to the short-run interactions and the autocorrelation left in the residuals.

3.4 Fiscal restrictions and estimation of the restricted models

In a first step the models (9 and 10) are estimated in their reduced forms, using a maximum likelihood procedure to create a benchmark.[31] If the trend is included, the reunification shift ultimately turns out to be unnecessary in the cointegration relationship. Therefore, we only included the dummy in the first differences of the trend model to capture permanent effects that result from German reunification.[32]

In a second step we start with testing the derived fiscal sustainability restriction in both specifications, (9) and (10). More precisely, we test whether the cointegrating coefficient between revenues and expenditures is not significantly different from -1 and all deterministic terms can be restricted to zero (cointegration around a zero-mean) using Wald-tests. This is clearly rejected (p:0.003; p:0.000).

Based on this, we test the even more comprehensive hypothesis of whether the identified cointegration relation with a coefficient of -1 between revenues and expenditures holds around a zero-mean, at least, until 1973:4, and around a non-zero mean thereafter. For the model with just a constant restricted to the cointegration relationship, this hypothesis cannot be rejected (p:0.909); Thus, the following three restrictions are imposed on the cointegration matrix,

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \cdot \begin{bmatrix} \beta_1 \\ \beta_2 \\ c_1 \\ c_2 \\ \delta_{73,1} \\ \delta_{73,2} \\ \delta_{91,1} \\ \delta_{91,2} \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix} \quad . \tag{11}$$

For the model with trend, restricting the cointegrating coefficient β_1 to -1 and the whole deterministic to zero until the first oil crisis initially leads to a rejection of the hypothesis

[31] Results for the unrestricted estimations are not shown because the focus in this paper is on restricted versions of the models.

[32] The insignificance may result from the characteristics of the linear combination. The reunification break in 1991 can be found in each of the level series and may consequently be eliminated by a linear combination. Thus, reunification does not seem to change the long-run equilibrium relationships in German public finances. However, in the first differences part, the unrestricted estimation indicates significantly smaller growth rates of public spending and revenues in the post-reunification regime (-0.008 [0.003]; -0.007 [0.003]). In contrast, reunification has no significant permanent effect on the growth rate of GDP.

at a five percent level (p:0.030). However, if only the cointegrating coefficient and the trend are restricted, it is clearly accepted (p:0.934) and, in the related estimation, the constant is found to be insignificant. Therefore, the following two restrictions are imposed on the cointegration matrix of the more general model including a trend:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} \beta_1 \\ \beta_2 \\ c_1 \\ c_2 \\ trend_1 \\ trend_2 \\ \delta_{73,1} \\ \delta_{73,2} \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \end{bmatrix} \quad . \tag{12}$$

In a last step, we turn to evaluate the dynamics related to Wagner's law. The corresponding Wald tests indicate that an additional restriction, which is in fact a Wagner's law falsification restriction on the second cointegration relation, is rejected in each specification (p:0.021; p:0.000) and thus Wagner's law cannot be falsified for our data.

Based on these findings, the restrictions laid out in (11) and (12) are imposed and the systems are re-estimated using a two stage procedure based on least squares:[33] At the first stage, the restricted cointegrating vectors are estimated, and, at the second stage, the loadings and the short-run coefficients are estimated using the estimated cointegrating matrix in identified form as an additional set of variables.[34]

Results and diagnostic checks

Table 4 presents the estimates for the long-run dynamics and the loadings of the restricted

[33]We refer to the LS estimator even at the second stage because the set of (short-run) regressors in each equation is the same.

[34]The loadings of both restricted models indicate significant budgetary disequilibrium corrections only to run through the revenue channel. Thus, systematic corrections, which may be due to systematic political decision-making or budgetary rules like debt brakes are based on revenue adjustments. In this way between 16 to 18% of an equilibrium error are corrected within one quarter to bring public finances back into their (un-)sustainable dynamic. In contrast, there is no tax-spend channel at work. A negative effect of deviations from the (un-)sustainable equilibrium on economic growth is only found significant only at the 10% level and only in the model with a constant in the cointegrating relationship. Concerning deviations from the Wagner's law relation, there is evidence that the required adjustment runs through all three correction channels. However, taking both specifications into account, this evidence is only robust for the public spending channel (between 6 and 18% of an error are corrected). An indirect type of a spend-tax channel can only be found in the model with constant (5% of an error are corrected by revenue adjustments). Concerning the short-run corrections in economic growth, even the sign of the coefficient is not robust.

models. With respect to the first cointegration relationship between expenditures and revenues (with a coefficient of -1), the only deterministic element that is siginificant in both specifications (model 1b and 2b) is the positive shift 1973. This indicates that the fiscal aggregates are cointegrated around a zero-mean until 1973:4, implying strict fiscal sustainability and zero debt ratios in the long run. But, subsequently the cointegrating vector only holds around a positive mean of 0.06 within the two specifications. This shift indicates a permanent wedge between expenditures and revenues of 6% from 1973:4 onwards, meaning that expenditures equal 1.06 times the revenues in the long-run equilibrium, or alternatively, deficits equal 6% of the revenues. As revenues and expenditures are both variables that have an upward trend, this wedge is related to growing deficits in absolute terms.

In section 2.3, we have shown that the long-run dynamics resulting from the second equilibrium relationship - Wagner's law - become decisive for fiscal sustainability if revenues and expenditures are cointegrated around a non-zero mean. This situation is given by the identified shift from 1973:4 on. Furthermore, Wagner's law cannot be falsified based on our framework: The additionally required minimum falsification restriction of a coefficient of -1 between expenditures and GDP is clearly rejected.[35] The coefficients for the influence of economic development on expenditures, are estimated with -1.18 (in the model with just a constant) or -1.31 (in the model with a trend and a constant), indicating long-run reactions of public spending to changes in GDP that are significantly larger than unity. Hence, before 1973:4, Wagner's law had no effect on the sustainability of German public finances. But from 1973:4 onwards, the deficits, which have been constant with respect to expenditures as well as to revenues, increase with respect to GDP, because Wagner's law generates an increasing share of public expenditures in GDP in the long run.

Therefore, it is the dynamic related to Wagner's law that started to ruin the sustainability of public finances from 1973:4 onwards. However, Wagner's law is not solely responsible: The permanent wedge between expenditures and revenues triggered by the structural economic changes located around the first oil crisis was the decisive precondition for the ruining influence of Wagner's law. How did this wedge develop? A detailed analysis shows that the combination of strong and permanent expenditure growth – driven in particular by an increase of public wages by 11% in 1974, but as well by increasing expenditure for a higher level of unemployment and a reform of the child subsidy – combined with sluggish revenues opened the wedge. Revenues were permanently depressed

[35] As already discussed, the deterministic is not decisive for the second long-run relationship.

Model	**Model 1b**		**Model 2b**	
	Restricted to fiscal sustainability		Restricted to fiscal sustainability	
Estimator	First stage: 2 Step LS		First stage: 2 Step LS	
	Second stage: LS		Second stage: LS	
Equilibrium relation	ec_1^r	ec_2^g	$ec_1^{r,trend}$	$ec_2^{g,trend}$
Variables				
r	1.000		1.000	
g	-1.000	1.000	-1.000	1.000
gdp		-1.183 ***		-1.312 ***
		0.060		*0.037*
constant	0.000	1.499 ***	0.005	2.087 ***
		0.211	*0.015*	*0.102*
D73	0.061 ***	0.026	0.061 ***	-0.096 ***
	0.007	*0.088*	*0.013*	*0.030*
D91	0.000	0.297 ***	-	-
		0.064		
trend			0.000	0.004 ***
				0.000
Loading parameter				
Δr	-0.184 ***	-0.054 ***	-0.161 ***	-0.074
	0.046	*0.014*	*0.062*	*0.055*
Δg	0.075	-0.060 ***	0.020	-0.175 ***
	0.038	*0.014*	*0.064*	*0.057*
Δgdp	-0.072 *	-0.060 ***	0.074	0.068
	0.038	*0.011*	*0.053*	*0.046*
Long-run restrictions (Wald-test)				
Fiscal Sustainability				
Test-statistic	0.547		0.136	
DF	3		2	
P-value	0.909		0.934	
Non-Wagner`s Law [1]				
Test-statistic	11.600		31.904	
DF	4.000		3.000	
P-value	0.021		0.000	
Model statistics				
Log-likelihood	1608.199		1605.110	
Det(cov)	7.46E-12		7.70E-12	
Model diagnostics				
R_{RW}^2: Δr	0.39		0.31	
R_{RW}^2: Δg	0.42		0.34	
R_{RW}^2: Δgdp	0.30		0.14	
M-Breusch-Godfrey tests (LM_4)	0.25		0.00	
M-Portmanteau tests (adj) (Q_{24})	0.33 (0.12)		0.22 (0.07)	
M-ARCH-LM test ($MARCH_{LM4}$)	0.00		0.00	
ec_{FS} [2]	0.14		0.14	
ec_{WL} [2]	0.87		0.06	

Note: [1]Non-Wagner restriction is additionally tested, i.e.non-Wagnerian coefficient with value equal to -1 is tested. If this restriction does not hold simultaneously, it is not implemented. Standard deviations in italics. ***, **, * corresponds to significance on the 1, 5, 10% level. *Diagonstics*: R_{RW}^2 compares the fit of the estimated model with the fit of pure random walk with drifts for each equation by comparing the sum of squared residuals obtained by each equation to the sum of squared residuals obtained by the random walk with drift. A value of 0.5 indicates a 50% better fit of the specified model than the fit of the drifted random walk (Koren and Stiassny , 1998)). Numbers in rows of tests are p-values. Null of M-Breusch-Godfrey and M-Portmanteau test (adj) is no residual autocorrelation. Null of M-ARCH-LM test is residual homoscedasticity. Lag order is 4 for M-Breusch-Godfrey test, 24 for M-Portmanteau test and 2 for M-ARCH test.

Table 4: Estimation results (restricted)

from 1975 on, in particular by the impact of an income tax tariff reform, but as well by tax reflief measures for investments.[36] Most of the decisive fiscal measures were directly related to the oil crisis. Wage demands were motivated by high inflation rates resulting partly from oil price increases and the fiscal relief on the revenue side was – although most of it was permanent - motivated especially to stimulate demand in the economic recession following the oil crisis.

Table 4 also provides some measures of the overall fit and diagnostics for the two estimated specifications. In addition to the standard error of the regressions, we computed R^2_{RW} as a measure of goodness of fit that is well suited for non-stationary time-series as it compares the fit of the estimated model with the fit of a pure random walk with drift, with respect to the development of the log levels (see as well Koren and Stiassny, 1998). This measure indicates a significantly higher degree of explanation for all three single equations than for pure random walk with drift models. Altogether, the goodness of fit of the model with just a restricted constant is slightly higher than the fit of the specification with trend.

This finding is supported by tests of the the adequacy of the models. The multivariate Portmanteau tests do not show any evidence for any high-order autocorrelation in the estimated residuals. For smaller lag orders, remaining residual correlation can only be found in the linear trend model. The only test rejecting its null hypothesis in every specification is the M-ARCH test, indicating conditional heteroscedasticity in the estimated residuals. Univariate versions of the tests reveal that this results from the residuals of the fiscal equations, which show higher volatility especially in the first half of the 1970s and - with respect to revenues also during the 1980s.[37] However, with respect to the high degree of long-run economic structure implemented in the models and with respect to the distortion that may result from unmodelled discrete or gradual parameter changes in long historical time series, we consider the results to be confirmative and thus the models to be adequate for our economic analysis.

4 Conclusion

In the time series literature on fiscal sustainability, cointegration between revenues and expenditures with a vector $\begin{bmatrix} 1 & -1 \end{bmatrix}$ has been established as a necessary condition for

[36] For details on the fiscal policy reaction see Ehrlicher (1991) or the annual analyses (1973/74, 1974/75, 1975/76) of the German Council of Economic Advisors.

[37] It could be useful to model the conditional variances of the residuals, using, for example, GARCH models (see, for example, Silvennoinen and Teräsvirta, 2009). The stochastic volatility VAR approach presented in Koop and Korobilis, 2009) provides a useful alternative.

sustainable public finances (see Hakkio and Rush, 1991). However, this cointegration relationship is not sufficient in growing economies, in which the effects of economic growth on the fiscal aggregates and therefore additional long-run restrictions have to be considered as well. In this paper, we argue that the widespread approach of merely integrating economic growth by analyzing ratios of revenues and expenditures in bivariate frameworks is not adequate for German data. Instead, we propose a three-dimensional vector error correction model, which includes government revenues, government expenditures and gross domestic product as the three decisive variables for sustainability analyses. In the case of pairwise cointegration, it enables us to implement more economic long-run information into the empirical analysis than an evaluation of ratios does: The three dimensional model allows us to test the second dominant long-run hypothesis in public finances - Wagner's law of an increasing share of public expenditures in GDP - simultaneously. Moreover, the interactions of the two equilibrium relationships, the fiscal sustainability and the Wagner's law restriction, can be evaluated in order to test a sufficient condition for fiscal sustainability.

Comprehensive tests including identified structural breaks indicate that the variables are all integrated of order one and that there are two cointegration relationships, which can be identified as one between expenditure and revenues and one between public spending and economic development. The estimation of unrestricted and restricted vector error correction models provides strong support for a cointegrating coefficient between revenues and expenditures of -1, fulfilling the necessary condition for sustainable public finances. At the same time, the hypothesis of Wagner's law cannot be rejected in any specification: This indicates an increasing public spending to GDP ratio over time. Significant coefficient estimates in the best-suited models indicate a 1 percent increase in gross domestic product to trigger an increase in expenditure of around 1.2 - 1.3 percent in the long-run.

With respect to fiscal sustainability the interaction of the two long-run relationships with the estimated deterministic in the revenue-expenditure cointegration relationship plays a decisive role. In fact, the revenue-expenditure relationship holds around a zero-mean until 1973, indicating that the sufficient condition for strict fiscal sustainability with zero-debt was fulfilled from 1960 to 1973. However, at the end of 1973, the fiscal reactions to the heavy economic distortions associated with the first oil crisis caused a permanent wedge between expenditures and revenues. This wedge indicates permanent post-oil-crisis deficits of around 6% of the government's revenues – caused by a strong and permanent expansion of expenditures while revenue growth was permanently reduced by a tax reform and tax relief measures. And while these deficits as a ratio of revenues or expenditures have been constant, Wagner's law of an increasing share of expenditures in GDP leads

to constantly increasing deficit to GDP ratios over time, indicating unsustainable public finances.

We therefore conclude that, although it was the reaction in public finances to the heavy economic distortions related to the first oil crisis which drove a wedge between expenditures and revenues, this alone did not ruin the sustainability of German public finances after 1973. The interplay between the shift to permanent deficits and the increasing share of public spending in GDP - captured in Wagner's law - was needed to put German public finances on an unsustainable path. Thus, Wagner's law has been decisive for ruining the sustainability, but not solely responsible.

These findings have important implications for current German fiscal policies. The long-run dynamics of German public finances have been characterized by two equilibrium relationships that only ruin fiscal sustainability if there is a permanent wedge between expenditures and revenues. Against this background, the German debt brake - to be faded in gradually for the federal government by 2016 and for the states by 2020 - plays a very important role: Looking ahead it should strongly reduce the wedge between expenditures and revenues that persisted since 1973 by limiting the structural deficits to 0.35% of GDP in the long run. In this respect, the good news is that the debt brake does not necessarily need to change the two dynamic long-run relationships, which have dominated German public finances since the 1960s - and are thus probably very hard to change - in order to recover sustainability. It is sufficient if it focuses on the wedge between expenditures and revenues. However, the bad news is that as long as the budget is not fully balanced, the dynamic of Wagner's law is likely to nonetheless exert an upward pressure on the deficit to GDP ratio. Therefore, Wagner's law will lead to gradually increasing deficit ratios with ongoing growth in the economy. This would even speak in favour of a stricter fiscal rule that does not accept any structural deficits in the long run.

Another important insight based on our findings is that strong deficit-financed expenditure increases can have devastating effects on the sustainability of public finances in Germany. It was the wedge between expenditures and revenues caused by fiscal reactions related to the oil crisis that became persistent and played an important role in turning German public finances unsustainable after 1973. This underlines how dangerous a strategy of large deficit-financed expenditure increases - even in crisis - can be in the long run, if these increases are not cut back or matched by corresponding revenue increases in the subsequent periods. This further stresses the need to consolidate public finances after the crisis-related deficit increases in 2009 and 2010.

Appendix

A The fiscal sustainability literature for German data

Study	Afonso (2005)	Bravo and Silvestre (2002)	Garcia and Hénin (1999)	Payne (1997)	Greiner and Kauermann (2008)*	Ballabriga and Martinez-Mongay (2005)	Artis and Marcelino (1998)	Fève and Hénin (2000)	Uctum and Wickens (2000)	Greiner and Semmler (1999)	Vanhoerebeek and van Rompuy (1995)	Caporale (1995)
Data set	Annual data EU countries 1970-2003	Annual data Austria, France, Germany, Netherlands 1960-2000	Semi-annual data G7 countries (Germany 1961:2–1996:2)	Annual data G7 countries (Germany 1951-1993)	Annual data Germany, Italy 1960-2003	Annual data EU countries, US, Japan 1977-2002	Annual data Some EU countries (Germany 1963-1994)	Semi-annual data G7 countries (Germany 1961:2–1996:2)	Annual data Some EU counties, UK, US 1965-1994	Annual data Germany (1955-1994)	Annual data Some EU Countries (Germany 1970-1994)	Annual and semi-annual data Some EU countries (Germany, 1960:1-1990:2)
Empirical method	Stationarity analyses of public debt [B]; Cointegration analyses [R/GDP, G/GDP]	Cointegration analyses [R/GDP, G/GDP]	Cointegration analyses and impulse response functions [R/GDP, G/GDP]	Cointegration analyses [R, G; R/GDP, G/GDP; R p.c, G p.c.]	Semi-parametric time-varying estimations (penalized spline smoothing) of the relationship between primary surpluses and public debt (Bohn, 1998) [(R-G)/GDP, B/GDP)]	Non-linear least squares estimations of the relationship between primary surpluses and public debt (Bohn, 1998) [(R-G)/GDP, B/GDP)]	Stationarity analyses of public debt ratios [B/GDP]; Cointegration between primary surpluses and debt ratio [B/GDP, (R-G)/GDP]	Stationarity analyses of public debt ratio[B/GDP]	Stationarity analyses of public debt ratio[B/GDP]	Stationarity analyses of public debt [B], primary and total surpluses [R-G]	Stationarity analyses of public debt ratio and deficit ratio [B/GDP, (G-R)/GDP]	Specification test for speculative bubbles [B/GDP, (R-G)/GDP]
Evidence for fiscal sustainability (Germany)	No	No	No	Yes	Yes	Yes	No	No	No	No	Yes	No
Long-run coefficient	-0.521 (Engle-Granger); -0.629 (Johansen)	-0.689 (Engle-Granger and Johansen)	-0.727 (Johansen)	-1.002;- 0.988; -1.002 (Engle Granger)	-	-	-	-	-	-	-	-

* For constant parameters, Greiner et al. (2007) find the same.

Table A.1: Fiscal sustainability analyses for German data

B Time series properties

ADF and KPSS tests

Model	Variable	ADF test Null: non-stationarity			KPSS test Null: (trend-) stationarity	
		T	p	deterministic	t	p
Level						
Constant and linear trend	GDP	-0.019	0		0.659	5
		-0.532	4		0.293	14
	R	-0.157	0		0.718	5
		-0.435	9		0.313	14
	G	-0.402	0	trend*	0.712	5
		-0.409	3		0.314	14
Constant	GDP	-4.456***	0	c***	3.242	5
		-2.406	4	c***	1.360	14
	R	-5.099***	0	c***	3.198	5
		-2.286	9	c***	1.342	14
	G	-3.807***	3	c***	3.176	5
		-2.502	6	c***	1.335	14
First differences						
Constant	GDP	-4.222***	3	c***	1.070	5
					0.675*	14
	R	-5.562***	2	c***	1.384	5
		-2.735*	8	c**	0.809	14
	G	-4.683***	2	c***	1.478	5
		-3.908***	3	c***	0.815	14

Notes: ADF Test: ***, **, * Null hypothesis rejected at the 1, 5, 10 % level. Critical values are taken from Davidson and MacKinnon (1993) for ADF tests and from Kwiatkowski, Phillips, Schmidt and Shin (1992) for KPSS tests. KPSS Test: *, **, *** Null hypothesis not rejected (accepted) at the 1, 5, 10% rejection probability.

Table B.1.1: Results of stationarity tests

Variable	**LLS test**				**Perron test (modified)**	
	Null: non trend stationary/random walk (unit root) with drift, change in level parameter *Alternative*: trend stationary, change in intercept of trend function (Specification under the alternative: deterministic trend (linear), constant, level shift dummy(ies))					
	Break-point: 1973Q4		Break-point: 1991Q1		Break-points: 1973Q4, 1991Q1	
	t-statistic	p	t-statistic	p	modified Perron t-statistic (none)	p
GDP	-0.812	0	-0.589	0	0.418	0
	-1.074	4	-0.616	4	-0.503	4
R	-0.585	0	-0.536	0	0.612	0
	-0.812	9	-0.638	9	-0.173	9
G	-1.142	3	-1.195	3	0.395	0
	-0.777	4	-1.416	6	-0.468	3

Table B.1.2: Results of stationarity tests with structural breaks

Johansen Trace Cointegration Test (model with constant)

Deter-ministic	No. of lagged levels (VAR in levels)	H_0: r = r_0	LR-test statistic	Critical values 10%	5%
		a. No structural breaks			
constant	1	$r_0 = 0$	209.2 [0.000]	32.25	35.07
		$r_0 = 1$	28.80 [0.020]	17.89	20.16
		$r_0 = 2$	4.14 [0.403]	7.60	9.14
	4	$r_0 = 0$	53.13 [0.000]	32.25	35.07
		$r_0 = 1$	24.31 [0.012]	17.89	20.16
		$r_0 = 2$	7.12 [0.123]	7.60	9.14
		b. Structural break in 1973:4			
constant	1	$r_0 = 0$	209.1[0.000]	38.79	41.47
levelshift73		$r_0 = 1$	30.11[0.008]	22.82	25.03
		$r_0 = 2$	6.69[0.384]	10.77	12.60
	4	$r_0 = 0$	58.01[0.000]	38.79	41.47
		$r_0 = 1$	28.50[0.015]	22.82	25.03
		$r_0 = 2$	8.45[0.224]	10.77	12.60
		c. Structural break in 1991:1			
constant	1	$r_0 = 0$	259.6 [0.000]	38.33	40.80
levelshift91		$r_0 = 1$	33.02 [0.002]	22.66	24.72
		$r_0 = 2$	4.44 [0.691]	10.93	12.74
	4	$r_0 = 0$	56.38 [0.000]	38.33	40.80
		$r_0 = 1$	26.61 [0.025]	22.66	24.72
		$r_0 = 2$	5.84 [0.506]	10.93	12.74
		d. Structural break in 1991:1 and 1973:4			
constant	1	$r_0 = 0$	260.3 [0.000]	46.57	49.40
levelshift73		$r_0 = 1$	34.82 [0.014]	28.62	30.99
levelshift91		$r_0 = 2$	7.46 [0.618]	14.33	16.33
	4	$r_0 = 0$	63.29 [0.001]	46.57	49.40
		$r_0 = 1$	33.78 [0.020]	28.62	30.99
		$r_0 = 2$	7.50 [0.613]	14.33	16.33

Notes: levelshift91-levelshift dummy 91:1, no additional impulse dummies were restricted to the cointegration relation; critical values of all Johansen trace tests are obtained by computing the respective response surface according to Doornik (1998) if there are no breaks, or according to Johansen et al. (2000) if there are up to 2 breaks. For further discussion of the test specifications in the event of structural breaks, see Johansen et al. (2000).

Table B.2.1: Results of cointegration tests (constant)

Johansen Trace Cointegration Test (model with constant and trend)

Deter-ministic	No. of lagged levels (VAR in levels)	H_0: r = r_0	LR-test statistic	Critical values 10%	5%
		a. No structural breaks			
constant	1	$r_0 = 0$	86.72 [0.000]	39.73	42.77
linear trend		$r_0 = 1$	31.67 [0.007]	23.32	25.73
		$r_0 = 2$	6.96 [0.359]	10.68	12.45
	4	$r_0 = 0$	52.57 [0.003]	39.73	42.77
		$r_0 = 1$	21.71 [0.152]	23.32	25.73
		$r_0 = 2$	4.45 [0.679]	10.68	12.45
		b. Structural break in 1973:4			
constant	1	$r_0 = 0$	88.89 [0.000]	44.22	47.45
linear trend		$r_0 = 1$	33.34 [0.014]	26.54	29.13
levelshift73		$r_0 = 2$	9.91 [0.235]	12.48	14.35
	4	$r_0 = 0$	60.09 [0.002]	44.22	47.45
		$r_0 = 1$	25.37 [0.133]	26.06	29.13
		$r_0 = 2$	6.26 [0.607]	12.48	14.35
		c. Structural break in 1991:1			
constant	1	$r_0 = 0$	120.1 [0.000]	43.58	46.80
linear trend		$r_0 = 1$	42.84 [0.000]	26.06	28.64
levelshift91		$r_0 = 2$	10.46 [0.183]	12.20	14.06
	4	$r_0 = 0$	57.87 [0.003]	43.58	46.80
		$r_0 = 1$	28.38 [0.053]	26.06	28.64
		$r_0 = 2$	9.93 [0.217]	12.20	14.06
		d. Structural break in 1973:4 and 1991:1			
constant	1	$r_0 = 0$	122.8 [0.000]	54.12	57.82
linear trend		$r_0 = 1$	46.18 [0.003]	33.42	36.41
levelshift73		$r_0 = 2$	14.34 [0.172]	16.17	18.33
levelshift91					
	4	$r_0 = 0$	67.64 [0.006]	54.12	57.82
		$r_0 = 1$	36.48 [0.049]	33.42	36.41
		$r_0 = 2$	15.20 [0.134]	16.17	18.33

Notes: levelshift91-levelshift dummy 91:1, no additional impulse dummies were restricted to the cointegration relation; critical values of all Johansen trace tests are obtained by computing the respective response surface according to Doornik (1998) if there are no breaks, or according to Johansen et al. (2000) if there are up to 2 breaks. For further discussion of the test specifications in case of structural breaks see Johansen et al. (2000).

Table B.2.2: Results of cointegration tests (constant and trend)

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