Causality between Expenditures and Revenues: Empirical Evidence from Switzerland

by

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Abstract

This study examines the causal relationship between revenues and expenditures of the Swiss federal government over the period from 1872 to 2002. Both, the standard and modified multivariate cointegration tests consistently support the hypothesis that the real federal revenues and expenditures are cointegrated. We also show that World War II has a significant impact on the stability of the cointegrating relationship. Furthermore, within the error-correction approach, we examine the causal relation between revenues and expenditures by estimating the short-run dynamics and the error-correction terms. In this study, we place more emphasis on the latter as the source of the causal relationship. Because both, the revenues and expenditures respond to the long-run budgetary non-equilibrium, we find bi-directional causality between federal revenues and expenditures.

Keywords: Budget deficit; Structural breaks, Cointegration test, Error-correction model

JEL classification: H 62, H 63, C22, C32

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1 Introduction

Recent increase in government budget deficits in several developed countries has raised the issue of whether governments should respond to a budgetary imbalance by changing its expenditures and allowing revenues to adjust accordingly, by cutting taxes, or by using both budgetary policy instruments simultaneously. Theoretical literature develops several approaches to explain why a large budget deficit is followed by an increase in taxes or by cutting expenditures.[1] The public finance literature investigates the fiscal synchronization hypothesis. It takes the view that in a representative democracy, budgetary decisions on taxation and allocation are made simultaneously by the executive and legislative branches of government.[2] An opposite view, known as the institutional separation hypothesis and put forward by BAGHESTANI and MCNOWN (1994), emphasises that these decisions are made independently. In contrast to this standpoint, FRIEDMAN (1982) searches for intertemporal causal relations between revenues and expenditures. In his 'tax-spend hypothesis', he argues that the rise in taxes leads to an increase in government expenditures and consequently worsens the budgetary balance. In this model, lowering taxes is a necessary condition to bring the development of budget deficit under control. Drawing on the *fiscal illusion arguments*, BUCHANAN and WAGNER (1977) agree that taxes influence expenditures but they suggest a negative effect. Finally, BARRO (1979) with his intertemporal tax smoothing model, argues that expenditures cause taxes.[3] He claims that a temporary increase in government expenditures, as seen during the wars, causes a permanent shift in tax rates. A similar argument was put forward by PEACOCK and WISEMAN (1979).

A number of empirical studies are concerned with the causal relation between revenues and expenditures in different countries. By applying GRANGER-causality test to fiscal data, some studies test the fiscal synchronization hypothesis by verifying the bidirectional causality between revenues and expenditures. In order to test the FRIEDMAN (1978) tax-spend hypothesis one searches for unidirectional positive causal effects of revenues on expenditures. And finally, to test the BUCHANAN and WAGNER (1977) hypothesis, one might examine the negative effect of revenues on expenditures. MANAGE and MARLOW (1986) apply this test to the U.S. federal fiscal data and show the bidirectional short-run causal relation between the revenues and expenditures. Comparable results are found by RAM (1988, 1988a) who finds support for the fiscal synchronization hypothesis by using the U.S. data. On the contrary, BAGHESTANI and MCNOWN (1994) come to a different conclusion when they apply the multivariate error-correction approach to the U.S. federal government data. They find a unidirectional short-run causality running from revenues to expenditures, while there are no long-run causal relations between these variables. For Switzerland, MANZINI and ZARIN-NEJADAN (1995) employ

1. A survey of theoretical and empirical studies is presented in PAYNE (2003).

2. See, e.g., WILDAWSKY (1964) or MUSGRAVE (1966).

3. This approach is a benchmark theoretical model that provides a positive explanation of the observed deviation from the tax smoothing model. See, e.g., ALESINA and PEROTTI (1995).

GRANGER-causality tests and find the unidirectional causality running from revenues to expenditures over the period from 1950 to 1992.

In this paper, we use long-run data from 1872 to 2002 to examine the causal relations between Swiss federal government revenues and expenditures. In contrast to previous studies and by considering long-run data, we ask whether the data exhibit significant structural breaks, and whether such breaks have an impact on the direction of the causal relations between federal revenues and expenditures. That structural breaks might play a role can be seen from the development of federal government revenues and expenditures given in *Figure 1*. It shows that World War I and II had a clear impact: they lead to an increase in expenditures and consequently to a budget deficit.

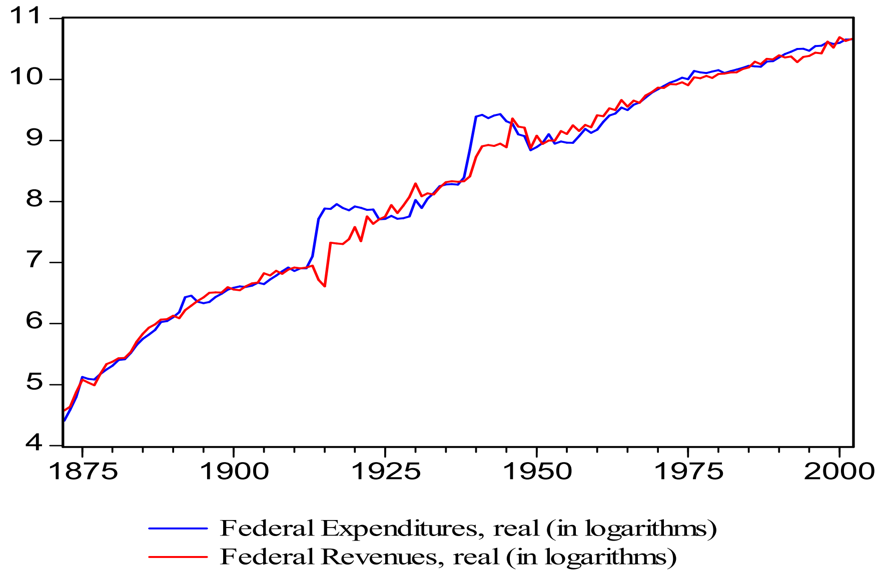

Figure 1: Swiss real federal revenues and expenditures (in logarithms), 1872 – 2002

We study two questions regarding the long-run development of the Swiss fiscal policy. Firstly, we examine whether an increase in the federal budget deficit was followed by raising revenues or by cutting expenditures. To investigate this question, we use a the multivariate error-correction model which allows to estimate both, short- and long-run causal relations. Secondly, we test whether there were structural breaks which changed the causal relations between revenues and expenditures. To estimate the structural changes in the data we apply several econometric approaches. We perform the PERRON (1989) test for a known, single structural break in the data, and the test of LANNE, LÜTKEPOHL and SAIKKONEN (2002) which allows for structural shifts in several numbers of periods. In order to estimate the number of cointegrating relation, besides the JOHANSEN (1988), we use the SAIKKONEN and LÜTKEPOHL (2000) test which allows for structural shifts in the level of the time series. To estimate structural breaks in the long-run relation we perform the GREGORY and HANSEN (1996) test. And finally, we examine the causal relation between revenues and expenditures within the modified error-correction approach as proposed by LÜTKEPOHL, TERÄSVIRTA and WOLTERS (1999).

The paper is organized as follows. *Section 2* reviews the empirical literature. *Section 3* provides a brief discussion of the used time series. Thus, it contains the discussion of time series properties of federal revenues, expenditures and GNP. Furthermore, it presents the results of the unit root and stationarity tests applied to these data. *Section 4* presents the results of the standard and the modified bi- and multivariate cointegration tests. *Section 5* shows the results of the causality test within the modified vector-error-correction approach. *Section 6* contains concluding remarks.

2 Review of the Empirical Literature

Whether the the development of fiscal data was consistent with the theoretical hypotheses on causal relation between revenues and expenditures has been examined by a number of studies. MANAGE and MARLOW (1986) support the fiscal synchronization hypothesis by using the annual U.S. federal fiscal data over the period from 1929 to 1982. Within a multivariate approach, they report bidirectional (feed-back) short-run causal relations between expenditures and revenues. Comparable results are obtained by using a bivariate model. In a similar vein, RAM (1988) uses annual fiscal data from 1929 to 1983 and supports the fiscal synchronization hypothesis. Similar econometric methods are also applied to the fiscal data from other countries. AHIAPOR and AMIRKHALKHALI (1989) find unidirectional causality from revenues to expenditures with Canadian data from 1926 to 1985. They show that an increase in taxes causes a growth in expenditures. For Greece, PROVOPOULUS and ZAMBARAS (1991) find causal relations which run from expenditures to tax revenues. Another study by HONDROYIANNIS and PAPARETROU (1996) applies these tests to post-World War II data and draws the same conclusion. By using fiscal series in relation to GDP, they find that expenditures and revenues are co-integrated. Within a vector-error-correction framework, they show that taxes are caused by expenditures. Following this evidence, they conclude that a reduction in size of government is required to bring the budget deficit under control.

Another approach is used by ISLAM (2001). Considering U.S. federal fiscal data over the period from 1929 to 1997, he observes long-run causality running from expenditures to revenues. He argues that treating the U.S. federal fiscal data over this period as I(1)-series is incorrect. He finds that the revenues and expenditures series are trend-stationary with breaks in the trends in 1940 for expenditure and in 1941 for revenue. Instead of taking the first differences he suggests to use a de-trending method to make the series stationary. By working with the detrended and, therefore, stationary series, he shows that in the long-run, expenditures do cause revenues. These outcomes are in line with the findings of ANDERSON, WALLACE and WARNER (1986); they use annual U.S. federal data for the post-World War II period. By employing causality test within a three-dimensional model which includes beside the fiscal variables real GNP and inflation, they conclude that an increase in government expenditures causes the same trend in taxes.

Most of the studies which use the post-World War II quarterly data for the U.S. federal government support the fiscal synchronization hypothesis insofar as they report a feed-back relationship between the taxes and expenditures. Using the bivariate error-correction method, MILLER and RUSSEK (1990) find feed-back in the U.S. from 1946 to 1987. They argue that "…over time fiscal authorities are unlikely to make spending decisions in isolation from tax decisions, and vice versa" (p. 228). Similar observations are found in HASAN and SUKAR (1995).

BAGHESTANI and MCNOWN (1994) come to a different conclusion when applying multivariate cointegration and error-correction analysis.[4)] Considering quarterly fiscal data from 1955 to 1989, they support the institutional separation hypothesis for the U.S. federal government. They show that the terms representing budgetary imbalance are insignificant in both equations, for revenues and expenditures. Hence, they examine the short-run dynamics in an error-correction model, and they report unidirectional causality from revenues to expenditures. Similar results are presented by HOOVER and SHEFFRIN (1992). They use quarterly fiscal data from 1950 to 1989 and search for effects of structural breaks caused by changes in government taxation and allocation policy on the stability the of causal relations, They apply a Chow-test and find a break in the late 1960's. Based on this evidence, they split the sample and show that this break significantly changed the causal direction. They find that revenues GRANGER -caused expenditures in the pre-1960 period, but find support for the institutional separation hypothesis for the latter period.

To sum it up, these studies produce different results depending on the econometric approach used. Most studies use the standard GRANGER-causality tests which allow to estimate only the short-run causal relations between revenues and expenditures. If the fiscal variables are cointegrated, the error-correction concept enables estimating both, short-run and long-run causal relations. Thus, we apply an error-correction framework to the Swiss data to examine the short-run dynamics as well as the impact of the error-correction terms. We place more emphasis on the latter source of causal relationship. Moreover, we use a multivariate approach as many of the studies show that the bivariate analysis reaches the ambiguous conclusions as a consequence of the omitted variables. Furthermore, when using the methodology of cointegration and error-correction analysis we take possible structural shifts in the data into account.

3 Data, Empirical Methodology, and Results

To perform the analysis, we use the annual budget data of the Swiss federal government for the period 1872-2002. We employ real federal government expenditures and revenues, real

4. PAYNE (1997) uses a similar econometric method to investigate Canadian fiscal data. He shows that expenditures significantly respond to budgetary non-equilibrium terms, and concludes that government should lower expenditures in order to reduce the budget deficit.

gross national product (GNP) and the GNP deflator.[5] We use the GNP deflator to generate the real series we need for our analysis. In order to eliminate heteroscedasticity we use the (natural) logarithms of the time series.

3.1 Results of Unit Root and Stationarity Tests

To examine the order of integration of time series, we perform different unit root and stationarity tests. To test the null hypothesis of a unit root we conduct the Augmented DICKEY-FULLER (ADF), the GLS-Modified Augmented DICKEY-FULLER (ADF-GLS) test, proposed by ELIOTT, ROTHEMBERG and STOCK (1996), as well as the PHILLIPS-PERRON (PP) test. We also apply the stationarity test of KWIATKOWSKI, PHILLIPS, SCHMIDT, and SHIN (KPSS) which has the stationarity of the series as the null hypothesis. Additionally, we conduct the unit root tests for data with possible structural shifts. We also apply the PERRON (1989) unit root test which allows for single structural break in the trend function of time series. Since this test has widely been criticized because of treating the time of the breaks as known, we use, in addition, the test developed by LANNE, LÜTKEPOHL and SAIKKONEN (2002) which allows for unknown break points. *Table 1* displays the results of the performed unit root and stationarity tests in both forms with and without a linear trend, which are applied to the fiscal series and GNP. The lag order is chosen by using the *Hannan-Quinn* information criterion.

The results of the unit root tests support the null hypothesis for revenues, expenditures and GNP, and stationarity for their first differences. The same result is provided by the stationarity test. Thus, we can assume that these three series are I(1).

Since standard unit root tests tend to incorrectly specify the trend-stationary time series with structural breaks as difference stationary,[6] we check the robustness of the estimated results by examining whether these series exhibit significant structural shifts. For this purpose we use two approaches. One is developed by PERRON (1989), which accounts for one-time structural change in the trend function of the series. For the case where the structural shift occurs in a number of periods and the time of its occurrence is unknown, LANNE, LÜTKEPOHL and SAIKKONEN (2002) develop an alternative framework.

For the PERRON test, we use three different models. The first model (A) allows for one-time change in the intercept of the trend function. The second one (B) accounts for the change in the growth rate of the trend function. Finally, the third model (C) allows for a change in the intercept and the growth rate. Critical values for these tests are given by PERRON (1989, 1990). He proposes two methods to choose the possible structural break points endogenously. One possibility is to select the break point by value which minimizes the t-statistics for testing the

5. Sources of the data: *Historical Statistics of Switzerland*, and several issues of the *Statistical Yearbook of Switzerland* (several issues) and data of the Federal Budget which we obtained from the Federal Statistical Office.

6. See, e.g., RAPPORT and REICHLIN (1989).

null hypothesis. An alternative possibility is to choose it by using the maximum modulus of the t-statistic (i) on the change in the intercept in model A, or (ii) on the change in the slope in models B and C. In performing these tests, we follow his first methodology.

Table 1: Results of unit root and stationarity tests

Variables	ADF-test $\hat{t}$	k	ADF-GLS-test $\hat{t}$	k	PP-test $\hat{t}$	k	KPSS-test $\hat{t}$	k
	Model with a constant							
Revenue	-1.054	6	1.522	6	-0.787	6	2.238**	6
Expenditure	-0.992	0	2.150*	0	-1.011	6	2.220**	6
GNP	-1.112	2	2.371*	3	-0.363	6	2.236**	6
	Model with a deterministic trend							
Revenue	-1.322	6	-1.607	6	-2.329	6	0.384	6
Expenditure	-2.236	0	-2.323	0	-2.296	6	0.380	6
GNP	-2.170	2	-2.376	2	-3.278	6	0.092	6
	First differences							
Revenue	-11.030**	1	-2.899**	2	-17.389**	6	0.131	6
Expenditure	-11.508**	0	-2.454**	3	-11.524**	6	0.097	6
GNP	-12.988**	1	-2.061**	2	-12.264**	6	0.063	6

'**', '*' or '(*)' show that the null hypothesis of no cointegration can be rejected at the 1, 5, or 10 percent level, respectively. – k is the number of lags based .on the HANNAN-QUINN criterion.

Usually, World War II is seen as a possible structural break.[7)] Accordingly, we check whether this period had an impact on the stationarity properties of the time series. The results are given in *Table 2*. They show that the expenditure series is compatible with a trend-stationary model which had in the forties a structural break in the slope but not necessarily in the intercept; the corresponding t-statistics are significant from 1942 to 1948. Contrary to this, for revenue the unit root hypothesis still holds, even if there has been a structural break during World War II. Finally, for GNP we derive only for the year 1948 a significant result (at the 5 percent level); there might have been a break in the intercept.

LANNE, LÜTKEPOHL and SAIKKONEN (2002) argue that the results of the PERRON (1989) test for a single are not valid if the structural change in time series occurs in a number of periods. They develop a test for the unit root in time series with the level shift by adding the (non-linear) shift function $f_{t\eta}(\theta)'\gamma$ to the test equation and propose to estimate the model

(1) $$y_t = \mu_0 + \mu_1 t + f_{t\eta}(\theta)'\gamma + x_t.$$

7. See BEN-DAVID and PAPELL (1995) for the search of the impact of World War II in the GNP series for the continental European countries.

Table 2: Unit Root Tests with a Structural Breaks

Break Point	Model A k	Model A $\hat{t}$	Model B k	Model B $\hat{t}$	Model C k	Model C $\hat{t}$
			Revenues			
1941	6	-1.678	6	-3.570	6	-3.551
1942	6	-1.589	6	-3.452	6	-3.600
1943	6	-1.591	6	-3.436	6	-3.635
1944	6	-1.548	6	-3.530	6	-3.663
1945	6	-2.373	6	-3.632	6	-3.688
1946	6	-1.522	6	-2.954	6	-3.722
1947	6	-1.869	6	-3.248	6	-3.687
1948	6	-1.408	6	-3.139	6	-3.654
1949	6	-1.892	6	-3.517	6	-3.608
1950	6	-1.789	6	-3.517	6	-3.603
			Expenditures			
1941	1	-2.789	1	-3.920(*)	1	-4.261*
1942	1	-3.274	1	-4.347*	1	-4.232(*)
1943	1	-3.325	1	-4.357*	1	-4.197(*)
1944	1	-3.093	1	-4.169*	1	-4.144(*)
1945	1	-3.415	1	-4.449*	1	-4.081(*)
1946	1	-3.107	1	-4.242*	1	-4.024(*)
1947	1	-3.334	1	-4.330*	1	-3.963(*)
1948	1	-2.938	1	-4.209*	1	-3.918
1949	1	-3.037	1	-3.892(*)	1	-3.870
1950	1	-3.120	1	-3.997*	1	-3.849
			GNP			
1941	1	-2.713	1	-2.679	1	-2.922
1942	1	-2.697	1	-2.660	1	-2.912
1943	1	-3.049	1	-2.973	1	-2.899
1944	1	-2.960	1	-2.899	1	-2.885
1945	1	-2.834	1	-2.801	1	-2.869
1946	1	-3.222	1	-3.164	1	-2.854
1947	1	-3.524(*)	1	-3.439	1	-2.844
1948	1	-3.870*	1	-3.775(*)	1	-2.834
1949	1	-3.646(*)	1	-3.600	1	-2.824
1950	1	-3.665(*)	1	-3.645	1	-2.812

'**', '*' or '(*)' show that the null hypothesis of no cointegration can be rejected at the 1, 5, or 10 percent level, respectively. k is the number of lags. Critical values are from PERRON *(1989)* for λ which is defined as a ratio of pre-break sample size to total sample size.

θ is a scalar parameter, $\gamma = [\gamma_1 \;\; \gamma_2]'$ is a two-dimensional parameter vector, and x_t is a stationary term, which is represented by an AR(p)-process. The shift function can be defined as

(2a) $$f_t^{(1)} = d_{tT_b} = \begin{cases} 0, & t < T_B \\ 1, & t \geq T_B \end{cases}$$

(2b) $$f_t^{(2)} = \begin{cases} 0, & t < T_B \\ 1 - e^{-\theta(t-T_B+1)}, & t \geq T_B \end{cases}$$

(2c) $$f_t^{(3)} = \left[\frac{d_{1,t}}{1-\theta L}, \frac{d_{1,t-1}}{1-\theta L} \right]'$$

Here, denotes the dummy variable with a shift at the time point T_B. There is always a sharp shift in θ, but (2b) and (2c) allow for a smooth (deterministic) transition if θ is not too large.

The procedure of the test is as follows: in a first step, the deterministic element in model (10) is estimated by generalized least squares (GLS) and then subtracted from the original series. After that, the ADF-test is conducted on the adjusted series in a second step. Critical values are given in LANNE, LÜTKEPOHL and SAIKKONEN (2002).

All three models are applied to revenues, expenditures and GNP. We consider the break points for the truncated sample [(0.15T), (0.85T)]. To select the AR-order, we use the Hannan-Quinn criterion. The estimated results and the corresponding critical values of the test statistic are plotted in *Figures 2* to *4*.

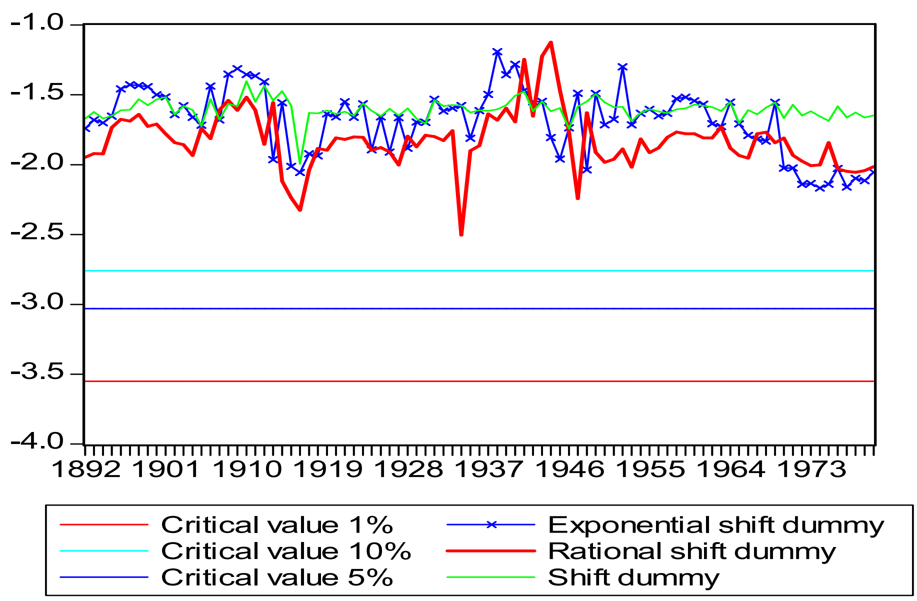

Figure 2: Unit root test results in presence of structural shifts for revenues

Figure 2 shows the values of test statistics obtained for all three models for the revenues series. It shows that there is no significant structural break in the series. These results support the conclusion of the PERRON (1989) test. Both the standard and the modified unit root tests suggest that federal revenues are non-stationary at levels.

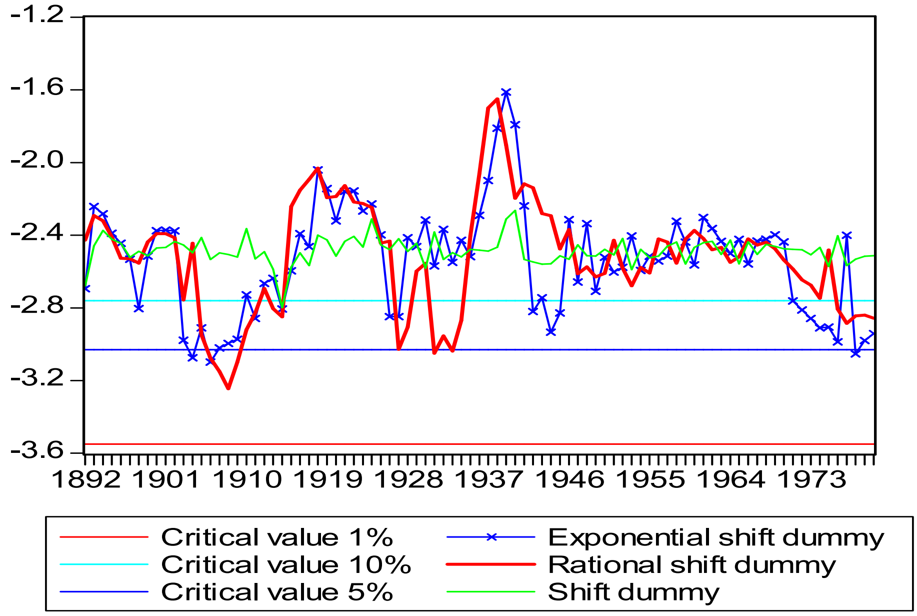

Figure 3: Unit root test results in presence of structural shifts for expenditures

Figure 3 displays the results for the expenditures series and shows the sensitivity of test-statistic values to the choice of the shift point. It reports that both, the exponential and the rational shift dummies indicate several shifts in expenditure series. The significant breaks are found during World War II and at several time points at the beginning of 1910's and 1930's.

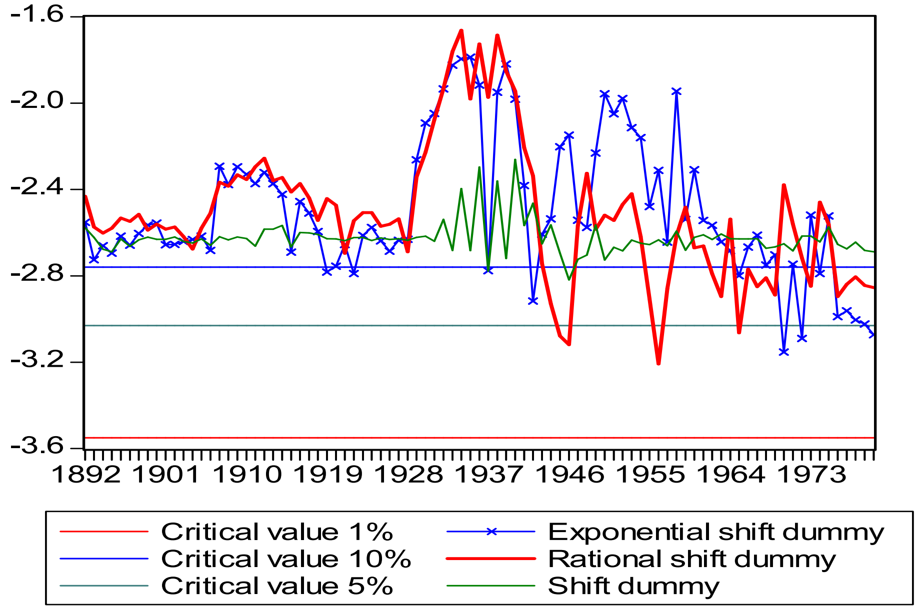

Figure 4: Unit root test results in presence of structural shifts for GNP

Finally, *Figure 4* presents the test values for real GNP series. Contrary to the findings reported by the Perron test, theset results suggest that the series might have had several structural changes since the second World War..

As a summary, the performed unit root tests detect several breaks in the federal expenditures and GNP during World War II. There remains the question as to what extent the structural shocks in these series are related to stability of cointegration relations: this topic will be clarified now.

3.2 Multivariate Co-integration Analysis

The results of the unit root analysis suggest that revenues, expenditures and GNP are integrated of order one. In a next step we perform multivariate tests for co-integration. Working with more than two I(1)-series, we estimate the number of cointegarion relations, i.e., the number of linearly independent cointegrating vectors. To do this, we use two different concepts. Firstly, we apply the JOHANSEN (1988) procedure. This test, however, may produce incorrect statistics if the data exhibit structural changes. For this situation, SAIKKONEN and LÜTKEPOHL (2000) recommend to take into account these structural shifts by performing the modified co-integrating rank tests.

Staring with the VAR or order p,

(3) $$Y_t = \sum_{j=1}^{p} A_j Y_{t-j} + u_t ,$$

where Y is the k-dimensional vector of the commonly dependent variables, A_j, j = 1, 2, …, p , are the (kxk)-dimensional parameter matrices, and u is white noise, the usual Error-Correction-Representation is

(4) $$\Delta Y_t = \nu_0^* + \Pi Y_{t-1} + \sum_{j=1}^{p-1} A_j^* \Delta Y_{t-j} + u_t$$

with

$$\Pi = I - \sum_{j=1}^{p} A_j \quad \text{and} \quad A_j^* = -\sum_{i=j+1}^{p} A_i \ ,$$

where the matrix Π can be decomposed into the product of the two (kxr)-matrices Γ · B' with r being the rank of Π. This can be re-written as

(4a) $$\Delta Y_t = \Pi^* \begin{bmatrix} Y_{t-1} \\ 1 \end{bmatrix} + \sum_{j=1}^{p-1} A_j^* \Delta Y_{t-j} + u_t .$$

where $\Pi^* = [\Pi \;\; \nu_0^*]$ is a (kx(k+1))-matrix with $\nu_0^* = -\Pi\ \mu_0$, and μ_0 is a deterministic term. Defining the level shift in period T_B by the dummy variable d_{tT_b} as in (2a) we can rewrite model (4a) as

$$(5) \qquad \Delta Y_t = \nu + \Pi^{shift}\begin{bmatrix} y_{t-1} \\ t-1 \\ d_{t-1,T_B} \end{bmatrix} + \sum_{j=1}^{p-1} A_j^3 \Delta y_{t-j} + \sum_{j=0}^{p-1} \delta_j \Delta d_{t-j,T_B} + u_t .$$

In this model, $\nu = -\Pi\mu_0 + (I_k - A_1 - \ldots - A_{p-1})\mu_1$, ,and $\Pi^{shift} = \Gamma[B' \; \eta \; \theta]$ is a (kx(k+2))-matrix of rank r, while $\eta = -B'\mu_1$, $\theta = -B'\delta$, and

$$\delta_j = \begin{cases} \delta, & j = 0 \\ -A_j^*\delta, & j = 1,\ldots,p-1 \end{cases}.$$

here, $\Delta d_{t-j,T_B}$ is an impulse dummy variable which takes on the value one in period $t = T_B + j$ and zero otherwise, and δ is a (kx1) parameter vector.

Working with this model, SAIKKONEN and LÜTKEPOHL (2000) develop a LR-test for cointegration rank with a level shift. The test procedure is as follows. Firstly, model (5) is estimated using the JOHANSEN (1988) maximum likelihood method. If the estimates of Γ and B and A_i^*, I = 1, 2, …, p-1, are available, these are used to estimate the parameters of deterministic part of the model by feasible GLS (FGLS). Then, the cointegration test is applied to the adjusted series. Critical values for the test-statistic are given in OSTERWALD and LENUM (1992) and in SAIKKONEN and LÜTKEPOHL (2000).

We carry out the cointegration test for the three-dimensional system which consists of expenditures, revenues, and GNP. In order to examine the consistency of the estimated results, we conduct additionally the tests for all pairs of the variables. The results for the full sample from 1982 to 2002 are given in *Table 3*. In order to use the SAIKKONEN and LÜTKEPOHL (2000) test, we use both the impulse and the shift dummy for the year 1946.[8)] For the three-dimensional systems which contain revenues, expenditures and GNP, both the JOHANSEN LR- and the λ_{max}-tests suggest that the cointegrating rank is two. The same results are obtained for the SAIKKONEN and LÜTKEPOHL (2000) test where the system has two linearly independent cointegration relations.

8 Hence, we performed the test by including dummy variables for all years during World War II; these findings provide similar evidence.

Table 3: Results of the Cointegration Tests

Null hypothesis	JOHANSEN test Full Sample [1872,2002]			SAIKKONEN and LÜTKEPOHL test Full Sample [1872,2002]*	
	Lags	Trace statistic	Maximum eigenvalue statistic	Lags	Trace statistic
Variables: Revenues, Expenditures and GNP					
r = 0		55.76***	30.41***		49.96***
r = 1	5	25.34***	21.05***	4	11.15*
r = 2		4.28	4.28		0.24
Variables: Revenues, Expenditures					
r = 0		49.51***	36.31***		23.89***
r = 1	2	13.19***	13.19***	3	2.98
Variables: Expenditures and GNP					
r = 0		32.40***	26.75***		19.46***
r = 1	1	5.64	5.64	4	1.37
Variables: Revenues and GNP					
r = 0		61.25***	56.70***		28.03***
r = 1	2	4.55	4.55	3	3.66

‘**’, ‘*’ or ‘(*)’ show that the null hypothesis of no cointegration can be rejected at the 0.1, 1, 5, or 10 percent level, respectively. Johansen test is performed under the assumption of no intercept and no trend. *Both the shift and the impulse dummy variables for the year 1946 are included by performing the SAIKKONEN and LÜTKEPOHL test (2000a) with structural shift. Critical values are from JOHANSEN (1995, Table 15.4) for the Johansen tests; the cointegrating rank tests are performed by using the Eviews 5.1. For the SAIKKONEN and LÜTKEPOHL test, the critical values are from SAIKKONEN and LÜTKEPOHL (2000a, Table 1); the cointegrating rank test is performed by using JMulty 4.04.

For this three-dimensional system we obtain two cointegrating vectors. Since any linear combination of two cointegrating vectors is cointegrating vector as well,[9)] we linearly transform these vectors, and study the pair wise cointegration (i) between revenues and expenditures, and (ii) between each fiscal variable and GNP.

Firstly, we consider the bivariate model which consists of revenues and expenditures. The JOHANSEN tests find two cointegrating vectors which would imply that both variables are stationary. A possible explanation is that the models are incorrectly specified due to the neglected structural changes in the data.[10)] In this case, JOHANSEN tests produce inconsistent results. One solution to this problem, which we apply, is to use the SAIKKONEN and LÜTKE-

9. See JOHANSEN and JUSELIUS (1990).

10. Comparative results are presented in DARRAT (1998).

POHL (2000) test test by introducing dummy variables which should account for the structural change in the data. Following this approach, we introduce both the impulse and shift dummies for a change in the year 1946. The test results show one cointegrating vector in the system. If we examine the cointegration in two-dimensional systems which consist of revenues (expenditures) and GNP, both tests suggest pairwise cointegration. These conclusions are in line with the results of the trivariate analysis.

In the light of these findings, we estimate each of the bivariate cointegrating vectors by using the maximum likelihood estimates. *Table 4* depicts the ML-estimates of the bivariate cointegrating vectors which we normalised for expenditures and revenues. It shows that revenues and expenditures are cointegrated with a cointegrating vector close to [1 -1].

Table 4: Results of Maximum Likelihood (ML) and Ordinary Least Squares (OLS) estimates of normalized cointegrating vectors

Cointegrating equation				Residual regression	
Revenues	Expenditures	GNP	Constant	ADF statistic	Estimates
-1.000	0.878	0	1.603	-	ML
-1.000	0.986	0	0.062	-3.854*	OLS
1.138	-1.000	0	1.826	-	ML
0.995	-1.000	0	0.840	-3.895*	OLS
-1.000	0	2.682	-7.143	-	ML
-1.000	0	1.709	0.780	-2.565	OLS
0	-1.000	1.027	7.245	-	ML
0	-1.000	1.696	0.882	-2.748	OLS

'**', '*' or '(*)' show that the null hypothesis of no cointegration can be rejected at the 1, 5, or 10 percent level, respectively. – k is the number of lags based .on the HANNAN-QUINN criterion.

In addition to the ML-estimates, we estimate the bivariate cointegrating vectors using the ENGLE and GRANGER (1987) two-step cointegration approach. This test is based on the ordinary least squares (OLS) residuals from the cointegrating model. It checks the null hypothesis of non-stationarity of estimated residuals by applying the ADF-test. *Table 4* presents the corresponding cointegrating vectors estimated by ordinary least squares (OLS) and the ADF-test statistics. The results are consistent with the findings of the JOHANSEN cointegration test for the models which contain revenues and expenditures. Given the significance of the ADF-unit root test statistics, it supports the conclusion of the JOHANSEN test that revenues and expenditures are cointegrated.

The latter procedure leads to different results when revenues (expenditures) are regressed on the GNP. Here, the ADF-test for residuals from both models generates the insignificant test-statistics which means that neither revenues nor expenditures are cointegrated with the GNP.

In order to investigate these differences from the findings of the JOHANSEN test,[11] we additionally we apply the GREGORY and HANSEN (1996) method. They suggest that "…standard cointegration tests are inappropriate to find the stationary linear combination of non-stationary variables if this system has a one-time structural shift."[12]

To cure this problem, we correct the co-integration relationship with structural breaks by introducing dummy variables. For this reason, GREGORY and HANSEN (1996) present three models to perform the residual-based cointegration test. The first model (C) accounts for a level shift in the cointegrating relation by including a dummy variable, which is defined as DU = 1 if $t > T_B$, and zero otherwise. The second model (C/T), the regime shift model, additionally introduces a time trend and accounts for a change in the slope vector. Finally, the third model (C/S) includes a regime shift dummy variable to correct for a regime shift in the co-integrating relationship. In principle, this approach can be used if the structural break T_B is unknown a priori; it does not require the information about T_B.[13] We investigate all three models to examine whether the long-run relationship between each of the fiscal variables and GNP are stable. After estimating these models, we apply the ADF-test to their residuals to examine the null hypothesis of no cointegration. The critical values are from GREGORY and HANSEN (1996).

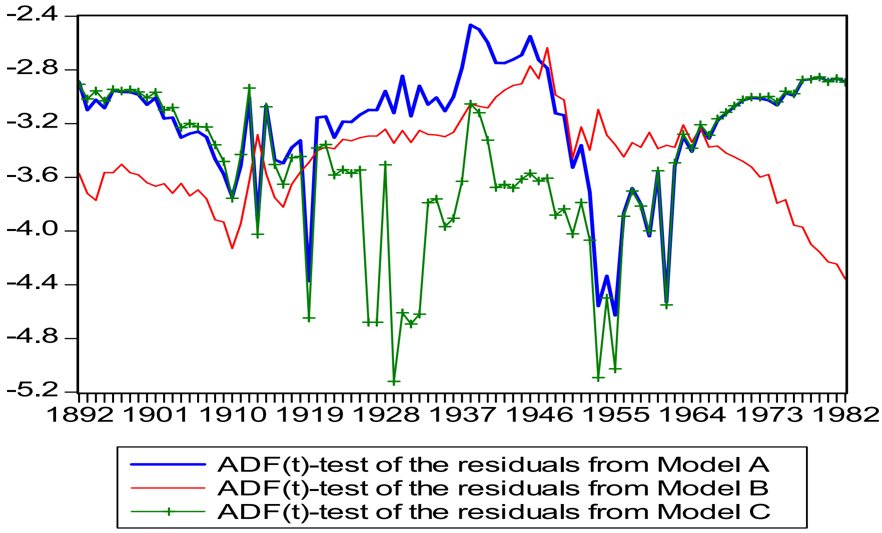

Figure 5: Regime shift with the ADF-test: co-integration between expenditures and GNP

Figures 5 and *6* display the ADF(T_B)-statistics of the residuals from each of the co-integrating models for expenditures and revenues regressed on GNP by using the truncated sample [(0.15T),(0.85T)]. Furthermore, we depict the ADF-test statistics values for the baseline mod-

11. See ENDERS et.al. (2001) for arguments of favouring the JOHANSEN (1995) cointegration method comparing with the residual-based cointegration tests.

12. See GREGORY AND HANSEN (1996, p. 100).Complementary to this method is the one of HANSEN (1992). For more details see MADDALA and KIM (1998).

13. See GREGORY AND HANSEN (1996, p. 103).

els in the figures. The lag length is selected on the basis of the HANNAN-QUINN information criterion. In a first step, we examine the models for expenditures. *Figure 5* illustrates that the significant ADF(T_B)-values are found for the several break-points in the pre- and post-World War II sub-period by using the models C and C/T.

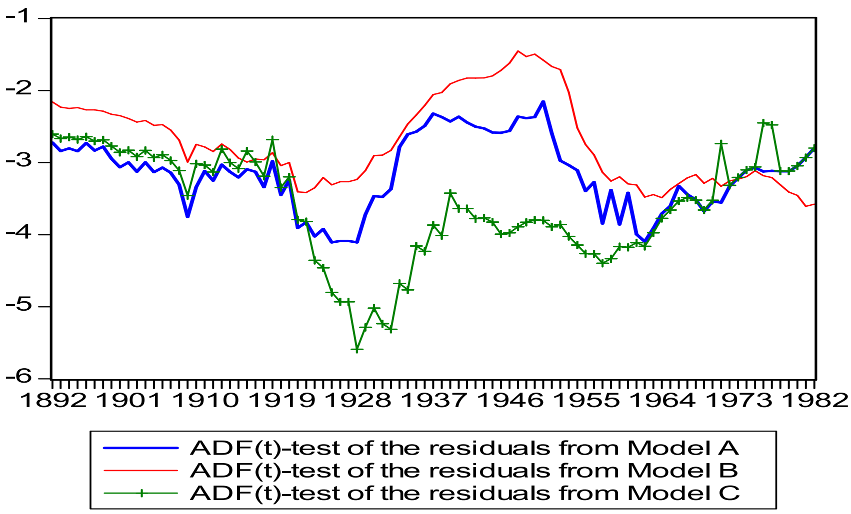

Figure 6: Regime shift with ADF-test: co-integration between revenues and GNP

We find the smallest test-statistics values for the periods from 1925 to 1933, and at the mid 1950s. Hence, we conclude that several structural breaks are present in the long-run cointegration relationship between the expenditures and GNP.

Regarding the cointegration model for revenues regressed on the GNP, *Figure 6* displays the ADF(T_B)-statistics of the residuals for all three models. The test rejects the null hypothesis of no cointegration for the period from 1924 to 1937 by using the model C/T. This provides evidence for the presence of significant structural shifts in cointegrating relationship between the revenues and GNP as well.

3.3 Testing for Granger Causality within the Error-Correction Framework

Given that revenues, expenditures, and GNP are cointegrated with two cointegrating vectors, we follow GRANGER (1983) and analyse the causality between revenues and expenditures within the vector error correction model. This approach allows us to estimate causal relations between the fiscal variables by both, short- and long-run relationships. Short-run causality is given by the lagged differences of the variables in the model. In this case, to check for causal relationships, we conduct the t-test for coefficients on these terms in the error-correction model. Long-run causality is given by the error-correction term which denotes the deviation of fiscal variables from their long-run budgetary equilibrium.

Using this concept, we estimate the complete error correction equation which specifies government revenues (expenditures) as dependent variable and includes up to four lags of the lagged differences of the variables.[14] Each error-correction equation includes two error-correction terms. One term denotes the budgetary disequilibrium, which is determined by the lagged residuals from the bivariate cointegration regression of revenues (expenditures) on expenditures (revenues), and is estimated by OLS; this term is given by ECTR (ECTTG). Another term represents the fiscal disequilibrium; it is represented by the deviation of revenues (expenditures) from their long-run equilibrium relationship with the GNP. This term is defined by the lagged residuals from the estimated bivariate cointegration regression of revenues (expenditures) on GNP by using OLS; this term is denoted by ECTRGNP (ECTTGGNP).[15]

The results of the error-correction models for revenues and expenditures estimated by the OLS are given in columns two and four of *Table 5*; the variables with non-significant t-values are excluded.[16] The Table displays the results of the diagnostic tests, which shows the correct specification of both models. The LM-test which examines the null hypothesis of no autocorrelation suggests that the errors are not autocorrelated. Furthermore, the test-statistics of the ARCH-LM test report no autoregressive conditional heteroskedasticity.

Given the results of the previous analysis, which suggest the presence of structural breaks in time series during World Wars, we modify the defined error-correction models following the methodology of LÜTKEPOHL, TERÄSVIRTA AND WOLTERS (1999). They propose to adjust the error-correction term by introducing dummy variables for the structural breaks into the bivariate cointegration model; we apply this methodology to both bivariate cointegrating models which considers the structural shifts in the real GNP. This adjustment is motivated by the conclusions from the GREGORY and HANSEN (1996) cointegration test (see *Figures 5* and *6*). In order to account for structural shifts in the level of real GNP, we introduce the shift dummy variables defined as $GNP^*_t = d_{T_B}\, GNP_t$, where $d_{T_B} = 1$ if $t \geq T_B$, the known break point, and zero otherwise. The results of the re-estimated error-correction models with the adjusted error-correction terms are displayed in columns three and five; they show that these modifications of the models do not produce significant changes in the magnitude of the short-run dynamics. The LM-test statistics provide no evidence for autocorrelation in residuals, and the ARCH-test statistics indicate no autoregressive conditional heteroskedasticity. The revenues regression performs better than the expenditures regression with respect to the LM- and the ARCH-test statistics.

14. In order to choose the lag order of the VAR-model we use the sequential modified LR test statistic, the final prediction error (FPE), the Akaike information criterion (AIC), and the Hannan-Quinn (HQ) information criterion.

15. In estimating the models, it was necessary to include dummy variables to account for outliers, which occurred over the time from 1941 to 1949 in the cointegration models for revenues (expenditures) and GNP. To account for the outliers in the model with revenues and expenditures, dummy variables for the years 1914, 1915, and 1941 to 1945 are included.

16. The models for revenues and expenditures include dummy variables for the years during World Wars I and II.

Table 5: Error-correction model for three variable systems with of revenues, expenditures and GNP

Explanatory Variable	Model for ΔR_t		Model for ΔTG_t	
	Baseline Model Coefficient (robust t-value)	Adjusted Model Coefficient (robust t-value)	Baseline Model Coefficient (robust t-value)	Adjusted Model Coefficient (robust t-value)
ΔR_t	-	-	0.078 (1.072)	0.077 (1.047)
ΔR_{t-1}	-0.244 (-5.667)	-0.250 (-5.693)	0.041 (0.716)	0.039 (0.687)
ΔR_{t-2}	0.015 (0.310)	0.014 (0.283)	0.028 (0.706)	0.026 (0.666)
ΔR_{t-3}	-0.079 (-1.913)	-0.080 (-1.926)	-0.048 (-1.038)	-0.051 (-1.065)
ΔR_{t-4}	0.144 (2.947)	0.145 (2.923)	0.141 (3.427)	0.141 (3.526)
ΔTG_t	0.324 (5.087)	0.323 (4.916)	-	-
ΔTG_{t-1}	0.067 (1.502)	0.063 (1.468)	0.145 (3.991)	0.143 (3.953)
ΔTG_{t-2}	0.142 (2.901)	0.142 (2.949)	-0.060 (-1.761)	-0.059 (-1.725)
ΔGNP_t	0.777 (6.844)	0.768 (6.599)	0.180 (1.072)	0.191 (1.136)
ΔGNP_{t-1}	-	-	-0.236 (-1.665)	-0.240 (-1.674)
$ECTR_{t-1}$	-0.206 (-6.409)	-0.204 (-6.187)	-	-
$ECTTG_{t-1}$	-	-	-0.115 (-2.274)	-0.115 (-2.545)
$ECTRGNP_{t-1}$	-0.019 (-0.794)	-0.006 (-0.263)	-	-
$ECTTGGNP_{t-1}$	-	-	-0.016 (-0.741)	-0.017 (-0.952)
Constant	0.005 (0.669)	0.006 (0.734)	0.025 (3.684)	0.026 (3.770)
Dummy Variables (to account for outliers)	Yes	Yes	Yes	Yes

Table 5: Error-correction model for three variable systems with of revenues, expenditures and GNP (Continued)

Diagnostic Statistics				
S.D. Dep. var.	0.045	0.045	0.047	0.047
R^2	0.856	0.856	0.840	0.841
R^2 adjusted	0.829	0.828	0.802	0.803
S.E. of regression	0.052	0.052	0.048	0.048
Durbin-Watson test	1.849	1.862	2.205	2.183
LM-tests of no autocorrelation*	0.511 (2)	0.438 (2)	1.003 (2)	0.804 (2)
LM-test of no ARCH*	0.197 (2)	0.177 (2)	0.428 (2)	0.415 (2)
White Heteroske-dasticity test	0.812	0.759	2.503	2.247
Skewness	0.314	0.246	0.209	0.220
Kurtosis	3.263	3.228	3.526	3.449
Jarque-Bera test of normality	2.542	1.617	2.471	2.166
F-test: H_0: $\beta i = 0$				
$\beta_{\Delta TG_t} = 0$	25.884	24.171	-	-
$\beta_{\Delta TG_{t-1}} = 0$	2.257	2.157	-	-
$\beta_{\Delta TG_{t-2}} = 0$	8.417	8.698	-	-
$\beta_{\Delta R_t} = 0$	-	-	1.149	1.097
$\beta_{\Delta R_{t-1}} = 0$	-	-	0.512	0.472
$\beta_{\Delta R_{t-2}} = 0$	-	-	0.498	0.444
$\beta_{\Delta R_{t-3}} = 0$	-	-	1.077	1.135
$\beta_{\Delta R_{t-4}} = 0$	-	-	11.744	12.438
$\beta_{ECTR_{t-1}} = 0$	41.076	38.287	-	-
$\beta_{ECTTG_{t-1}} = 0$	-	-	5.173	6.477
$\beta_{ECTRGNP_{t-1}} = 0$	0.631	0.069	-	-
$\beta_{ECTTGGNP_{t-1}} = 0$	-	-	0.550	0.907

Δ is the operator for first differences, R denotes federal revenues, TG represents federal expenditures, ECTR is the error correction term obtained from regression of the real revenues on expenditures and a constant, ECTTG is the error correction term obtained from regression of the real expenditures on revenues and a constant; ECTRGNP is the error correction term obtained from regression of the real revenues on real GNP and a constant; ECTTGGNP is the error correction term obtained from regression of the real expenditures on revenues and a constant. Robust t-statistics indicate heteroscedasticity consistent estimates. The F-tests indicates at what significance level the variable can be excluded from the regression. The number of lags is in parentheses

The most important outcome is that in both models the error-correction terms which measure the budgetary non-equilibrium of the revenues (ECTR) in the revenues equation and those of the expenditures (ECTTG) in the expenditures equation are statistically significant at the 1 percent level and have the expected negative sign. The results are robust even in the modified models. This observation implies that both, the revenues and expenditures adjust to long-run budgetary equilibrium. These results confirm the cointegration analysis and suggest that the error-correction representations are valid. In contrast, the fiscal disequilibrium error-correction terms in both models, for revenues and expenditures, are statistically insignificant.

The causality results implied by the short-run dynamics terms of the lagged differences suggest bi-directional feed-back relationship as well: expenditures are significantly affected by the lagged changes in revenues, while revenues are significantly influenced by both, current and the lagged changes in expenditures. Changes in GNP have a significant impact on the changes in revenues, while they have no effect on expenditures. The resulting estimation, however, implies another important effect, namely the impact of fluctuations in economic output on fiscal variables. This question, which addresses the issue of business cycles, should be investigated in the further research.

Some remarks may are to be made at this point. The results of causality test which are based on the error-correction model show bidirectional causality between federal revenues and expenditures in Switzerland over the considered period. This supports the fiscal synchronization hypothesis. More specifically, based on the significant error-correction terms which capture the effect of budgetary disequilibrium, we find long-run bi-directional causal relations. Moreover, we show short-run bi-directional causality between revenues and expenditures. Hence, we find that changes in revenues are significantly influenced by both, the current and the lagged changes in expenditures, while expenditures are influenced only by the lagged changes in the revenues.

4 Concluding Remarks

This paper investigates the causal relationship between federal revenues and expenditures by using the long-term fiscal data of the Swiss federal government. Employing the multivariate cointegration test, we show that revenues and expenditures are cointegrated. Hence, the results point to significant structural changes in the budgetary policy after World War II. Working with the error-correction model we find a bi-directional causality between the revenues and expenditures relating to both, the short- and long-run relations. Our results suggest that the Swiss government takes the allocation policy into consideration when makes decisions on the level of tax revenues, and vice versa. These findings, however, differ from the evidence which is reported for the U.S. federal government.

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Appendix: Data and Sources

- Federal revenues
- Federal expenditures
- Federal public debt

Sources: Historical Statistics of Switzerland, several issues of the Statistical Yearbook of Switzerland, and Swiss Federal Finance Administration

- Real Gross National Product (GNP)
- GNP deflator

Sources: Swiss Federal Statistical Office

- Consumer price index

Sources: Federal Reserve Bank of St. Louis, FELIX ANDRIST

- Real monetary aggregate M3

Sources: Historical Statistics of Switzerland, and Swiss National Bank