BUDGET BALANCE THROUGH REVENUE OR SPENDING ADJUSTMENTS? SOME HISTORICAL EVIDENCE FOR THE UNITED STATES

by

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Abstract

Budget deficits can be eliminated in two ways, by increasing taxes or by cutting spending. In recent years, the question which of these two ways is--or should be--chosen by the government has received considerable attention.

This paper provides a historical perspective on government reactions to deficits by looking at a long series of US-budget data, from 1792-1988. The main findings are that, on average and in present value terms, 50-65% of a deficit due to tax cuts and about 70% of a deficit due to higher government spending are eliminated by future spending cuts. Only the remainder, about 35-50% or 30%, respectively, is eliminated by future tax changes.

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1. Introduction

Budget deficits can be eliminated in two ways, by increasing taxes or by cutting spending. In recent years, the question which of these two ways should be chosen by the government has recently received considerable academic as well as political attention (see, e.g., the Spring 1989 issue of the Journal of Economic Perspectives). The question which of these two ways the government will actually choose is critical for at least two key issues in macroeconomics.

The first issue concerns the testing of the Ricardian equivalence theorem and its policy implications; see Barro (1974) and (1989). Even rational forward-looking households will change consumption in reaction to a tax cut (with current government spending held constant), if deficits signal changes in future government spending; see Feldstein (1982). If no change in future government spending is signalled, current tax changes leave the present value of taxes unchanged and should therefore not affect consumption. But if consumers expect that deficits will be eliminated by lower spending, they should increase consumption in response to a tax cut.[1] Then it would be difficult to use Ricardian analysis for policy evaluation.

The second issue concerns optimal taxation. Barro (1979) has shown that, in a model where excess burden is a convex function of the tax rate, a welfare maximizing tax policy must not include predictable changes in tax rates. Tax rates should approximately follow a random walk. But if tax changes are permanent, a deficit caused by tax cuts will have to be eliminated entirely by spending cuts, not by tax increases.[2]

This paper provides a historical perspective on how the US-government has typically adjusted taxes and spending in reaction to imbalances in its budget. A long-term perspective seems to be appropriate for two reasons. First, budget balance is a requirement that restricts fiscal policy only in the long run. Second, government debt is a variable that usually changes only very slowly over time. This study will therefore use a very long time series of US-budget data, covering fiscal years 1792-1988.

The main findings are that, on average and in present value terms, 50-65% (depending on model specification) of a deficit caused by tax cuts and about 70% of a deficit caused by higher government spending are eliminated by future spending cuts. Only the remainder, about 35-50% and 30%, respectively, is eliminated by future tax changes. Thus, if expectations about future government behavior are based on the historical record of US-government behavior, rational forward-looking consumers should consider 50-70% of any tax cut as an increase in net wealth. Tax cuts signal spending cuts. Bohn (1988a) suggests that this statistical link between deficits and later spending changes may have an economic interpretation and does not just reflect anticipations. But the two interpretations are statistically indistinguishable.

The fact that tax rates (represented by the ratio of tax revenue to GNP) respond significantly to earlier deficits implies a rejection of the random walk hypothesis of tax rates. The results are not entirely unfavorable to the "tax-smoothing" model, however, since at least half of a deficit financed tax cut signals spending cuts.

In estimating the government's response to deficits, some econometric issues related to the non-stationarity of time series are important. Consistent with Ahmed and Yoo (1989), I cannot reject the non-stationarity of government spending and government debt even when measured as shares of GNP. But since the intertemporal budget constraint implies that the deficit is stationary (see Trehan and Walsh (1988)), taxes, spending, and debt are cointegrated. Error-correction models (see Engle and Granger (1987)) or a vector autoregression in which one of the non-stationary variables is replaced by the deficit (see Campbell (1987)) must be used. These methods of estimation impose the constraint that spending and tax reactions to an initial deficit always add up to unity. Interestingly, this approach gives the main variable of interest, the deficit, a prominent role in the regressions.

The question of how the budget is balanced is closely related to questions about causality between taxes and spending (see Gramlich (1989), Furstenberg et. al. (1986)). This study reexamines the question with a longer sample and with an econometric specification that reflects the cointegration properties. I find significant statistical causation in both directions, from taxes to spending and from spending to taxes. More loosely, the topic is also related to the literature on the dynamics of government debt (see Barro (1979) and (1986), Kremers (1989)) in that similar fiscal policy decisions are modeled. But the focus here is on the long run constraints on spending and taxes imposed by the budget constraint and not on the short run dynamics of debt.

The paper is organized as follows. Section 2 sets up the expectational problem, derives the government budget constraint, and reviews the econometric issues raised by the non-stationarity of key budget variables. Section 3 briefly summarizes the data. Section 4 presents the empirical results and Section 5 contains concluding remarks.

2. Analytical Issues

Rational forward-looking households must forecast the present value of tax payments in order to determine optimal consumption. Thus, in assessing the impact of current fiscal policy on the economy, one has to consider the implication of current fiscal policy on future policies. This section formalizes the problem.

2.1. The Prediction Problem

Consider a forward-looking, infinitely-lived household who, in period t, obtains new information about government spending, taxes, and debt. The key question in determining optimal consumption is how permanent income varies with changes in fiscal policy.

Some notation is useful. Let fiscal policy be summarized by a vector $X^F = (T, G, B)$, which includes taxes, T_t, government spending, G_t, and government debt B_t. New information about fiscal policy is $\hat{X}_t^F = X_t^F - E_{t-1}X_t^F$. The conditional expectation E_{t-1} may be based on some larger set of variables, denoted by X. Throughout the paper, X is assumed to include T, G, and B as its first three elements. Denote the present value of the future realizations of any variable z by

$$PV(z)_t = \sum_{j\geq 1} \rho^j \cdot z_{t+j} , \tag{1}$$

where $\rho = 1/(1 + r)$ is a discount factor with $r > 0$. Then the permanent component of a series z is

$$z_t^p = (1 - \rho) \cdot [z_t + PV(z)_t] . \tag{2}$$

The question for consumers is how to evaluate permanent takes, T_t^p, which are a part of permanent income. By rearranging the sums in (2), one can show that

$$z_t^p = z_t + PV(\Delta z)_t , \tag{3}$$

where Δ denotes the difference operator (see Campbell (1987)). In particular, the permanent component of taxes is the sum of current taxes plus a weighted sum of future changes. New information about permanent taxes depends on the current innovation and new information about future changes in taxes,

$$\hat{TP}_t = \hat{T}_t + (E_t[PV(\Delta T)_t] - E_{t-1}[PV(\Delta T)_{t-1}]) \tag{4}$$

where innovations be denoted by carets (^). Current taxes are known. The question of determining optimal consumption therefore reduces to evaluating the present value expressions in (4). In revising consumption plans in period t, households have to predict how taxes will change in the future.

The solution of this prediction problem has important implications for assessing fiscal policy. Traditional macroeconomic models usually assume that the permanent component varies with the current value, i.e. they de-emphasize the expectational effect. Economists applying Ricardian equivalence argue that movements in expected future taxes generally offset movements in $\hat{T}_t$ (Barro (1989)).[3] Thus, the issue in assessing the effect of fiscal policy on consumption is how future taxes vary with new information about fiscal policy. In particular, do changes to the present value expression $E_t[PV(\Delta T)_t] - E_{t-1}[PV(\Delta T)_{t-1}]$ offset changes in $\hat{T}_t$?

The expected present value expressions are linear functionals defined on the stochastic process of information variables, X. Assuming projections on X are linear, responses to innovations $\hat{X}_t$ are characterized by a vector of coefficients. Thus, for any variable z defined on the process X, there is a vector of projection coefficients f_z satisfying

$$E_t[PV(\Delta z)_t] - E_{t-1}[PV(\Delta z)_t] = f_z \cdot [X_t - E_{t-1}X_t] .$$

For further reference, let this be denoted more compactly by

$$PV(\Delta \hat{z})_t = f_z \cdot \hat{X}_t . \tag{5}$$

The empirical section will estimate the coefficients of such projections. But before turning to estimation, it is useful to consider the government budget constraint, which imposes constraints on the process X as well as on the projections f_z.

2.2. The Intertemporal Budget Constraint

The basic variables in the government budget are tax revenues, T_t, expenditures, G_t, and initial government debt, B_t. Government spending excludes interest payments and taxes include seignorage. Assuming a constant interest rate r on government debt, these variables are linked by the budget equation

$$B_{t+1} = G_t - T_t + (1 + r) \cdot B_t + \varepsilon_t \; . \tag{6}$$

where the random variable ε_t measures a capital gain or loss on initial debt. The error term ε_t reflects the fact that the observed time series of T_t, G_t, and B_t do not satisfy an exact linear constraint. I follow the literature in assuming a constant <u>expected</u> return on government debt in order to preserve tractability; cf. Barro (1979), Hamilton and Flavin (1986), Trehan and Walsh (1988).

The existence of capital gains requires a decision about information sets, namely whether final debt, B_{t+1}, is first observed in period t or t + 1. Unless specifically noted, the subsequent analysis assumes that current spending, taxes, and initial debt, B_t, as well as all lagged variables are in the time-t information set, but not ε_t and B_{t+1}.[4]

Two implications of the government's intertemporal budget constraint are important. The first concerns the econometric properties of taxes, spending, and debt implied by budget balance in a setting with non-stationary variables. (Section 4 will verify that all three variables are indeed non-stationary.) Second, I will show that intertemporal budget balance imposes some cross-equation restrictions on the projection vectors f_z.

Starting with the budget equation (6) and recursively eliminating future values of debt, one obtains

$$(1 + r) \cdot B_t = \sum_{j\geq 0} \rho^j \cdot E_t[T_{t+j} - G_{t+j} - \varepsilon_{t+j}] + LB , \tag{7}$$

where $LB = \lim_{j\to\infty} \rho^j \cdot B_{t+j}$.

If LB is positive, the government would be able to roll over its debt including interest payments for ever. On the other hand, LB = 0 implies an intertemporal constraint on the evolution of $(T_t, G_t, B_t, \varepsilon_t)$:

$$(1 + r) \cdot B_t = \sum_{j\geq 0} \rho^j \cdot E_t[T_{t+j} - G_{t+j} - \varepsilon_{t+j}] . \tag{8}$$

Trehan and Walsh (1988) have shown that this constraint holds, if government debt is difference stationary. That is:

Lemma 1: $\Delta B_{t+1} = B_{t+1} - B_t$ stationary $\to$ LB = 0.

Proof: see Trehan and Walsh (1988). The variable ε_t does not affect this part of their proof.

Stationarity of ΔB_{t+1} has implications for the stochastic process of the other variables in the budget equation (6), since it implies stationarity of the linear combination $G_t - T_t + r \cdot B_t + \varepsilon_t$ of the vector $(G_t, T_t, B_t, \varepsilon_t)$. Thus, intertemporal budget balance imposes a cointegration constraint on the vector $(G_t, T_t, B_t, \varepsilon_t)$. Assuming ε_t is stationary, $X_t^F = (G_t, T_t, B_t)$ is also cointegrated, with cointegrating vector $\beta' = (1, -1, r)$. This stationary linear combination is the budget deficit

$$DEF_t = G_t - T_t + r \cdot B_t . \tag{9}$$

Sometimes the notation DEF_t^r will be used to indicate the dependence on r. The important implication for the prediction problem is that the process X, which includes X^F, should be modeled as a cointegrated system when computing projections.[5]

The intertemporal budget constraint (8) has a second set of implications, which constrain the response of taxes and spending to variations in time t policy. Using the present value notation defined in (1), equation (8) is equivalent to

$$(1 + r) \cdot B_t = T_t + E_tPV(T)_t - \left[G_t + E_tPV(G)_t + \varepsilon_t + E_tPV(\varepsilon)_t\right] \qquad (10)$$

Looking at innovations, this implies

$$PV(\hat{T})_t - PV(\hat{G})_t - PV(\hat{\varepsilon})_t = (1 + r) \cdot \hat{B}_t + \hat{G}_t + \hat{\varepsilon}_t - \hat{T}_t \qquad (11)$$

for all possible realizations of $\hat{T}_t$, $\hat{G}_t$, $\hat{B}_t$ and $\hat{\varepsilon}_t$. Applying formulas (2) and (3), this is equivalent to

$$PV(\Delta\hat{T})_t - PV(\Delta\hat{G})_t - PV(\Delta\hat{\varepsilon})_t = r \cdot \hat{B}_t + \hat{G}_t - \hat{T}_t + \hat{\varepsilon}_t \ . \qquad (12)$$

This equation links the three projections on the left to the innovations on the right. In terms of equation (5), these links imply cross-equation restrictions on the projection coefficients f_z for z = T, G, and ε:

Lemma 2: If the intertemporal budget constraint (8) holds, the projection equations (5) must satisfy

$$f_{TT} - f_{GT} - f_{\varepsilon T} = -1 \qquad (13a)$$

$$f_{TG} - f_{GG} - f_{\varepsilon G} = 1 \qquad (13b)$$

$$f_{TB} - f_{GB} - f_{\varepsilon B} = 1 + r \qquad (13c)$$

where f_{zx} is the element in the vector f_z corresponding to variable $x \in X = (T, G, B, \ldots)$, which indicates the reaction in the present value of changes in variable z to an innovation variable x.

Proof: Compare (12) and (5).[6]

The coefficients f_{TT} and f_{GT} (f_{TG} and f_{GG}) describe the reactions of future taxes and spending to initial innovations in taxes (spending), respectively. Since the variable ε_t only represents an error introduced by ignoring variations in expected returns, one should hope that the $f_{\varepsilon X}$ coefficients are small. Their size may be interpreted as a measure of how well the approach fits the data. If the $f_{\varepsilon X}$ are small, the coefficients f_{TT} and f_{GT} in (13a) and f_{TG} and f_{GG} in (13b) add up to approximately one. Thus, these four coefficients indicate what fraction of a deficit caused by a tax cut or a spending increase will be corrected by future tax increases or spending cuts, respectively.

To sum up, government's intertemporal budget constraint requires that a budget deficit is offset by either increased taxes or reduced spending in the future. The question is which of the two, revenue or spending, will be adjusted. To answer it, the process X must be estimated.

2.3. The Econometric Approach

Engle and Granger (1987) show that a cointegrated process X has an error-correction representation (ECM)

$$A(L)\Delta X_t = -\alpha \cdot \beta' X_{t-1} + u_t \tag{14}$$

or

$$A(L)\Delta X_t = \alpha \cdot DEF_{t-1} + u_t \tag{15}$$

where $A(0) = I$, $A(1)$ is finite and u_t a stationary disturbance vector. The cointegrating vector β equals $(1, -1, -r)$ if $X = X^F$ and $(1, -1, -r, 0, \ldots, 0)$ if the information set X contains more variables. In addition, assume that u_t

has zero autocorrelation and that A(L) is of finite order k. Denote the number of variables in X by n.

Projections of the type needed in (6) can be computed as follows. Note that $\hat{X}_t = \Delta\hat{X}_t = u_t$. Rearranging system (15) as a first order system augmented by the identity

$$DEF_t = -\beta'\Delta X_t + DEF_{t-1} , \qquad (16)$$

one obtains the first order stochastic difference equation

$$X^*_t = A^* \cdot X^*_{t-1} + u^*_t ,$$

where $X^{*\prime}_t = (\Delta X'_t, \ldots, \Delta X'_{t-k-1}, DEF_{t-k})$ and $u^{*\prime}_t = (u_t, 0, \ldots, 0)$ are $(n \cdot k + 1)$-vectors, and A^* is a $(n \cdot k + 1) \times (n \cdot k + 1)$ matrix of coefficients of the form

$$A^* = \begin{vmatrix} A_1 & A_2 & \cdots & A_k & \alpha \\ I & 0 & \cdots & 0 & 0 \\ \vdots & & & & \vdots \\ 0 & \cdots & & -\beta' & 1 \end{vmatrix}$$

where the A_i are coefficient matrices.[7] Let Δz_{t+j} be the s-th element of ΔX_{t+j} and let h be the 0-1 vector that selects element Δz from ΔX^*, $\Delta z_{t+j} = h\Delta X^*_{t+j}$. Then $E_t\Delta z_{t+j} = h\cdot(A^*)^j\cdot X^*_t$, $E_t\Delta z_{t+j} - E_{t-1}\Delta z_{t+j} = h\cdot(A^*)^j\cdot u^*_t$, and

$$PV(\Delta\hat{z})_t = h \cdot \sum_{j\geq 1} (\rho A^*)^j \cdot u^*_t = h\rho A^* \cdot [I - \rho A^*]^{-1} \cdot u^*_t$$

is a linear combination of $u^*_t = (\Delta\hat{X}_t, 0, \ldots, 0)$. Let x be the i-th element in the vector X. In comparison with equation (6), one can see that the coefficients f_{zx} in (6) are

$$f_{zx} = \{h\rho A^* \cdot [I - \rho A^*]^{-1}\}_{si} \qquad (17)$$

where $\{\}_{sx}$ selects the element in row s and column i of a matrix. Equation

(17) shows how the projections f_z depend on the parameters of the ECM. Asymptotic standard errors can be computed in the usual way.

A useful alternative representation has been derived by Campbell (1987) (see also Campbell and Shiller (1988)). Campbell replaces one element of ΔX^F by DEF, using (16) repeatedly, to obtain a vector autoregression (VAR)

$$C(L)Y_t = v_t , \tag{18}$$

where Y_t contains DEF and all elements of ΔX except for the one. C(L) is a k-th order polynomial and v_t is a linear transformation of u_t. Campbell shows that an unconstrained estimation of this VAR automatically satisfies the cointegration restrictions. One can show that

$$f_{zx} = \{h\rho C^* \cdot [I - \rho C^*]^{-1}\}_{si} \tag{19}$$

where C* denotes the VAR-companion matrix.

A simplified approach will also be used, which is motivated by the fact that B_t enters into the cointegrating vector only with weight r, which may be small. Therefore, one may approximate the cointegrating linear combination DEF^r by DEF^0 to compute projections, which may be based on a subset of X that excludes B.

3. Data

The intertemporal budget constraint imposes a restriction only for the long run. Statistically, this is reflected by the fact that cointegration restricts the long run behavior of time series. Given the considerable inertia in the level of debt (with the notable exception of wartime years), one should suspect that a very long-term analysis is needed to obtain significant insights about government behavior in this area. Therefore, the analysis uses the longest available data set for the United States.

Early budget data, from 1792-1970, are available in the Historical Statistics of the United States. The basic budget series are total government receipts, total government outlays, outlays for interest payments, and debt. The series were updated and extended to 1988, using the Historical Tables, Budget of the United States and some other supplementary sources.[8]

The budget data are annual and collected on a fiscal year basis. From 1789-1842, fiscal years are calendar years. Fiscal year (FY) 1843 covers January to June 1843. From FY1844 to FY1976, the fiscal year dated t covers the period from July of calendar year t - 1, to June of year t. After the transition quarter of July-September 1976, fiscal years FY1977 on begin in October of year t - 1 and end in September of year t.

Since the study concerns government behavior, it makes sense to focus on the fiscal year as a basic time unit, regardless in which month it starts.[9] The 1976 transition quarter was included in FY1976, as many statistical tables do. Finally, all flow data for FY1843 and FY1976 were annualized to obtain a consistent fiscal-year series from FY1792 through FY1988.

In principle, the government budget constraint can be derived in terms of nominal variables, real variables, i.e. relative to prices, or relative to some other scale variable, provided the interest rate is interpreted appropriately. Since the nation's productive activity forms the basis for all taxation, it seems appropriate to use GNP-ratios as basic variables here. This definition also mitigates the heteroskedasticity problems that would be severe if unscaled variables were used. The variable r must then be interpreted as the difference of real interest rate and growth rate of the economy.[10]

Early data on nominal and real GNP have been compiled by Berry (1988) for calendar years 1789-1973. Berry's series uses commerce department data from

1929 on. The commerce department series has been revised since his publication. I use the updated series for 1929-1988, which involves a slight upward revision (0.8111%) in 1929. To match the old and new 1929 values, Berry's 1789-1928 data are adjusted by this factor. Moreover, real GNP data are converted to a uniform 1982 = 100 basis.

Since GNP is only available on a calendar year basis, a slight mismatch in measuring the fiscal variables as GNP-ratios is inevitable. For most of the period, fiscal year t starts before calendar year t. Interpreting the start of a fiscal year as the relevant time for budgetary decisions, I deflate revenue and spending of FY t and debt at the beginning of FY t by the GNP of calendar year t-1. Fortunately, the choice does not seem to be important for the results (see estimate No. 12 in Table 5 below). But the lack of a precise match between GNP and tax series should caution against taking a rejection of "tax smoothing" too serious.

In spite of widespread unhappiness with government accounting data (see Eisner (1989)), I did not attempt any adjustments to the budget data, e.g., to reflect off-budget items or government assets. One reason is the unavailability of data for the early years, which even prevented an adjustment from par to market values of debt.[11] A better reason is the fact that the actual budget data are the most easily available numbers for political decision-making. The working hypothesis is that government behavior is primarily influenced by data reflected in the official budget. An empirical analysis should then use the data as they were originally defined and collected.

To sum up, the empirical analysis will use the following three series:

(1) Outlays net of interest payments deflated by GNP, G_t.

(2) Receipts deflated by GNP, T_t.

(3) Debt at the beginning of a fiscal year deflated by GNP, B_t.

Complete data are available for 1792-1988. To have enough lags in the estimation, the sample period 1800-1988 is used throughout the empirical analysis. The series are graphed in Figures 1 and 2. Summary statistics are in Table 1. (Data are available from the author).

In Figures 1 and 2, one can see the impact of the three major wars (Civil War, WWI, and WWII), which led to sudden increases in spending and debt. The share of government activity in GNP changed significantly over the sample period, even excluding wartime peaks, from close to zero in the 18th century to about 20% currently. For the empirical analysis, the pictures suggest that all three variables may be non-stationary and heteroskedastic.

Notice that the average deficit has been positive, though not significantly. This raises the question whether the intertemporal budget constraint (8) holds with $r > 0$, or if (7) holds with $LB > 0$ and/or $r \leq 0$. But notice that the mean of ΔB is much closer to zero than the mean of DEF. The difference is largely due to large number of positive "capital gains" realizations in the inflationary period since the end of the Gold Standard, 1934 to 1980. Over this period, the error ε_t averages more than 3% of GNP per year when computed from the budget equation (6) with $r = 2\%$. Before 1934 and after 1980, realizations are much smaller and their average is near zero. Thus, questions about the intertemporal budget constraint depend on the interpretation of the 1934-1980 period. If inflation was anticipated, one might seriously question whether the discount rate satisfies $r > 0$. On the other hand, the 1934-1980 period may be interpreted as an atypical transition period, in which individuals learned about inflation risk in a fiat money system and were repeatedly surprised by accelerating inflation. Then the sample average as proxy for expected returns on government debt would suffer from a peso-problem. I chose not to consider this period as evidence against

$r > 0$. In any case, even though a model with $r > 0$ was used to motivate the possibility of cointegration, the time series properties of the fiscal data will be tested below and not assumed. Interestingly, real returns on government debt since 1980 seem much more in line with those before 1930 than those during 1934-1980. This provides an additional motivation for taking a long-term view.

4. Empirical Results

In this section, time series properties of the data are analyzed and reactions of future taxes and spending to current fiscal policy are estimated.

4.1. Time Series Properties

Preliminary, but important issues are the questions of stationarity and cointegration. Even though tax-GNP and spending-GNP ratios are bounded by [0, 1], they do not have to be stationary (see Ahmed and Yoo (1989)).

Several tests for stationarity are displayed in Table 2. For each series, two augmented Dickey-Fuller tests (ADF) with different lag lengths were computed. The first lag length was based on the Akaike information criterion computed in AR(k)-models of the differenced series (i.e., under H_0 that the series is non-stationary). Second, the "long lag" version suggested by Said and Dickey (1985) and Schwert (1987) was used (with $k = 13$). A problem with this type of test is that the significance levels are not valid for heteroskedastic data. Therefore, an adjusted version due to Phillips and Perron (1986) and Phillips (1987), which is valid under heteroskedasticity, was also computed.[12] All of these tests can be coefficient-based or based on a t-statistic. For the ADF-tests the results were the same and only the t-statistics are displayed, denoted by ADF(k). For the Phillips-Perron test both the coefficient-based and the t-type statistic are displayed and denoted by $Z\rho$ and $Z\tau$, respectively.

Table 2 shows that one cannot reject non-stationarity of taxes T, government spending G, and debt B at the 5% level in any test. Their differences are stationary with high significance.[13]

Concerning cointegration, there are again several tests available. According to theory, the deficit (9) should be the stationary linear combination of $X_t = (T_t, G_t, B_t)$. Thus, a direct test for cointegration is obtained by testing the stationarity of DEF^r. The results for different values of r are displayed in Table 2.[14] All of them indicate stationarity.

Alternatively, the relevant linear combination of X_t^F can be estimated. Following Johansen (1988), maximum likelihood estimates of the cointegrating vectors and tests for the number of cointegrating vectors are computed in Table 3, Panel A. One cannot reject the hypothesis that the number of cointegrating vectors is 1 (while one can reject the number 2). The estimated vector[15] is (0.79, -0.69, -0.048). After normalization to $\beta = (1, -0.877, -0.060)$, it is close to the theoretically expected vector of the form (1, -1, -r). Specifically, one cannot reject the hypothesis that β is of this form for values for r between -1% and 14%. The point estimate subject to $\beta = (1, -1, -r)$ is r = 2.90%.

Since r = 0 is a possible choice, the properties of the bivariate system (T_t, G_t) were also explored. As Panel B of Table 3 shows, one cannot reject the hypothesis that the system has one cointegrating vector. The point estimate, (1, -0.985), is not significantly different from (1, -1).

As another alternative, Engle and Yoo (1987) suggest a Dickey-Fuller test on the residual of a regression of one of the potentially cointegrated variable on the others. Here, an augmented Dickey-Fuller test (with one lag) of the residual from regressing T_t on G_t and B_t yields a t-statistic of 3.783, which is barely significant.[16] The cointegrating vector is not measured very precisely so that this approach was not pursued further.

Overall, one may conclude that X_t^F is non-stationary and cointegrated with a cointegrating vector of the form (1, -1, -r) for a range of discount rates r. As Engle and Granger (1987) show, a statistically valid estimation and testing of such a vector process will use error-correction models.

4.2. Error-Correction Predictions

Having verified that an error-corrections model of the form (15) is appropriate, the projection coefficients f_z can be computed from (17) or from the VAR-transformation (18) as indicated by (19). Estimates were computed for different interest rates, for several different information sets, and for the limiting case $r \to 0$. Results did not differ much across most specifications. Therefore, I will present only one set of estimates in detail and summary statistics of the others.

Table 5 displays the results of estimating (15) with information set $X = X^F$ and $r = 3\%$.[17] Coefficient estimates with ordinary and heteroskedasticity-robust t-statistics (see White (1984)) are in Panel A. Spending and taxes appear to influence each other and debt, while debt has little effect on other variables. The deficit has a significant positive effect on taxes and a negative effect on spending, as one would have hoped.

Panel B shows estimated projections f_{sx} with their asymptotic standard errors and t-statistics. One can see that a unit innovation in taxes will, on average, be followed by a decrease in taxes of $-f_{TT} = 0.49$ and an increase in spending of $f_{GT} = 0.50$. Both values are different from both zero and one with high significance. Reassuringly, $-f_{TT} + f_{GT} = 0.99$ almost exactly adds up to

1.0, as suggested by equation (13a), leaving only $f_{\varepsilon T} = -0.01$ as unexplained correlation of $\hat{T}_t$ with the error $PV(\Delta\hat{\varepsilon})_t$.

Thus, about half of all tax increases are permanent and signal spending increases. This aspect provides support for the "tax and spend" hypothesis. The permanence of tax cuts implies that forward-looking consumers should react rather strongly to current tax changes, namely with a marginal propensity to consume of about 0.5. Behavior consistent with the simple Ricardian neutrality recipe of "tax-cuts do not matter" should only be expected, if consumers can somehow be convinced that the current change is, against all historical precedent, only temporary and does not signal spending changes.

Concerning "tax smoothing" as a positive theory of policy, the 50% temporary component is troubling. Though a large fraction of all tax changes are explained as anticipation of spending changes, giving the tax-smoothing model some explanatory power, some tax changes are apparently reversed. Before rejecting tax-smoothing one should recognize, however, that the tax series is some steps removed from the theoretically ideal of a marginal tax rate. Measurement error could show up as a temporary component, though it could hardly explain such a large and highly significant value.

A unit innovation in government spending increases future taxes on average by only $f_{TG} = 0.30$ and is followed by spending cuts of $-f_{GG} = 0.64$, which again adds up to almost 1.0. Thus, most changes in spending seem to be temporary. Once heteroskedasticity is taken into account, one cannot even reject the hypothesis that spending does not cause tax changes. (Significant effects were found in other specifications; see below.) When one looks at how deficits, which may arise from tax cuts or spending increases, are typically eliminated, the quantitative answer depends somewhat on the source of the deficit. In both cases, the point estimates suggest a "compromise solution" of both tax increases and spending cuts. Depending on the source, the division of the adjustments has historically been between 30% and 49% on the revenue side and between 50% and 64% on the spending side.

For other specifications based on the information set (T, G, B), Table 5 displays the point estimates and robust t-statistics of the projections. For comparison, regression No. 1 replicates the results of Table 4. Regressions No. 2-5 show that the results are not sensitive to interest rate r or lag length. In defining revenues, the definition of seignorage is not undisputed; regression No. 6 uses an alternative definition.[18] Regression No. 7 uses the assumption that end of period debt, B_{t+1}, is in the period-t information set. Regressions 8-10 use the VAR specification (17), as suggested by Campbell (1987). No other modifications change qualitative results. The VAR-models seem to suffer from multicollinearity problems. If anything, taxes are less permanent and the effect of taxes on spending is larger than specification No. 1 suggested. This is good news for tax-smoothing, but leads to an even higher marginal propensity to consume from tax cuts.

Projections for the limiting case of $r \to 0$ are displayed in Table 6. This case is analyzed in more detail for several reasons. First, the three-variable system reduces to two variables, making the estimates even more precise. The approximation is justified by the fact that ΔB in the three-variable system seems to be rather unimportant. Moreover the limiting case has the nice feature that the $f_{\varepsilon x}$ coefficients vanish so that the adjustments of spending and taxes add up to 1.0.[19] Finally, a small system can be taken as starting point to explore the addition of other variables in the information set without using up too many degrees of freedom. For the interpretation it is important, however, <u>not</u> to assume that r actually equals zero, which would invalidate the theory. Instead, the case should be considered as approximation where r is positive but so small that the role of debt in the cointegrating vector becomes negligible.

Table 6 displays the results for the limiting case and several extensions. Estimates No. 1-3 are for the basic ECM and the two VAR-specifications. They are consistent with the results of Tables 4 and 5 based on the full three variable vector. The response of future taxes to initial tax changes is even smaller than in the full model, only about 0.35, but still significant. 65% of the adjustment to the deficit financed tax change comes though spending adjustment. The response of future taxes to an impulse to spending is also similar to the previous values, between 26% and 32%, depending on the specification. Here this response is clearly significant, which was somewhat unclear in the full model. Thus, the "spend and tax" direction of causality also has some statistical support.

Individuals as well as the government presumably observe a much larger set of variables than one could ever put in a VAR. It is therefore important to explore whether the results are sensitive to the inclusion of more variables into the information set X. Previous studies of government behavior (e.g., Barro (1979) and (1986), Kremers (1989), Horrigan (1986)) have focussed on output growth and inflation as likely determinants. Regressions No. 4-7 show the effects of including real growth and inflation in the ECM, each with or without the current value.[20] The estimated impact of growth and inflation on the present values taxes and spending in regressions 4-7 are 0.04 (t = 0.5), 0.05 (t = 0.7), 0.065 (t = 0.2), and -0.05 (t = -0.2), respectively. None of these values is significant, though both inflation and growth enter significantly into either the ΔT or the ΔG equation (or both).

The reason why no variables other than G and T matter may be that the projections do not concern short run dynamics, for which growth and inflation may be important, but long run adjustments. In addition, I am using GNP-shares, which already include proportional reactions of fiscal variables to growth and inflation (unlike the studies referenced). A significant value for any other variable than T and G in the projections would mean that that variable permanently changes the share of government in the economy. Growth may cause such a shift, if demand for government services has an income elasticity above one. But in fact, the effect is negligible. For inflation, an effect would have meant that inflation had persistent real effects. Overall, the results hold up.

Another possible problem may be time-variation in the government's behavior. Regressions 8-11 re-run the basic regression for 4 subperiods. Regressions 8 and 9 split the sample in 1917, which marks a shift in taxation from a tariff-based to an income-based system (see Gardner and Kimbrough (1989)). The period 1918-1988 is also closer to the period considered by previous fiscal policy studies (e.g. Barro (1979) and (1986)). Regression 10 excludes the Civil war period and prior years, for which data may not be as reliable. Regression 11 explores whether war periods are somehow special. One might suspect that the "big movements" during the wars drive the previous results. Therefore, the three major war periods were excluded.[21]

As Table 6 shows, none of the estimates No. 8-11 differs significantly from those for the overall sample. Excluding war periods seems to reduce the estimated effect of government spending on taxes slightly (to 0.20), but it reduces the standard errors even more so that the effect is more significant than in model No. 1.

Finally, I explored whether the misalignment between fiscal variables measured by fiscal years and GNP measured by calendar year matters. Therefore, fiscal variables were deflated by a fiscal-year GNP series obtained by interpolating annual values, instead of using the timing conventions of Section 3. The estimates based on the alternative data set shown as No. 12. The method of scaling seems to make little difference.[22]

The uniformity of the results might not be so surprising, if one recalls that all ECM models explain changes in the endogenous variables by two components, an autoregressive part and a cointegrating vector. Various specifications of the autoregressive part are used to explore the robustness, but all use the deficit as cointegrating vector. The crucial common result is that the deficit enters with a positive coefficient into the tax equation and with a negative coefficient into the spending equation. This pulls taxes up and spending down whenever the deficit is large.

If one abstracted from the autoregressive part (as a counterfactual experiment), a high initial deficit would be expected to decline exponentially over time at a rate determined by the sum of the two coefficients on the deficit. The relative size of the coefficients determines how the adjustment is divided between tax increases and spending cuts. For the basic ECM of Table 4, for example, the deficit coefficients 0.170 and -0.192 imply that any initial deficit declines by about 36% per year with a slightly larger adjustment of spending than taxes. If the autoregressive coefficients were zero, 0.17/(0.17 + 0.192) = 47% of any deficit--independent of its cause--would be eliminated by tax increases and 0.192/(0.17 + 0.912) = 53% by spending cuts. The full result with autoregressive component is not much different for a deficit triggered by a tax cut (see Table 4B or 5). For a deficit caused by high spending, the full estimate puts more emphasis on spending adjustment, suggesting that the autoregressive structure has some significance for innovations in spending. The relative size of the coefficients on the deficit is similar in all ECM regressions (with somewhat stronger emphasis on spending adjustment in some cases) which means that the results are not much influenced by the choice of the autoregressive specification.

5. Conclusions

The paper has analyzed a long series of US-budget data to explore the typical response of taxes and spending to changes in fiscal policy. Tax changes are found to signal substantial spending changes, implying that on average 50%-65% (depending on specification) of a deficit caused by lower taxes will be eliminated by reduced spending, only 35%-50% by higher future taxes. Thus, the marginal propensity to consume of forward-looking, "Ricardian" consumers may be as high as 65%. This should be taken into account when using Ricardian equivalence reasoning in evaluating fiscal policy.

Concerning government spending, only about 30% of all changes in spending are found to be permanent and accommodated by subsequent changes in taxes. Thus, spending changes "cause" tax changes, but the effect is smaller than the effect of taxes on spending. The fact that tax changes anticipate spending changes provides some support for the "tax-smoothing" model of government behavior, though the the fact that some tax changes are reversed leads to a statistical rejection of the model.

Footnotes

[1]Whether actual consumer behavior is as forward looking as the Ricardian equivalence theorem assumes is still a disputed question. I am not taking a position in this dispute about consumer behavior, but merely pointing out that even if consumers satisfy all "Ricardian" assumptions, expectations about government activity are needed to apply the Ricardian approach (see below for more discussion).

[2]Interestingly, Barro's (1979) analysis seems to suggest that the "Ricardian experiment" of a deficit financed tax cut followed by offsetting tax increases should rarely be observed. See Bohn (1988a).

[3]Two reasons for giving expectational factors less weight must be carefully distinguished. One issue is whether consumers are forward looking, i.e., whether their behavior depends on T_t^p, the other is what value the expectational expression in (4) takes. Most of the discussion on Ricardian equivalence has been about the first aspect, e.g., about rationality, liquidity constraints, bequests (see the Spring issue of the Journal of Economic Perspectives). These issues are not addressed here. Instead, the point is that even forward looking consumers will respond to current tax policy, unless the expectational effect perfectly offsets the change in current taxes; see Feldstein (1982).

[4]The alternative of known B_{t+1} will also be considered in the empirical analysis; the formal analysis is similar to the basic case and therefore omitted.

[5]Note that cointegration of X^F and ΔB implies cointegration of (G_t, T_t, B_{t+1}), which is important for the case with B_{t+1} in the information set.

[6]For an alternative information set that includes B_{t+1}, $X_t = (T_t, G_t, B_{t+1}, \ldots)$, one can derive similar restrictions using the fact that the right hand side of (12) is equal to $\hat{B}_{t+1}$: $f_{TT} - f_{GT} - f_{\varepsilon T} = 0$, $f_{TG} - f_{GG} - f_{\varepsilon G} = 0$, and $f_{TB} - f_{GB} - f_{\varepsilon B} = 1$. In addition, equation (11) implies restrictions on the projections in levels, $PV(\hat{T})_t$ and $PV(\hat{G})_t$. But since G and T are non-stationary, the formulation in differences is empirically more useful.

[7]They are obtained from the lag polynomial A(L) and a by using (16) repeatedly until one obtains an equation of the form

$$X_t = \sum_{i=1}^{k} A_k \cdot X_{t-k} + \alpha \cdot DEF_{t-k-1} + u_t \,.$$

[8]Details are available from the author. The definitions follow the unified budget concept, i.e. leave the Federal Reserve off the balance sheet.

[9]Moreover, a transformation to calendar years would create time-aggregation problems.

[10]For $r > 0$ to hold in this case, the real interest rate must exceed the expected growth rate, which is related to the question of dynamic efficiency (see Abel et. al. (1989)). But even when growth exceeds the interest rate on riskfree government bonds for long periods, it seems prudent to discount risky tax revenue (which depends on output) at a higher rate; see Kremers (1989).

[11]The algebra of budget constraints is valid for par as well as for market values, if the error ε_t is interpreted appropriately. If there is a restatement of par values unrelated to a market valuation change, it will induce an error in the budget equation with par values. But if the yield on the par value of debt is a smooth series, errors in a budget equation with par values may actually be smaller than those in an equation based on market value. In any case, the impact of ε_t is an empirical question.

[12]An issue in this test is the size of the lag window. Since there is autocorrelation in differenced data, it should not be chosen too small. I picked $k = 10$ arbitrarily.

[13]The positive $Z\tau$-statistic for ΔG is difficult to interpret. Perhaps the extreme over-differencing involved in regressions involving the second differences is responsible. Whatever it is, it may also be responsible for the insignificant value on ΔT.

[14]Recalling the discussion in Section 3, the discount rate r is the expected real interest rate minus the expected growth rate, which is not easily observable. Fortunately, the results are identical for a wide range of values. An exact determination is therefore not needed and will not be attempted.

[15]The estimator is the canonical variate corresponding to the largest squared canonical correlation between the vector X_t and its first difference, adjusted for significant autocorrelations; see Johansen (1988). The scale can be normalized arbitrarily; in the text, the coefficient on T was set to 1.0, which differs from Johansen's normalization.

[16]Engle and Yoo's simulations yield critical 1% (5%) values of 4.35 (3.78). Of course, the simulations are not strictly applicable, though similar, so that the inference should be interpreted cautiously.

[17]Lag lengths were always chosen by the Akaike information criterion; $r = 3\%$ is consistent with the (rounded) estimated cointegrating vector.

[18]The question is whether seignorage as part of revenue is defined as money times nominal interest rate or as change in money holding. The first definition is appropriate if money is part of debt, the second, if money is not considered a liability. I generally chose the first version, but here explore the alternative. Fortunately, it does not seem to matter.

[19]Since $PV(\hat{\varepsilon})$ is finite for a stationary error process ε, one can replace $PV(\Delta\hat{\varepsilon})$ in (11) by $\rho \cdot \hat{\varepsilon}_t + (1 - \rho) \cdot PV(\hat{\varepsilon})$ (or not replace $PV(\hat{\varepsilon})$ in going from (11) to (12)). Then the $\hat{\varepsilon}_t$ on both sides of (11) cancel as $\rho \to 1$.

I could have written all projections in Section 2 in terms of $PV(\hat{\varepsilon})$ instead of $PV(\Delta\hat{\varepsilon})$.

[20]The models are ECMs with 4 lags of each variable and cointegrating vector (1, -1, 0). Because fiscal and calendar years are not perfectly aligned, inflation in the later part of the fiscal year may or may not be considered known. Hence 2 regressions were run for each variable. Nominal GNP and the GNP-deflator, the measure of inflation, are from Berry (1988) and updated, as discussed in Section 3, except that the deflator was adjusted by Barro's (1986) correction for World War II price controls.

[21]To look at post-war data separately, I reestimated model No. 1 for 1954:1 to 1988:3, using quarterly post-war National Income and Product Account series. The estimates were $f_{TT} = -0.43$ ($t = -2.1$) for the effect of T on PV(ΔT) and $f_{TG} = 0.37$ ($t = 1.2$) for the effect of G on PV(ΔT). Thus, more recent data seem to be similar to the long-run estimates. Since the long-run estimates are preferable for reasons outlined in Section 3, a detailed analysis of postwar data was not undertaken.

[22]Moreover, if such changes in data definition have little effect, it seems unlikely that measurement error can explain the temporary component of taxes.

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Table 1: Summary Statistics

Series	Mean	Std. Dev.	Autocorrelations at Lags: 1	2	3	4	5
B	21.446	21.19	0.977	0.930	0.877	0.826	0.783
T	7.083	7.16	0.977	0.949	0.926	0.901	0.870
G	7.490	9.12	0.927	0.806	0.695	0.618	0.580
ΔB	0.126	4.31	0.560	0.164	-0.037	-0.147	-0.138
ΔT	0.096	1.18	0.154	-0.133	0.030	-0.093	-0.177
ΔG	0.098	3.34	0.351	-0.078	-0.259	-0.294	-0.211
DEF^0	0.407	4.37	0.738	0.414	0.155	-0.033	-0.107

Legend: The sample period is 1800-1988. All values are percentages of GNP.

Table 2: Stationarity Tests

Variable	k	$ADF(k)$	$ADF(13)$	$Z\tau$	$Z\rho$
T	5	-0.17	-0.16	-0.39	-0.96
G	6	-1.49	-0.80	-1.55	-9.39
B	2	-1.95	-2.12	-2.41	-6.34
ΔT	0	-11.72*	-3.89*	-6.90*	-129.79*
ΔG	0	-9.48*	-5.06*	+2.35	-66.35*
ΔB	0	-7.27*	-3.27*	-2.70	-57.32*
DEF^0	5	-4.69*	-3.50*	-3.21*	-38.57*
DEF^2	5	-4.41*	-3.21*	-3.43*	-37.99*
DEF^4	5	-4.11*	-2.94*	-3.59*	-36.79*

Legend:

$ADF(k)$ is the augmented Dickey-Fuller t-statistic computed with lag length k.

$Z\tau$ is Phillips' adjustment of the Dickey-Fuller t-statistic.

$Z\rho$ is Phillips' adjustment of the coefficient estimate in the Dickey-Fuller regression, multiplied by the sample size $N = 189$.

* indicates significant rejections of non-stationarity.

Critical values for $N = 100/250$ observations are

ADF and $Z\tau$ 5%: 2.88/2.89 - 1%: 3.46/3.51

$Z\rho$ 5%: 13.7/14.0 - 1%: 19.8/20.3

Here $N = 189$ so that the critical values are in between.

Table 3: Co-integration Tests

Panel A: $X_t = (T_t, G_t, B_t)$, 1800–1988, Regressions with 6 Lags

Squared canonical correlations between X and ΔX:

.126608	.049221	.002861

Canonical Variates (in columns):

.787362	-.710308	.489718
-.690898	.780573	-.267916
-.047594	-.077970	-.025856

Maximum Number of Co-Integrating Vectors, p:

p	Test Value	95% Interval
2	0.54157	[0.0, 5.3]
1	10.08110	[1.0, 13.9]
0	35.66628**	[7.0, 26.1]

** = rejection

Restriction to (1.0, -1.0, -r): $\chi^2(1) = 3.67$, significance = 5.55%
Restriction to (1.0, -1.0, 0): $\chi^2(2) = 4.77$, significance = 9.21%

Panel B: $X_t = (T_t, G_t)$, 1800–1988, Regressions with 4 Lags

Squared canonical correlations between X and ΔX:

.220139	.000122

Canonical Variates (in columns):

.519935	.232806
-.514422	-.081587

Maximum Number of Co-Integrating Vectors, p:

p	Test Value	95% Interval
1	0.02312	[0.0, 5.3]
0	47.01600**	[1.0, 13.9]

** = rejection

Restriction to (1.0, -1.0): $\chi^2(1) = 0.07$, significance = 79%

Table 4: An Error Corrections Model. Panel A: Estimates

Variable and lag		Equation 1: ΔT			Equation 2: ΔG			Equation 3: ΔB		
		COEF	t-value	Robust t-value	COEF	t-value	Robust t-value	COEF	t-value	Robust t-value
ΔT	1	-0.369	-4.702	-3.634	1.200	4.592	3.385	-1.178	-6.087	-4.124
ΔT	2	-0.790	-8.229	-6.631	-0.488	-1.527	-1.535	0.034	0.143	0.126
ΔT	3	-0.228	-2.270	-2.026	0.431	1.292	1.545	-0.770	-3.111	-3.277
ΔT	4	-0.284	-3.089	-2.814	-0.136	-0.444	-0.562	-0.546	-2.408	-1.892
ΔG	1	0.302	12.575	5.573	0.215	2.692	1.361	0.743	12.535	8.828
ΔG	2	0.206	5.101	3.424	-0.335	-2.488	-1.649	0.604	6.069	5.597
ΔG	3	0.187	4.000	3.421	-0.056	-0.362	-0.322	0.518	4.500	3.398
ΔG	4	0.187	3.827	3.211	-0.203	-1.251	-0.859	0.626	5.209	3.761
ΔB	1	-0.028	-0.968	-0.749	-0.213	-2.176	-1.645	0.378	5.227	4.466
ΔB	2	0.039	1.244	1.437	0.012	0.110	0.144	-0.107	-1.372	-1.040
ΔB	3	-0.004	-0.117	-0.102	0.053	0.533	0.462	0.052	0.693	0.549
ΔB	4	-0.024	-0.864	-0.736	-0.004	-0.049	-0.036	0.224	3.297	2.294
DEF		0.170	4.825	3.301	-0.192	-1.663	-1.789	0.224	2.581	2.017
Constant		-0.010	-0.152	-0.185	0.247	1.146	1.507	-0.181	-1.133	-1.289
Std. error			0.807			2.682			1.986	
R^2			0.565			0.398			0.803	
Adj. R^2			0.533			0.353			0.788	
F-test on ΔT			0.000			0.000			0.000	
F-test on ΔG			0.000			0.009			0.000	
F-test on ΔB			0.562			0.237			0.000	

Table 4 continued. Panel B: Projections

Innovation in: Effect on:	T $PV(\Delta T)$	T $PV(\Delta G)$	G $PV(\Delta T)$	G $PV(\Delta G)$
ESTIMATE	-0.4889	0.4997	0.3036	-0.6444
Standard Error:	0.1230	0.1421	0.1679	0.1940
Robust Error:	0.1176	0.1419	0.2669	0.3125
t-Value:	-3.974	3.515	1.808	-3.322
Robust t-Value	-4.157	3.522	1.138	-2.062

Legend: The error correction model is as described in the text with DEF based on r = 3%. It is estimated by OLS for 1800-1988. The columns "COEF" have the coefficient. "F-test" indicates at what significance level one can exclude the variable from the regression. "Robust" indicates heteroskedasticity-consistent estimates (White (1984)). Standard errors of the projections are valid asymptotically.

Table 5: Results with alternative specifications

Model	Projections							
	T on PV(ΔT)		T on PV(ΔG)		G on PV(ΔT)		G on PV(ΔG)	
1	-0.49	(-4.16)	0.50	(3.52)	0.30	(1.14)	-0.64	(-2.06)
2	-0.39	(-5.06)	0.58	(6.80)	0.30	(1.47)	-0.66	(-2.90)
3	-0.45	(-1.96)	0.56	(2.02)	0.33	(1.31)	-0.61	(-2.03)
4	-0.49	(-3.54)	0.51	(3.65)	0.29	(0.96)	-0.71	(-2.28)
5	-0.48	(-4.87)	0.47	(3.25)	0.31	(1.35)	-0.56	(-1.77)
6	-0.50	(-3.70)	0.49	(3.00)	0.29	(1.24)	-0.66	(-2.37)
7	-0.50	(-4.07)	0.48	(3.29)	0.25	(0.66)	-0.72	(-1.59)
8	-0.39	(-0.17)	0.58	(0.22)	0.30	(0.06)	-0.66	(-0.13)
9	-0.51	(-6.97)	NA		0.29	(0.76)	NA	
10	NA		0.56	(1.01)	NA		-0.22	(-0.10)

Legend: Robust t-statistics are in parentheses. Numbers refer to different regressions. No. 1 is described in detail in Table 4. The other models differ from No. 1 as follows:

1. ECM with (ΔT, ΔG, ΔB), Lags = 4, r = 0.03 (= basic case from Table 4)
2. ECM with (ΔT, ΔG, ΔB), Lags = 2
3. ECM with (ΔT, ΔG, ΔB), Lags = 6
4. ECM with (ΔT, ΔG, ΔB), r = 0.005
5. ECM with (ΔT, ΔG, ΔB), r = 0.06
6. ECM with (ΔT, ΔG, ΔB), with different computation of seignorage (see text).
7. ECM with (ΔT_t, ΔG_t, ΔB_{t+1}) and DEF computed with B_{t+1}, Lags = 4, r = 0.03.
8. VAR with (ΔT, ΔG, DEF), Lags = 4, r = 0.03.
9. VAR with (ΔT, ΔB, DEF), Lags = 4, r = 0.03;
   excludes ΔG, hence PV(ΔG) cannot be computed.
10. VAR with (ΔG, ΔB, DEF), Lags = 4, r = 0.03;
    excludes ΔT, hence PV(ΔT) cannot be computed.

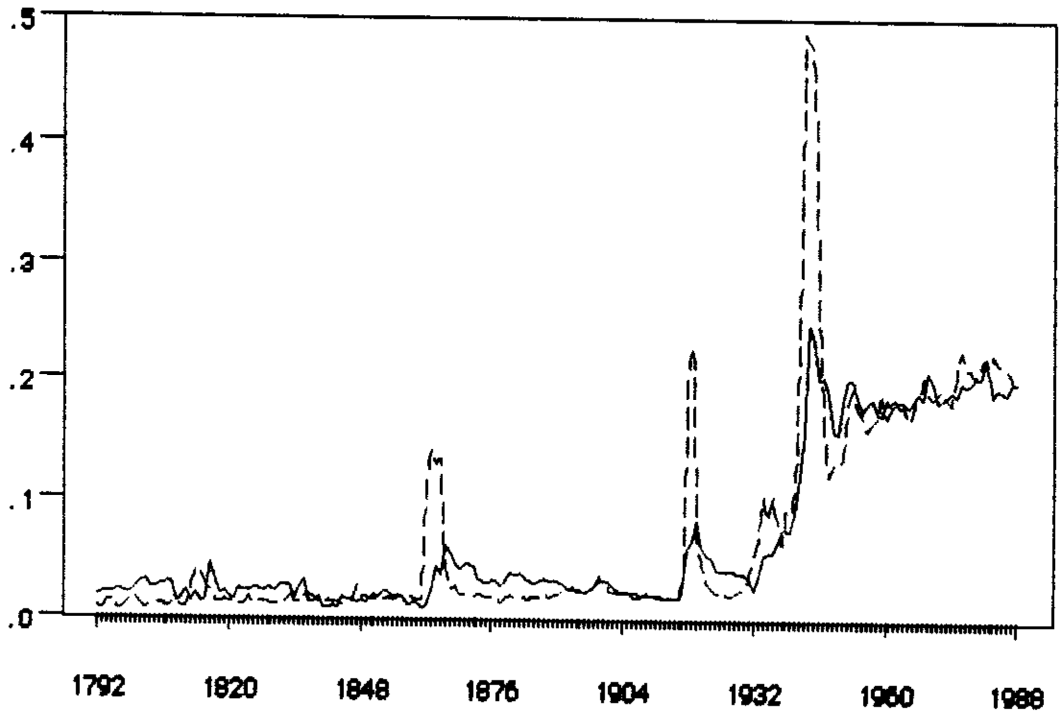
Table 6: The Limiting Case $r \rightarrow 0$

Model	Projections							
	T on PV(ΔT)		T on PV(ΔG)		G on PV(ΔT)		G on PV(ΔG)	
1	-0.35	(-4.11)	0.65	(7.68)	0.28	(2.33)	-0.72	(-6.00)
2	-0.35	(-4.25)	0.65	(7.93)	0.26	(3.41)	-0.74	(-9.55)
3	-0.37	(-1.52)	0.63	(2.63)	0.32	(0.39)	-0.68	(-0.84)
4	-0.40	(-4.75)	0.60	(7.27)	0.28	(1.97)	-0.72	(-4.99)
5	-0.34	(-3.55)	0.66	(7.00)	0.28	(1.92)	-0.72	(-4.96)
6	-0.38	(-3.03)	0.62	(4.92)	0.26	(2.08)	-0.74	(-5.89)
7	-0.43	(-5.59)	0.57	(7.39)	0.32	(1.87)	-0.68	(-4.00)
8	-0.44	(-3.79)	0.56	(4.87)	0.35	(2.24)	-0.65	(-4.25)
9	-0.33	(-2.95)	0.67	(6.10)	0.24	(2.10)	-0.76	(-6.58)
10	-0.33	(-2.90)	0.67	(5.99)	0.26	(2.06)	-0.74	(-5.81)
11	-0.29	(-3.35)	0.71	(8.28)	0.20	(3.17)	-0.80	(-12.52)
12	-0.37	(-4.98)	0.63	(8.31)	0.27	(2.14)	-0.73	(-5.73)

Legend: Numbers refer to different regressions as in Table 5. All regressions except No. 3 have 2 lags.

1. ECM with (ΔT, ΔG), 1800-1988.
2. VAR with (ΔT, DEF).
3. VAR with (ΔG, DEF), Lags = 6
4. ECM with (ΔT, ΔG, GNP-growth$_t$)
5. ECM with (ΔT, ΔG, GNP-growth$_{t-1}$)
6. ECM with (ΔT, ΔG, Inflation$_t$)
7. ECM with (ΔT$_t$, ΔG$_t$, Inflation$_{t-1}$)
8. ECM with (ΔT, ΔG), 1800-1917.
9. ECM with (ΔT, ΔG,), 1918-1988.
10. ECM with (ΔT, ΔG), 1879-1988.
11. ECM with (ΔT, ΔG), excluding major wars (1861-1866, 1917-1919, 1941-1947).
12. ECM with (ΔT, ΔG), 1800-1988, using interpolated GNP instead of initial GNP.

Figure 1: Revenue and Spending as fractions of GNP



Legend:

---- Spending

—— Revenue

Figure 2: Public Debt as fraction of GNP