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ON THE PREDICTABILITY OF TAX-RATE CHANGES

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ABSTRACT

Some previous analyses have suggested that the smoothing of tax rates over time would be a desirable guide for public debt management. One implication of this viewpoint is that future changes in tax rates would be unpredictable based on current information. This proposition is tested by examining the behavior of U.S. federal and total government tax (and "non-tax") receipts relative to GNP. The sample for the federal government goes back to 1879, while that for total government starts in 1929. Some econometric problems with using time-averaged data are discussed. The main empirical results accord with the theoretical analysis--in particular, there is first, little indication of drift in the tax rates; second, insignificant relations of tax-rate changes to the own history of changes; and third, little explanatory value for tax-rate changes from a vector of lagged variables, which include the behavior of government spending and real output. If the findings are sustained, they imply that the existing U.S. time series data do not isolate periods in which current overall tax rates would be perceived as high or low relative to expected future rates. Accordingly, it may be impossible to use these data to evaluate policies that entail intertemporal manipulation of aggregate tax rates.

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Some previous papers (Barro, 1979, 1980; Kydland and Prescott, 1980) suggested that the smoothing of tax rates over time would be a desirable guide for debt-management policy. For example, the large temporary outlays by government during wartime would be primarily debt-financed in order to avoid a substantial excess of wartime tax rates over rates that would be expected for later years. Similarly, assuming that real government spending is not strongly procyclical, a countercyclical response of the public debt allows for smoothing of tax rates over the business cycle.

Heuristically, the case for intertemporal uniformity of tax rates--say, on factor incomes--emerges if the (own- and cross-) responsiveness of factor supplies to after-tax rewards is similar at different dates. For example, the Ramsey-like rule for taxation in inverse relation to own supply elasticities yields this answer in the context of a uniform intertemporal pattern of elasticities.[1]

Departures from uniform taxation over time would be suggested if factor supply elasticities interact, for example, with the contemporaneous level of government spending or with the state of the business cycle. The signs or magnitudes of these effects are not apparent on theoretical grounds--conceivably, the uniformity of tax rates over time may remain as a satisfactory approximation to optimal policy. The theory has also not been applied to contexts of uncertainty about future values of government spending, aggregate real income, and so on.

The basic approach in this paper is first, to adopt the criterion of constant expected overall tax rates as an approximate guide to optimal public finance; and second, to regard this proposition as a positive theory about government behavior. The properties of tax collections over time are examined empirically to test whether actual behavior departs significantly from that dictated by this simple rule for intertemporal public finance.

A previous empirical investigation (Barro, 1979) considered the implications of tax smoothing at the level of the federal government for the determination of U.S. public debt. The present analysis looks directly at the behavior of taxes--specifically, at propositions that concern the unpredictability of changes in future tax rates.

Suppose that τ_t represents the (average marginal) tax rate applying to incomes that accrue during period t. (The restriction to income taxes is not central to the analysis.) The basic hypothesis is that τ_t is set in accordance with a rule that generates equality between τ_t and all expected future tax rates, as perceived at date t. In particular, constancy of tax rates emerges if the realizations for all future values of real government spending, real GNP, and so on, equal their mean values as conditioned on date t information.

The level of τ_t is determined from the government's intertemporal budget constraint, taking account of tax effects on the scale of economic activity (that is, on the tax base). Departures of real government spending, real GNP, etc., from their prior expectations generate revisions in tax rates. In a simple setting where taxes are proportional to income, the tax rate change depends on a weighted sum of changes in expected future values of government spending relative to aggregate income. For present purposes, the important point is that τ_t is set at each date so that

$$(1) \qquad E(\tau_{t+i} | I_t) = \tau_t \quad \text{for} \quad i = 1, 2, \ldots$$

applies, where I_t represents date t information. In other words, tax rates follow a Martingale process. Alternatively, in first-difference form, all future changes in tax rates are unpredictable:

$$(2) \qquad E(\tau_{t+i} - \tau_{t+i-1})|I_t = 0 \quad \text{for} \quad i = 1, 2, \ldots$$

Equation (2) is the main proposition that is tested in this paper. The full distribution of tax-rate changes need not be time-invariant in order to satisfy equations (1) and (2), but the empirical analysis embodies this additional restriction. In this form tax rates are generated from a random walk.

The random-walk model for tax rates is reminiscent of similar propositions for some asset prices, which have been the subject of considerable empirical investigation. See Fama (1970) for a survey of this area. The approach is also analogous to the study of consumption that has been carried out by Hall (1978).

Suppose that real government spending, aside from interest payments, and real GNP are not themselves generated from random-walk processes. In this case the unpredictability of changes in future values, as shown for tax rates in equation (2), would not apply for these other variables. The essence of the tax-rate-smoothing policy implied by equations (1) and (2) is that any foreseeable behavior for real government spending,[2] real GNP, etc., is incorporated in the setting of the current tax rate, so as to avoid a pattern whereby tax rates would vary with the predictable changes in the other variables. Tests for the unpredictability of tax-rate changes are most interesting in an environment where some future changes in real government spending, real GNP, etc., are forecastable. In particular, it would be less interesting to find that tax-rate shifts were unpredictable if changes in the government spending-GNP ratio were also unpredictable. Accordingly, the empirical analysis includes tests in the form of equation (2) for other variables--notably, for the government spending-GNP ratio--along with the tests for tax rates. A comparison across the various equations is of substantial interest from the perspective of assessing the tax-rate-smoothing model.

Empirical Counterparts of Tax Rates

Although average marginal tax rates matter in the theoretical analysis, data considerations limit the empirical investigation to aggregate average tax rates. The implicit assumption is the absence of substantial changes over time in the relation of these average rates to the underlying average marginal tax rates.

The spirit of the theory pertains to an overall package of taxes at each date, rather than to individual components. Specifically, the finding of predictability of tax-rate changes for particular categories of taxation would not invalidate the central thesis. Therefore, the analysis deals with the overall tax (and so-called non-tax) receipts for a specified government entity. The primary results deal with the U.S. federal government, although findings are indicated also for the U.S. total government sector.[3] An attempt was made to consolidate the Federal Reserve with the federal government by excluding from receipts the transfers made by the Federal Reserve to the U.S. Treasury. (Curiously, this item appears under corporate tax liabilities.) Details on the definitions of tax variables are contained in the notes to Table 1.

Table 1

Variables Used in Regressions

Date	(1) TAXF	(2) GF	(3) TAXT	(4) GT	(5) CAS	(6) DY	(7) r	(8) R·H/GNP
1879	.029	.019	--	--	0	.099	--	--
1880	.028	.013	--	--	0	.139	--	--
1881	.029	.015	--	--	0	.016	--	--
1882	.028	.015	--	--	0	.048	--	--
1883	.027	.017	--	--	0	-.021	--	--
1884	.025	.017	--	--	0	.021	--	--
1885	.027	.018	--	--	0	-.004	--	--
1886	.028	.018	--	--	0	.054	--	--
1887	.030	.018	--	--	0	.022	--	--
1888	.030	.019	--	--	0	-.034	--	--
1889	.029	.020	--	--	0	.044	--	--
1890	.030	.020	--	--	0	.072	--	--
1891	.025	.021	--	--	0	.044	--	--
1892	.024	.023	--	--	0	.092	--	--
1893	.023	.024	--	--	0	-.049	--	--
1894	.022	.025	--	--	0	-.029	--	--
1895	.021	.021	--	--	0	.111	--	--
1896	.022	.023	--	--	0	-.020	--	--
1897	.025	.021	--	--	0	.095	--	--
1898	.027	.032	--	--	.005	.017	--	--
1899	.030	.027	--	--	0	.089	--	--
1900	.029	.023	--	--	0	.025	--	--
1901	.026	.021	--	--	0	.111	--	--
1902	.025	.020	--	--	0	.009	--	--
1903	.023	.020	--	--	0	.049	--	--
1904	.022	.024	--	--	0	-.013	--	--
1905	.021	.021	--	--	0	.072	--	--
1906	.021	.018	--	--	0	.110	--	--
1907	.020	.018	--	--	0	.016	--	--
1908	.020	.023	--	--	0	-.086	--	--
1909	.019	.020	--	--	0	.116	--	--
1910	.019	.019	--	--	0	.028	--	--
1911	.019	.018	--	--	0	.026	--	--
1912	.018	.017	--	--	0	.055	--	--

(continued)

Variables Used in Regressions

Date	(1) TAXF	(2) GF	(3) TAXT	(4) GT	(5) CAS	(6) DY	(7) r	(8) R·H/GNP
1913	.018	.018	--	--	0	.009	--	--
1914	.018	.018	--	--	0	-.045	--	--
1915	.017	.018	--	--	0	-.009	--	--
1916	.017	.017	--	--	0	.076	--	--
1917	.021	.108	--	--	.23	.007	--	--
1918	.056	.220	--	--	.28	.116	--	--
1919	.083	.137	--	--	0	-.036	--	--
1920	.074	.047	--	--	0	-.045	--	--
1921	.073	.051	--	--	0	-.091	--	--
1922	.048	.030	--	--	0	.147	--	--
1923	.046	.026	--	--	0	.114	--	--
1924	.045	.025	--	--	0	-.002	--	--
1925	.040	.024	--	--	0	.081	--	.003
1926	.040	.022	--	--	0	.062	.113	.003
1927	.041	.023	--	--	0	-.005	.316	.003
1928	.039	.026	--	--	0	.006	.355	.004
1929	.037	.023	.109	.093	0	.064	-.118	.004
1930	.034	.029	.119	.115	0	-.098	-.236	.003
1931	.027	.051	.125	.152	0	-.080	-.385	.003
1932	.029	.049	.152	.166	0	-.149	.176	.004
1933	.048	.064	.167	.173	0	-.021	.577	.003
1934	.054	.090	.160	.181	0	.075	.037	.001
1935	.055	.083	.157	.171	0	.086	.355	.001
1936	.061	.100	.156	.183	0	.127	.286	.001
1937	.078	.075	.170	.154	0	.045	-.422	.001
1938	.076	.094	.176	.185	0	-.042	.347	.001
1939	.074	.091	.170	.182	0	.073	.060	.001
1940	.086	.093	.177	.172	0	.072	-.056	.001
1941	.123	.158	.200	.221	.004	.143	-.187	.001
1942	.145	.348	.206	.396	.162	.136	.074	.001
1943	.205	.439	.256	.476	.205	.148	.229	.001
1944	.195	.444	.243	.478	1.09	.073	.177	.001
1945	.200	.385	.251	.422	.603	-.014	.315	.001

(continued)

Table 1 (continued)

Variables Used in Regressions

Date	(1) TAXF	(2) GF	(3) TAXT	(4) GT	(5) CAS	(6) DY	(7) r	(8) R·H/GNP
1946	.187	.151	.243	.198	0	-.157	-.216	.002
1947	.185	.110	.244	.165	0	-.020	-.049	.002
1948	.166	.119	.227	.179	0	.041	.013	.003
1949	.149	.143	.216	.213	0	.006	.219	.003
1950	.174	.127	.240	.197	.071	.084	.215	.002
1951	.194	.162	.257	.227	.097	.078	.143	.003
1952	.193	.192	.259	.257	.030	.037	.127	.003
1953	.190	.198	.258	.265	.021	.038	.004	.003
1954	.173	.178	.245	.252	0	-.013	.438	.002
1955	.181	.159	.252	.234	0	.065	.233	.003
1956	.184	.159	.260	.236	0	.021	.064	.004
1957	.184	.167	.261	.248	0	.018	-.136	.004
1958	.174	.186	.255	.272	0	-.002	.354	.003
1959	.183	.174	.264	.256	0	.058	.116	.004
1960	.188	.171	.274	.256	0	.023	-.001	.004
1961	.186	.183	.275	.273	0	.025	.240	.003
1962	.187	.184	.277	.272	0	.056	-.092	.003
1963	.191	.180	.282	.270	0	.039	.183	.003
1964	.178	.173	.271	.265	.001	.051	.145	.003
1965	.179	.168	.272	.261	.007	.057	.114	.004
1966	.186	.178	.280	.272	.025	.058	-.120	.005
1967	.187	.193	.284	.293	.047	.027	.218	.004
1968	.198	.195	.300	.298	.073	.043	.088	.005
1969	.207	.188	.314	.293	.046	.025	-.147	.006
1970	.192	.193	.304	.305	.021	-.003	-.009	.006
1971	.184	.194	.300	.309	.007	.030	.122	.004
1972	.192	.196	.311	.306	.001	.056	.136	.004
1973	.194	.189	.311	.298	0	.053	-.263	.006
1974	.200	.197	.318	.313	0	-.014	-.401	.007
1975	.184	.218	.303	.336	0	-.013	.274	.004
1976	.191	.210	.313	.324	0	.057	.197	.004
1977	.195	.207	.316	.317	0	.052	-.107	.004
1978	.200	.200	.319	.309	0	.043	.008	.005
1979	.206	.197	.322	.306	0	.023	.097	.006

(continued)

Notes to Table 1:

TAXF is total federal government receipts less transfers from the Federal Reserve, divided by nominal GNP. Before 1929 an estimate of interest received by the federal government was also deducted. (The original data included this interest as a component of revenue.)

GF is total federal expenditures less net interest payments, divided by nominal GNP. Before 1929 an estimate of gross interest paid was deducted. (Interest received appears on the receipt side of the accounts.)

TAXT is total government receipts (intergovernmental transfers are netted out) less transfers from the Federal Reserve, divided by nominal GNP. Data were obtained since 1929.

GT is total government expenditures (intergovermental transfers are netted out) less net interest payments, divided by GNP. Data were obtained since 1929.

CAS is battle deaths per 1,000 total population, as discussed in Barro (1981, Table 1).

$DY \equiv \log (Y_t/Y_{t-1})$, where Y is real GNP, 1972 base.

r is the total nominal return over the year for a value-weighted portfolio of all New York Stock Exchange issues (as compiled by the University of Chicago's Center for Research on Security Prices) less an inflation rate. The inflation rate from 1948 to 1979 is $\log(P_t/P_{t-1})$, where P_t is the December value of the seasonally-unadjusted CPI for an urban consumer, exclusive of shelter. (See n. 7 below.) For 1926-47, the inflation rate is based on the overall CPI for an urban consumer.

R is the annual average interest rate on 4-6 month maturity prime Commercial Paper.

H is the annual average of seasonally-adjusted high-powered money (total currency outside the U.S. Treasury plus reserves of member banks at the Federal Reserve).

R•H/GNP is the ratio of R•H--the cost per year of holding the stock of high-powered money--to nominal GNP.

Data since 1929 for government receipts and expenditures, GNP, net interest payments, and transfers from the Federal Reserve to the U.S. Treasury are from the National Income and Product Accounts of the U.S., 1929-74 and issues of U.S. Survey of Current Business.

(continued)

(Notes to Table 1 continued)

Earlier data on federal receipts and expenditures are from Firestone (1960, Table A-3). Data before 1929 on interest paid and received by the federal government are from issues of the Annual Report of the Secretary of the Treasury, Washington D.C., U.S. Government Printing Office. Federal Reserve transfers were zero before 1929. Earlier figures for real and nominal GNP are from Long-Term Economic Growth, 1860-1970, Series A1, A7. Values before 1889 are based on Gallman's data, which were obtained from Anna Schwartz.

CPI data, compiled by the Bureau of Labor Statistics, were obtained from the Chase Data Bank.

R is from Banking and Monetary Statistics, Banking and Monetary Statistics, 1941-70, and issues of the Federal Reserve Bulletin.

H is from Friedman and Schwartz (1963, Table B-3), Banking and Monetary Statistics, 1941-1970, and issues of the Federal Reserve Bulletin.

One interesting issue concerns the treatment of inflationary finance, which is excluded in conventional measures of tax collections. The current tax rate on holdings of high-powered (government-issue) money, H, is determined by a short-term nominal interest rate, R. The flow, $R \cdot H$, represents the expected costs per period that are imposed on holders of money. In a perfect-foresight setting, the present value of these flows (back to some "initial" date) corresponds also to the present value of government revenue from money creation. Departures of the actual present value of revenues from this magnitude are associated with unexpected capital gains or losses on cash holdings--see Phelps (1973, pp. 74-5) and Auernheimer (1974) for discussions of this matter. The implications of adding the tax on cash balances to the usual concepts of taxation are discussed in the empirical section--quantitatively, the differences in results are insubstantial.

Appropriate empirical counterparts for the overall tax base are not straightforward. Net and gross national product come immediately to mind--the latter concept might be preferable because reported depreciation is largely arbitrary from an economic standpoint and because the (true) depreciation component of GNP is potentially subject to taxation. In any event tax assessments are not necessarily limited to final product or net income--levies can be based on intermediate flows, including governmental transfer payments, and on various stock variables, such as overall wealth or estates. Some experimentation indicated that the results were insensitive to the choice of tax base among GNP, NNP, or either of these concepts augmented by governmental transfers. The results discussed in this paper use GNP as the proxy for the tax base.

Hence, tax rate variables are measured as federal or total government tax (and non-tax) receipts relative to GNP. The hypothesis of unpredictability for changes in future average marginal tax rates translates empirically into a proposition of unpredictability for changes in future values of tax receipts relative to GNP.

The analysis is limited to annual observations on tax receipts. Within-year data do not seem meaningful because of discrepancies between the time of tax accrual (which is pertinent for allocative effects) and the time of payment to the government.

Government expenditure ratios are measured analogously--as either federal or total annual government spending relative to GNP. The total government figures exclude intergovernmental transfers. Net interest payments are determined endogenously, given an initial debt stock, by the tax/deficit policy in conjunction with the time path of other government spending. From the standpoint of tax-rate smoothing, the pertinent matter is the predictability of changes in government spending aside from interest payments. Therefore, net interest payments have been excluded from the government expenditure variables. (However, the results are little changed if this adjustment is not made.) Before 1929 an estimate of federal interest paid is excluded from spending and an estimate of interest received by the federal government is deducted from total receipts. See the notes to Table 1 for details.

Time-Aggregation Problems

Working (1960) discussed a difficulty in testing random-walk hypotheses with time-averaged data on commodity or stock prices. The same problem arises in the present context where annual averages of tax rates are used.[4] If the random-walk model applies at some interval that is shorter than a year (and which might be infinitesimal), then a random walk would not appear in the time-averaged annual data. Suppose, for example, that a positive innovation to the tax rate (reflecting, say, a change in information about future real government spending) occurs during year t. This change affects period t's average annual tax rate by less than one-to-one--depending on the timing of the informational shift during the year--but alters expected future tax rates on a one-to-one basis. Therefore, future time-averaged tax rates, $\bar{\tau}_{t+i}$, would not be related to $\bar{\tau}_t$ by a unitary coefficient. In terms of first differences from one year to the next, the serial independence of tax-rate changes would be replaced by a pattern of positive association.

Using first differences of time-averaged observations, $D\bar{\tau}_t \equiv \bar{\tau}_t - \bar{\tau}_{t-1}$, Working's analysis shows--for the case where the interval for the fundamental random-walk model is infinitesimal and where the underlying distribution of the disturbances is time-invariant--that the simple correlation between $D\bar{\tau}_t$ and $D\bar{\tau}_{t-1}$ equals .25. Note that the simple correlations of $D\bar{\tau}_t$ with earlier lag values remain equal to zero. With the inclusion of four lagged values, $D\bar{\tau}_{t-i}$, it can be shown (see Appendix I) that the <u>partial</u> correlations of $D\bar{\tau}_t$ with each lagged value are given by (.29, -.08, .02, -.01). Subsequent partial correlations would be negligible. Generally, $D\bar{\tau}_t$ can be written as a moving-average process that involves a pattern of weights on the underlying innovations applicable to periods t and t-1. For testing purposes it is convenient to approximate this process in an autoregressive form in terms of the time-averaged variables. Assuming normality for the underlying disturbances, the approximation is

$$(3) \qquad D\bar{\tau}_t = .29D\bar{\tau}_{t-1} - .08D\bar{\tau}_{t-2} + .02D\bar{\tau}_{t-3} - .01D\bar{\tau}_{t-4} + \text{white noise.}$$

This equation replicates the pattern of partial correlations that was just described.

For a case where current information, I_t, is limited to current and past tax rates, equation (3) suggests that the random-walk model can be tested via univariate autoregressions in which the coefficients are constrained to equal the hypothesized values. (Note that the constant equals zero--that is, a drift in the tax rate violates the underlying theory.) Although this procedure is carried out empirically, it has the shortcoming of ignoring the predictive content of other variables, such as real government spending and real GNP. Unfortunately, simple results for time-averaged data do not generally obtain when additional variables are introduced.

Suppose that another variable, X, is added to the analysis. Assume that this variable is generated also from an underlying random-walk process. It is assumed here that the innovations to τ and X are bi-variate normal. The X-variable is potentially of interest if its innovations are correlated contemporaneously with those of τ--denote this correlation by the fixed parameter, ρ. The other parameters of the distributions are also treated as time-invariant. In the absence of time-averaging, the latest observed tax rate, τ_t, would still define the mean value for all future rates--values of X up to X_t would be irrelevant here, despite the condition, $\rho \neq 0$. However, when τ is observed only in time-averaged form, the observations on X can become pertinent--essentially, this variable may help to pin down the latest value of the fundamental τ series, given that only $\bar{\tau}_t$ is observed. Aside from the situation where $\rho = 0$, a case where the observation on X is <u>not</u> helpful arises when this variable is observed in the same type of time-averaged form as that applying to τ. In this case equation (3) continues to apply--in particular, the coefficients on all lagged values of first differences of the time-averaged X variable, $D\bar{X}_{t-i}$, equal zero. (See Appendix I.)

The results change if the X-variable--still generated from an underlying random-walk process--is observed directly, rather than in time-averaged form. (For example, if stock prices plus accumulated dividends are generated from a random walk (with drift), but X represents the full return on equity over the year or the end-of-year stock price, rather than the annual average of stock prices.) For the case where $D\bar{\tau}_{t-1}$ and DX_{t-1} are the only included right-side variables, it is shown in Appendix I that the regression coefficient of $D\bar{\tau}_t$ on DX_{t-1} has the same sign as the underlying contemporaneous correlation, ρ. The coefficient on $D\bar{\tau}_{t-1}$ is reduced below .25 when $\rho \neq 0$--further, the coefficient becomes negative if $|\rho|$ is sufficiently large.[5]

The analysis becomes more complicated if the movements in the X-variable are themselves serially correlated. Note that, unlike for tax rates, the theory does not suggest any special form for the X-process--therefore, the random-walk case cannot generally be assumed. In any event the model no longer implies either that variables like DX_{t-i} would be irrelevant for

$D\bar{\tau}_t$ in the form of equation (3) or that the coefficients of the $D\bar{\tau}_{t-i}$ variables would equal those shown in the equation.

Suppose that all variables dated t-1, as well as t, are excluded on the right side of an equation for $D\bar{\tau}_t$. Despite the presence of time-averaging, the regression coefficients of all right-side variables in this form--which are dated up to t-2--would be zero. Thus, $D\bar{\tau}_{t-2}$, ..., and all variables, DX_{t-2}, ..., would be irrelevant for $D\bar{\tau}_t$. Therefore, tests for the unpredictability of tax-rate changes can be carried out in this form in a multivariate setting.

With the tax rate change, $D\bar{\tau}_t$, examined only in relation to variables that are dated two or more years previously, there are questions about the power of statistical tests. The comparison with parallel relationships for real government spending and other variables is important in this respect--that is, the presence of predictive power in these other equations would suggest that the tests for tax-rate changes were meaningful. Also, the presence of drift in the tax rate--that is, a test for a nonzero constant in the $D\bar{\tau}_t$ equation--is not sensitive to the exclusion of date t-1 explanatory variables. Despite questions about statistical power in annual equations with first lags omitted, it is unclear how else to proceed in the multivariate case. The possibility for a direct analysis--as shown in equation (3) for the univariate setting--depends strongly on the detailed statistical properties of the additional variables, X, which are not the focus of the theory. Further, with respect to aggregate tax rates, it does not seem feasible to use data at an interval finer than one year.

Drift in the Tax and Spending Ratios

Table 2 reports the estimated coefficients and standard errors for equations that include only the constant term. For the federal government, the variable is either the change in the ratio of federal tax receipts to GNP, $D(TAXF)_t \equiv (TAXF)_t - (TAXF)_{t-1}$, or the change in the ratio of federal spending to GNP, $D(GF)_t \equiv GF_t - GF_{t-1}$. The periods considered are 1884-1979, 1884-1929, 1930-1979, and 1948-1979. Data and definitions of variables appear in Table 1. Graphs of the tax and spending ratios are shown in Figure 1.

The estimated constants correspond, of course, to the means of the dependent variables over each sample. Since the federal tax and spending ratios rose over all samples that are considered, the estimated constants in the first-difference specification--that is, the estimated drift for each ratio in level form--are all positive. However, the point estimates are very close to zero for the 1884-1929 period. Over all samples considered, the estimated constants differ insignificantly form zero at the 5% level, although significance would have been attained in some cases if a less stringent critical value had been adopted.

Over the longer samples--1884-1979 or 1930-1979--the point estimates of drift coefficients for the tax and spending ratios are very close. However, the substantially greater sample variance for the spending ratio (which is discussed further in a later section) implies that the estimated drift coefficients for this variable do not differ significantly from zero. For the federal tax ratio, the estimated drift coefficient for the 1884-1979 sample

Table 2

Estimated Drift Coefficients and Sample Standard Deviations

for Changes in Tax and Spending Ratios

Sample	Dependent Variable	Estimated Drift Coefficient	Sample Standard Deviation
1884-1979	D(TAXF)	.0019(.0012), t = 1.6	.0116
"	D(GF)	.0019(.0041), t = 0.5	.0402 } F^{95}_{95} = 12.0 (1.4)
1884-1929	D(TAXF)	.0002(.0012), t = 0.2	.0079
"	D(GF)	.0001(.0042), t = 0.0	.0286 } F^{45}_{45} = 13.1 (1.6)
1930-1979	D(TAXF)	.0034(.0020), t = 1.7	.0140
"	D(GF)	.0035(.0069), t = 0.5	.0487 } F^{49}_{49} = 12.1 (1.6)
"	D(TAXT)	.0043(.0017), t = 2.5	.0120
"	D(GT)	.0043(.0065), t = 0.7	.0461 } F^{49}_{49} = 14.8 (1.6)
1948-1979	D(TAXF)	.0007(.0019), t = 0.3	.0106
"	D(GF)	.0027(.0024), t = 1.1	.0134 } F^{31}_{31} = 1.6 (1.8)
"	D(TAXT)	.0024(.0017), t = 1.4	.0097
"	D(GT)	.0044(.0026), t = 1.7	.0145 } F^{31}_{31} = 2.2 (1.8)

Notes: Dependent variables are the first differences of tax and spending ratios, as defined in Table 1. The 5% critical level is 2.0 for the t-ratios that are shown for the estimated drift coefficients. For the sample standard deviations, the F-ratios are the square of the value for spending divided by that for taxes. (These values are appropriate if the innovations to taxes and spending are independent.) 5% critical values for the hypothesis of equal variances are noted in parentheses.

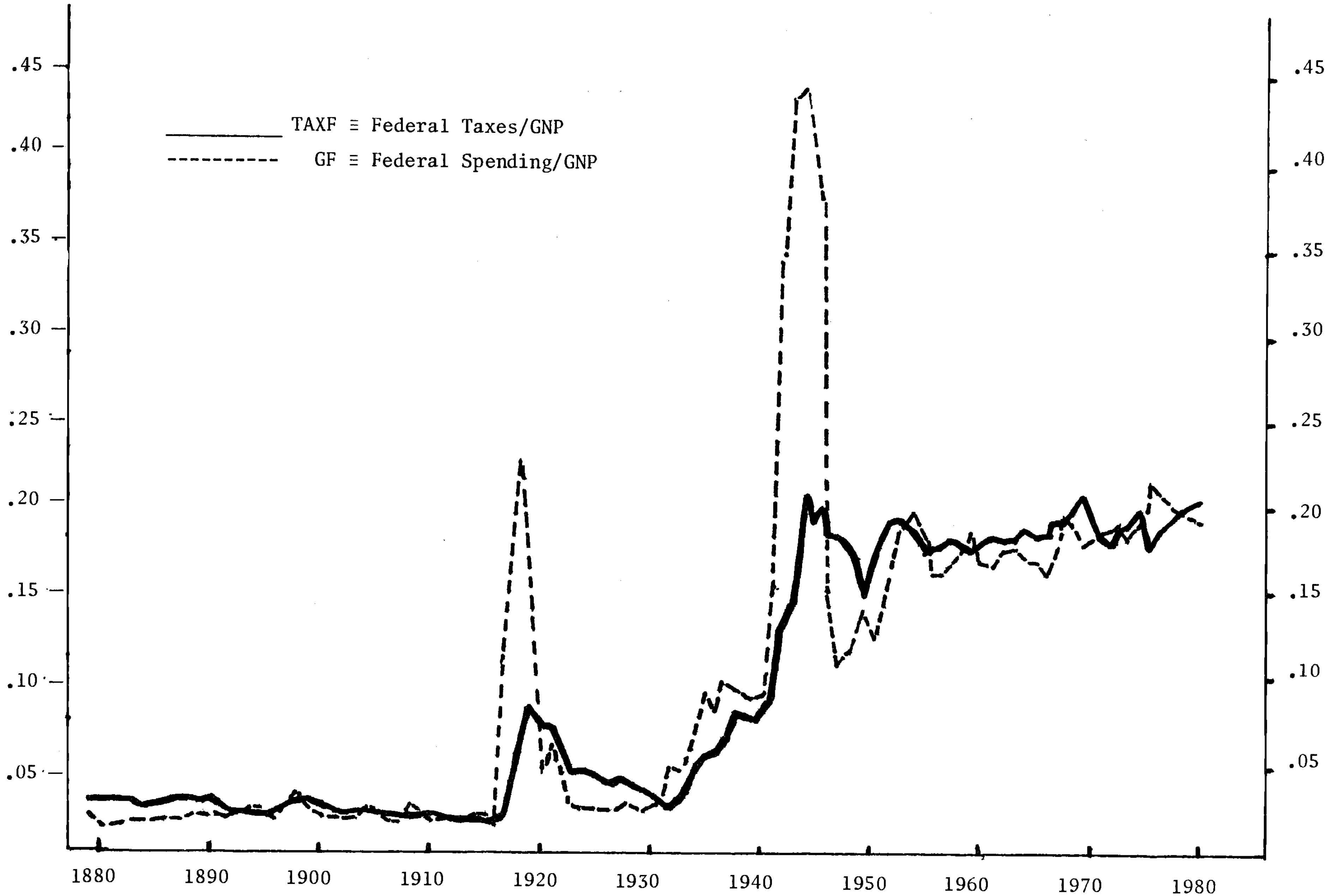

Figure 1

Federal Tax and Expenditure Ratios, 1879-1979 is .0019, s.e. = .0012 (t = 1.6), while that for 1930-1979 is .0034, s.e. = .0020 (t = 1.7). For the post-World War II period (1948-1979), the situation is reversed--the spending variable exhibits a larger estimated coefficient and t-ratio than the corresponding tax variable. For the federal spending ratio, the estimated drift coefficient is .0027, s.e. = .0024 (t = 1.1), while that for the tax ratio is .0007, s.e. = 0019 (t = 0.3).

When the total government sector is substituted for the federal government, there is a greater indication of drift in the spending and tax ratios. (See Figure 2--note that data have been obtained for total government variables only since 1929.) The estimated coefficient for tax-rate changes over the 1930-79 sample, .0043, s.e. = .0017, is significant at the 5% level. The point estimate for changes in the spending ratio, .0043, is the same, but the standard error, .0065, greatly exceeds that for tax-rate changes. Estimated drift coefficients for 1948-79--.0044, s.e. = .0026 for spending and .0024, s.e. = .0017 for taxes--are higher than those found for the federal government, but again insignificantly different from zero at the 5% level.

Except for some weak indication from the post-World War II sample, the results do not support the view that a drift in the government spending ratio over some period would be smoothed out (through the use of debt policy) and not appear in the tax ratio. On the other hand, the findings for the federal government are consistent--at conventional significance levels--with the absence of drift in both spending and tax ratios. The historical rise in these ratios, as shown in Figure 1, is not necessarily an indication of systematic trends. Even for the total government sector over the 1930-79

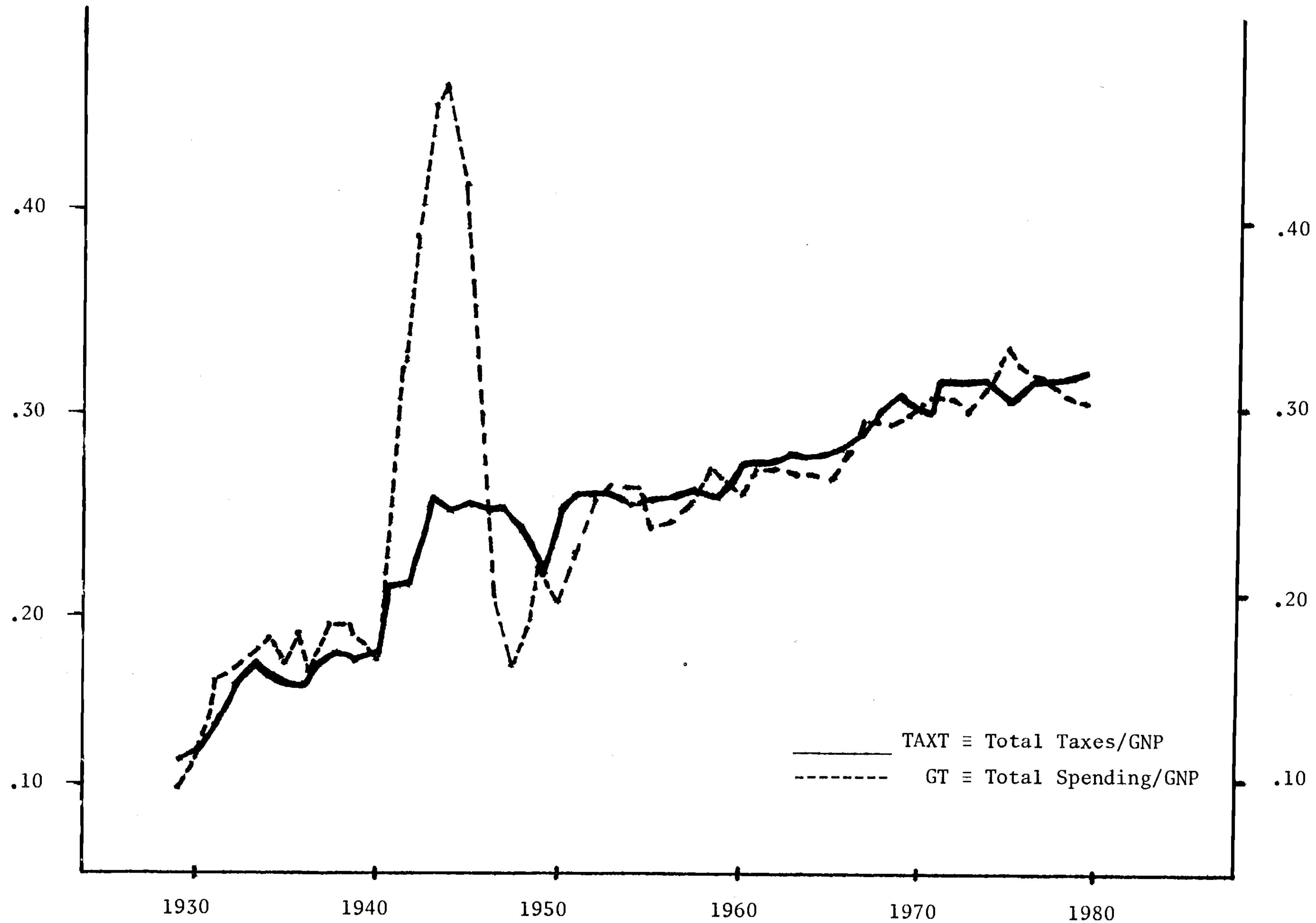

Figure 2

Total Government Tax and Expenditures Ratios, 1929-1979 period, there is only a weak indication of drift. Restrictions on constant terms are reconsidered below as parts of joint hypotheses with other coefficients.

Results from Univariate Autoregressions

Table 3 reports results for OLS regressions that include a constant and four annual lags of the dependent variable. The form of these equations is

$$(4) \quad DZ_t = \alpha_0 + \alpha_1 DZ_{t-1} + \alpha_2 DZ_{t-2} + \alpha_3 DZ_{t-3} + \alpha_4 DZ_{t-4} + \text{error term},$$

where Z represents either TAXF or GF. The sample periods and dependent variables coincide with those just discussed. The regressions were run also with first lags deleted and with the coefficients of the four lags constrained to equal those shown in equation (3). For each sample and choice of dependent variable, Table 3 reports the following:

1) the F-ratio for the hypothesis that the coefficients of the four lagged dependent variables are all zero, but where the constant is unrestricted, $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$;

2) the F-ratio when the hypothesis of a zero constant, $\alpha_0 = 0$, is added;

3) the unrestricted point estimate and standard error for the first lag coefficient, α_1 (the full regression results are shown in appendix Table A1);

4) for the case where the first lag of the dependent variable is omitted, the F-ratios for zero coefficients on lags 2-4, $\alpha_2 = \alpha_3 = \alpha_4 = 0$, with the constant first unrestricted and then set to zero; and

5) F-ratios for the hypothesis shown in equation (3), $\alpha_1 = .29$, $\alpha_2 = -.08$, $\alpha_3 = .02$, $\alpha_4 = -.01$, with the constant first unrestricted and then set to zero.

From the perspective of testing the random-walk model with time-averaged data, the F-ratios listed under (5) are of most interest. Those listed under (4) also constitute a valid test of the theory. The constraints shown under (1) and (2) are not implications of the underlying random-walk model.

With the change in the federal spending ratio, D(GF), used as the dependent variable and for the longer samples, 1884-1979 and 1930-1979, the hypothesis from equation (3), $\alpha_1 = .29$, $\alpha_2 = -.08$, $\alpha_3 = .02$, $\alpha_4 = -.01$, is rejected at the 5% level. With the constant unrestricted and 5% critical values shown in parentheses, the results are $F^4_{91} = 3.9$ (2.5) for the 1884-1979 period and $F^4_{45} = 2.7$ (2.6) for the 1930-79 sample. With the constant set to zero, the corresponding results are $F^5_{91} = 3.1$ (2.3) and $F^5_{45} = 2.2$ (2.4). The last statistic is just below the 5% critical level. Overall, there is indication from the longer samples that the past history of changes in the federal spending ratio has some predictive power for future changes. Over the 1948-79 sample, the random-walk hypothesis would be accepted for the federal spending ratio--the result is $F^4_{27} = 1.3$ (2.7) with the constant unrestricted and $F^5_{27} = 1.2$ (2.6) with the constant set to zero.

For the tax-rate change, D(TAXF), the random-walk model from equation (3) is accepted over all samples. With the constant unrestricted, the hypothesis, $\alpha_1 = .29$, $\alpha_2 = -.08$, $\alpha_3 = .02$, $\alpha_4 = -.01$, corresponds to statistics of F^4_{91} = 1.3 (2.5) for the 1884-1979 sample, F^4_{45} = 0.8 (2.6) for the 1930-79 period, and F^4_{27} = 1.7 (2.7) for the 1948-79 sample. With a zero constant included in the null hypothesis, the corresponding statistics are F^5_{91} = 1.4 (2.3), F^5_{45} = 1.0 (2.4), and F^5_{27} = 1.4 (2.6). In all cases one accepts the hypothesis that the past history of changes in the federal tax-GNP ratio has no predictive value for subsequent changes.

The results of another valid test of the random-walk model--$\alpha_2 = \alpha_3 = \alpha_4 = 0$, with the first lag value omitted--are shown also in Table 3. The conclusions correspond to those just discussed--rejection for the D(GF) variable over the 1884-1979 and 1930-79 samples, but acceptance for D(GF) over the 1948-79 period and for the D(TAXF) variable over all samples.

It may be worth noting the pattern of estimated coefficients for the 1948-79 sample when D(TAXF) is the dependent variable. As indicated in Table A1 of the appendix for the case where the first lag of D(TAXF) is omitted, these estimates and standard errors are -.37(.17) for $D(TAXF)_{t-2}$, -.22(.17) for $D(TAXF)_{t-3}$ and -.20(.17) for $D(TAXF)_{t-4}$. This pattern of negative coefficients on past tax-rate changes would be predicted by a model that specified a target level of tax rates. In this case, shifts in tax rates would tend to be reversed later. Although the pattern of estimated coefficients is suggestive of this mechanism, the insignificant F-values imply that the post-World War II data are also consistent with the random-walk model for tax rates. The F-values for the case where the first lag of D(TAXF) is deleted are (from Table 3) F^3_{28} = 2.2 (5% critical value = 3.0) with the constant unrestricted and F^4_{28} = 1.7(2.7) with the constant constrained to zero.

Table 3

Univariate Autoregressions

Sample	Dependent Variable	Test: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$		$\hat{\alpha}_1$	Test: $\alpha_2 = \alpha_3 = \alpha_4 = 0$ First lag omitted		Test: $\alpha_1 = .29$, $\alpha_2 = -.08$, $\alpha_3 = .02$, $\alpha_4 = -.01$	
		α_0 Unrestricted	$\alpha_0 = 0$		α_0 Unrestricted	$\alpha_0 = 0$	α_0 Unrestricted	$\alpha_0 = 0$
1884-1979	D(TAXF)	$F^4_{91} = 2.1(2.5)$	$F^5_{91} = 2.2(2.3)$	.22(.10)	$F^3_{92} = 1.3(2.7)$	$F^4_{92} = 1.6(2.5)$	$F^4_{91} = 1.3(2.5)$	$F^5_{91} = 1.4(2.3)$
"	D(GF)	" 9.3	" 7.5	.44(.10)	" 5.1	" 3.9	" 3.9	" 3.1
1930-1979	D(TAXF)	$F^4_{45} = 0.8(2.6)$	$F^5_{45} = 1.2(2.4)$	.18(.15)	$F^3_{46} = 0.6(2.8)$	$F^4_{46} = 1.2(2.6)$	$F^4_{45} = 0.8(2.6)$	$F^5_{45} = 1.0(2.4)$
"	D(GF)	" 5.9	" 4.8	.44(.15)	" 4.2	" 3.2	" 2.7	" 2.2
1934-1979	D(TAXT)	$F^4_{41} = 0.8(2.6)$	$F^5_{41} = 1.4(2.4)$	-.12(.15)	$F^3_{42} = 0.9(2.8)$	$F^4_{42} = 1.6(2.6)$	$F^4_{41} = 2.5(2.6)$	$F^5_{41} = 2.4(2.4)$
"	D(GT)	" 4.4	" 3.6	.38(.15)	" 3.4	" 2.6	" 2.0	" 1.6
1948-1979	D(TAXF)	$F^4_{27} = 1.6(2.7)$	$F^5_{27} = 1.3(2.6)$	-.07(.19)	$F^3_{28} = 2.2(3.0)$	$F^4_{28} = 1.7(2.7)$	$F^4_{27} = 1.7(2.7)$	$F^5_{27} = 1.4(2.6)$
"	D(GF)	" 1.4	" 1.4	.15(.19)	" 1.6	" 1.5	" 1.3	" 1.2
"	D(TAXT)	" 1.3	" 1.5	-.05(.19)	" 1.8	" 1.9	" 1.5	" 1.5
"	D(GT)	" 1.8	" 2.1	.10(.19)	" 2.4	" 2.6	" 1.9	" 1.8

Notes: Autoregressions use the indicated dependent variable, with a constant and four annual own lags as right-side variables. The form is shown in equation (4). F-statistics apply to the hypotheses listed in the heading. 5% critical values are shown in parentheses. α_0 is the coefficient of the constant term.

Table 3 indicates also the statistics for tests of the hypothesis, $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$. The F-values for the D(GF) variable over the longer samples are substantially greater than before--for example, $F^4_{91} = 9.3$ applies to the 1884-1979 period when the constant is unrestricted. The statistics for the D(TAXF) variable remain below the 5% critical levels, although the F-values obtained from the 1884-1979 sample are larger than those found in tests of the other hypotheses. In any event the previous discussion demonstrated that $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ is not an implication of the underlying random-walk model.

Overall, the evidence from the longer samples supports the idea that tax rates are set so as to smooth out predictable movements in federal spending relative to GNP. The significant F-values for the D(GF) variable in tests of equation (3) indicate that some smoothable variations in the federal spending ratio have been isolated. For the 1948-79 period, the lack of predictive power from the own past history is accepted for both the tax and spending ratios. This finding is consistent with the underlying theory--however, the results are less interesting in that no smoothable movements in D(GF) were detected.

The results for the total government sector (for 1934-79 and 1948-79 samples) are basically similar to those just described. The main difference is that the F-value for the case of the spending ratio over the 1934-79 sample is somewhat smaller than that found for the federal spending ratio over the 1930-79 period.

Results from Vector Autoregressions

The variables selected for vector autoregressions were those that seemed promising, a priori, as predictors for tax-rate changes. The two types of variables considered were those that pertained to the evolution of government spending and those that related to aggregate output fluctuations.[6] The ratio of federal spending to GNP, as discussed before, is one of the included variables. A measure of the persistence of these expenditure changes is likely to be important for tax rate determination--in particular, tax rates should respond strongly and contemporaneously to spending changes that are viewed as largely permanent. Some previous analysis (Barro, 1981) isolated a war-intensity variable as a good indicator of the temporary nature of the accompanying changes in defense spending. This variable, which is defined for war years as the concurrent U.S. casualty rate (CAS), is included in the vector autoregressions. (See Table 1 for a definition and tabulation.) I have not found any other variables that signal the duration of changes in government spending.

The growth rate of real GNP, DY, is included as a business cycle-type variable. The real rate of return on equity, r,[7] has also been used, primarily because it functions as a good predictor for subsequent values of DY. Together, the DY and r variables provide some predictive value for subsequent growth rates of output. Therefore, these variables would be likely to pick up any systematic "cyclical" patterns in tax rates. See Table 1 for a listing of the DY and r variables.

I have not attempted to include any political variables, such as the proclamation of a tax "surcharge" for 1968, the announcement of a "one-time tax rebate" for 1975, or Reagan's promise during 1980 to cut tax rates for 1981 and later years. The issue is whether these pronouncements have any information content--holding fixed the other included variables--for subsequent changes in overall tax rates. It is unclear how to quantify these types of announcement variables over the full sample in order to test for their predictive value.

Four annual lags of each variable have been included in the vector autoregressions. The previous discussion of time-averaging indicates the difficulty in interpretation for first-lag values. As mentioned, the random-walk model does not generally predict own-lag coefficients as shown in equation (3) or zero values for the coefficients of other variables. Since coefficient hypotheses in representations that include first-lag values are sensitive to the detailed specification for all variables--on which the theory provides no guidance--it seems best to focus on settings in which the first lags are omitted. For this case, with the tax-rate change as the dependent variable, the random-walk model predicts zero coefficients for all independent variables. Clearly, the interest in these tests is heightened if some predictive power remains for changes in the federal spending ratio and output growth, even when all first lags are eliminated.

Results are presented for 1930-79 and 1948-79 samples. (The r variable was unavailable before 1926, although some satisfactory approximations can probably be generated from available stock price indices and dividend data. Since the quality of real GNP data also deteriorate before 1929, it may not pay to extend the sample much before 1930.)

The format of Tables 4-7 is as follows:

1) The presence or absence of first-lag variables and the sample period are indicated.

2) The dependent variable for each regression is shown in the first column.

3) F-statistics and 5% critical values are shown for the hypothesis that the coefficients of all lagged variables are zero--for the case of the D(TAXF) and D(GF) variables, the F-ratio is shown also when the hypothesis of a zero constant is added.

4) F-values are indicated for the hypothesis of zero values for all lags of one variable--D(TAXF), D(GF), CAS, DY, or r--with no restrictions imposed on the coefficients of the other variables; the full regression results with D(TAXF) and D(GF) as dependent variables are shown in Table A2 of the appendix.

Consider first the results for the 1930-79 sample when first lags of all variables are excluded (Table 4). For the federal tax-rate change, D(TAXF) in line 1, the hypothesis that all lagged coefficients equal zero corresponds to a statistic, $F^{15}_{34} = 1.3$ (5% critical value = 2.0) when the constant is unrestricted, and $F^{16}_{34} = 1.4$ (2.0) with the constant set to zero. Therefore, the hypothesis is accepted that tax-rate changes, $D(TAXF)_t \equiv (TAXF_t - TAXF_{t-1})$, are unpredictable, based on the information contained in lagged values up to date t-2 for the five variables considered. The F-values are also below the 5% critical level for each variable considered separately. The largest value, $F^{3}_{34} = 2.6$ (2.9), arises for the lags of the equity return, r.

A parallel hypothesis for changes in the federal spending ratio, $D(GF)_t$ in line 2, is rejected. The hypothesis of zero coefficients for lagged values up to date t-2 corresponds to a statistic, $F^{15}_{34} = 4.2$ (2.0), when the constant is unrestricted, and $F^{16}_{34} = 4.4$ (2.0) with the constant set to zero. The individual F-values indicate separate significance only for the lags of the wartime intensity variable, CAS, where the statistic is $F^{3}_{34} = 6.2$ (2.9). This result reflects the predictable effect of war on subsequent changes in federal spending (which is negative, because of the temporary nature of war[8]). The insignificance of the CAS variable in the D(TAXF) equation indicates that this predictable influence on spending does not carry over to a foreseeable movement in tax rates. Deficit spending during wars allows for the smoothing of tax rates.

The distinction between spending and tax behavior does not hinge entirely on the war variable. With the lags of the CAS variable deleted, the lags of the remaining four variables are jointly significant for D(GF)--the statistic is $F^{12}_{37} = 2.8$ (2.0). These variables are still jointly insignificant for D(TAXF), where the statistic is $F^{12}_{37} = 1.3$.

The results for output growth, DY in line 4 of Table 4, indicate some explanatory power even with first lags of all variables omitted. The statistic for zero coefficients on all lagged variables (with no restriction on the constant) is $F^{15}_{34} = 2.4$ (2.0). For individual variables, there is significance for the lags of DY, r and CAS--the respective statistics for F^{3}_{34} (5% critical value = 2.9) are 4.3, 4.1 and 4.0. Therefore, the equation for tax-rate changes could have picked up a systematic response to business fluctuations--that is, to the expectation that output was currently high or low relative to "normal" (with allowance for drift in the level of output). To this extent, the findings rule out an important cyclical pattern of the federal tax-GNP ratio.[9]

The independent variables are jointly significant when CAS is used as the dependent variable (F^{15}_{34} = 15.2 (2.0) in line 3 of the table).[10] The main role is played by the lags of CAS and D(GF) (F^{3}_{34} = 23.8 (2.9) and 22.6, respectively). The variables considered lack explanatory power for future values of the real rate of return on equity, r (line 5).

Table 5 contains regression results in the same form for the 1948-79 sample. The conclusions on the tax-rate variable, D(TAXF) in line 1, are similar to those just described. That is, the hypothesis of unpredictability for tax-rate changes is again accepted. However, significant predictive power no longer obtains for future changes in the federal spending ratio--the statistics (line 2) are F^{15}_{16} = 1.9 (2.4) with the constant unrestricted and F^{16}_{16} = 2.1 (1.9) with the constant set to zero. These statistics are just below the 5% critical values. The individual F-values indicate that the most important change from the previous results is the loss in predictive power for the lags of the CAS variable. This change reflects the elimination of the World War II years from the sample. In any case, since no smoothable variations in the federal spending ratio were isolated, the absence of predictability for tax-rate changes over the 1948-79 period does not provide strong support for the theory.

The equation for output growth (line 4 of Table 5) also indicates lack of explanatory power over the 1948-79 sample, as indicated by the statistic, F^{15}_{16} = 0.6 (2.4). With lagged values incorporated only up to date t-2, the present set of variables does not identify situations where

Table 4

Vector Autoregressions, 1930-79 Samples, Lags 2-4 Included

Dependent Variable	Overall F		Individual F's d.f.: (3, 34) (5% value = 2.9)				
	Constant = 0 d.f.: (16, 34) 5% value = 2.0	Constant Unrestricted d.f.: (15, 34) 5% value = 2.0	D(TAXF)	D(GF)	CAS	DY	r
(1) D(TAXF)	1.4	1.3	0.0	0.8	1.1	1.6	2.6
(2) D(GF)	4.4	4.2	0.5	1.3	6.2	1.2	0.9
(3) DY		2.4	1.3	1.5	4.3	4.1	4.0
(4) CAS		15.2	2.8	22.6	23.8	1.4	0.0
(5) r		0.9	0.6	1.2	0.1	1.0	1.1

Notes to Tables 4-7: Results apply to OLS vector autoregressions with the dependent variable listed in the first column. Independent variables are a constant and lagged values up to t-4 of the five variables, D(TAXF), D(GF), CAS, DY, and r. Variables are defined and tabulated in Table 1. Regressions in Tables 4 and 5 delete the (t-1) lag values. Overall F applies to a test for zero coefficients on all of the lagged variables. For the D(TAXF) and D(GFED) variables in rows 1 and 2, the F-value is indicated also with the constant set to zero. Individual F's apply to a test for zero coefficients on the lags of the one variable indicated. d.f. is the degrees of freedom for the F ratio.

subsequent output growth would be expected to depart from the normal drift. In this sense the results also would not detect predictable tax-rate changes that were associated with anticipated movements in output.

Finally, the results over the 1948-79 period do reveal some explanatory power for future values of the war-intensity variable, CAS (line 3), but none for r (line 5).

Results that include the first lags of all variables are shown in Table 6 for the 1930-79 period and in Table 7 for the 1948-79 period. The addition of first lags raises the F-ratios over both samples when the dependent variable is D(TAXF), D(GF) or DY.[11] For the 1930-79 period, the statistics for the D(TAXF) variable are now $F_{29}^{20} = 2.5$ (1.9) with no restriction on the constant, and $F_{29}^{21} = 2.6$ (1.9) with the constant set to zero. Comparable results for the D(GF) variable are $F_{29}^{20} = 9.7$ (1.9) and $F_{29}^{21} = 9.3$ (1.9). For the DY variable, the result (with no constraint on the constant) is $F_{29}^{20} = 10.2$ (1.9). The individual statistics indicate the separate significance of CAS and D(GF) for the D(TAXF) variable; of CAS and D(TAXF) for the D(GF) variable; and of r, CAS and DY for the DY variable.

If the time-averaging problem had been ignored, these results would have indicated substantial predictive power from the included independent variables for future changes in the federal spending ratio and output. The explanatory power would have been viewed as much reduced, but still significant, for the federal tax-rate change. This interpretation is unclear because the

Table 5

Vector Autoregressions, 1948-79 Samples, Lags 2-4 Included

Dependent Variable	Overall F		Individual F's d.f.: (3, 16) (5% value = 3.2)				
	Constant = 0 d.f.: (16, 16) 5% value = 2.3	Constant Unrestricted d.f.: (15, 16) 5% value = 2.4	D(TAXF)	D(GF)	CAS	DY	r
(1) D(TAXF)	1.6	1.7	1.6	0.2	0.2	0.0	0.4
(2) D(GF)	1.9	1.9	2.9	0.3	0.7	1.0	0.9
(3) DY		0.6	0.9	0.1	0.4	0.2	0.9
(4) CAS		5.1	7.0	5.7	4.2	4.9	0.9
(5) r		1.2	0.9	1.9	0.9	0.3	1.0

time-averaging of data--in conjunction with some contemporaneous correlation of tax-rate changes with the D(GF) or other variables--could account for the apparent predictability of tax-rate changes when first lags of variables are introduced. (The results with D(GF) and DY as dependent variables would also be affected.) Similar observations apply to the results for the 1948-79 period with first lags of variables included, as shown in Table 7. (However, with D(TAXF) or D(GF) as the dependent variable, the F-statistics are now just below the 5% critical values.)

Inclusion of the Tax on Cash Balances

The analysis has been redone with taxes defined to include the inflation tax on holdings of high-powered money.[12] This levy was measured as R•H, where R is the annual average of the 4- to 6-month commercial paper rate and H is the annual average of high-powered money (total currency outside the U.S. Treasury plus reserves held by commercial banks at the Federal Reserve). The values of R•H are shown relative to nominal GNP in Table 1. Quantitatively, the inclusion of this tax component has a small impact on calculated overall tax rates, with the largest effects in terms of percentage points occurring since the rise in interest rates in the late 1960s.[13] For example, the federal tax rate is raised in 1969 form .207 to .214, in 1974 from .200 to .208, and in 1979 from .206 to .213.

This change in the definition of tax rates does not alter the general nature of the results that have been reported earlier. In terms of Tables 4-7, the main change is a small reduction in the F-values when D(TAXF) is used as the dependent variable.

Table 6

Vector Autoregressions, 1930-79 Samples, Lags 1-4 Included

Dependent Variable	Overall F		Individual F's d.f.: (4, 29) (5% value = 2.7)				
	Constant = 0 d.f.: (21, 29) 5% value = 1.9	Constant Unrestricted d.f.: (20,29) 5% value = 1.9	D(TAXF)	D(GF)	CAS	DY	r
(1) D(TAXF)	2.6	2.5	1.9	3.3	5.1	0.7	1.1
(2) D(GF)	9.3	9.7	5.2	1.5	7.3	1.3	2.1
(3) DY		10.2	1.8	2.6	12.8	8.1	18.2
(4) CAS		12.8	3.9	9.5	10.9	0.4	0.1
(5) r		0.6	0.2	0.8	0.1	0.6	0.5

Table 7

Vector Autoregressions, 1948-79 Samples, Lags 1-4 Included

Dependent Variable	Overall F		Individual F's d.f.: (4, 11) (5% value = 3.4)				
	Constant = 0 d.f.: (21, 11) 5% value = 2.6	Constant Unrestricted d.f.: (20,11) 5% value = 2.6	D(TAXF)	D(GF)	CAS	DY	r
(1) D(TAXF)	2.3	2.4	1.0	0.5	0.5	0.0	0.6
(2) D(GF)	2.5	2.4	1.4	0.6	1.5	0.5	1.8
(3) DY		2.7	0.6	0.5	0.4	0.9	4.0
(4) CAS		8.7	1.1	4.3	6.5	2.0	1.3
(5) r		0.8	0.5	0.7	0.7	0.3	0.6

Results with Total Taxes and Spending

The conclusions from the vector autoregressions are not greatly modified if federal taxes and spending are replaced by total government measures. Because of data limitations, the 1930-79 sample is now replaced by 1934-79. The findings for 1934-79 show first, no predictability for changes in tax rates when first lags of variables are excluded ($F^{15}_{30} = 1.5$); second, significant explanatory power in this setting for changes in total spending relative to GNP ($F^{15}_{30} = 4.6$); third, significance for tax-rate changes when first lags are included ($F^{20}_{25} = 2.9$); and fourth, a much larger F-value in this case for changes in the spending ratio ($F^{20}_{25} = 8.1$). The results over the 1948-79 sample are also similar to those discussed previously for the federal government.

The Volatility of Tax and Spending Ratios

The underlying theory implies that tax-rate movements would smooth out predictable variations in the ratio of government spending to income. In this respect the model is reminiscent of interest-rate term-structure models, where the long rate is supposed to smooth out predictable movements in short rates. Shiller (1979, 1980) has used such models to generate propositions that concern the relative volatility of variables--for example, the variance of changes in long-term interest rates should be smaller than that of short rates. The parallel proposition here would be an excess of the variance of changes in spending ratios over that for changes in tax rates.

The sample standard deviations (about sample means), $\hat{\sigma}$, for changes in spending and tax ratios are shown over various periods in Table 2. The

$\hat{\sigma}$-values are higher for the spending ratios in all cases. For the 1884-1979 sample, the results are $\hat{\sigma}_{D(GF)} = .0402$ and $\hat{\sigma}_{D(TAXF)} = .0116$. Over the 1930-79 sample, the comparable values are .0487 and .0140. When total government measures are used, the results over the 1930-79 period are .0461 versus .0120.

For the 1948-79 period, the spending ratios are far more stable and the differences in $\hat{\sigma}$-values are less dramatic. The values are .0134 for D(GF) and .0106 for D(TAXF). Corresponding figures for total government are .0145 and .0097.

The greater volatility in spending ratios than in tax ratios supports the underlying view of tax-smoothing. However, it is clear that a smaller variance for changes in tax ratios than for changes in spending ratios does not, per se, rule out a pattern of predictable movements in tax rates. Therefore, the volatility tests should be viewed as supplementary to the tests that have been carried out earlier.

Concluding Observations

The present evidence is generally supportive of the tax-rate smoothing model of intertemporal public finance. Valid tests of the random-walk model for aggregate federal and total government tax rates led to acceptance at conventional significance levels.[14] In some cases parallel hypotheses for the ratio of government spending to GNP and for output were rejected. Therefore, the analytical procedure was capable of detecting systematic movements of tax rates that mimicked predictable changes in government spending and aggregate output. The volatility tests for taxes versus government spending were also consistent with the tax-rate-smoothing viewpoint.

Given the limitation to annual data and the necessity of deleting first lags in the vector autoregressions, the approach can miss predictable patterns in overall tax rates that apply to short time intervals. For example, if a change occurs that would induce a permanent shift in tax rates, but adjustment-cost considerations dictate postponing the effective date for tax law changes until the following calendar year, then tax rates would be perceived for some portion of a year as high or low relative to expected long-run values. The tests that delete first-lag values would not pick up this relationship. However, the results from the univariate autoregressions do rule out simple, statistically significant patterns of association for overall tax-rate changes from one year to the next.

From the viewpoint of intertemporal substitution effects, the important relation concerns current tax rates relative to anticipated future rates. For example, an expectation of rising tax rates on labor earnings would generate a positive substitution effect on current labor supply. Similarly, anticipations about future changes in the investment tax credit have been emphasized as a source of intertemporal substitution effects on investment demand (Kydland and Prescott, 1977, pp. 482-86). The present techniques and explanatory variables were incapable of identifying situations where current overall tax rates for the federal or total government sector were temporarily significantly above or below their long-run expected values. If this finding is sustained in more general circumstances, it suggests that existing aggregate time series observations will not be useful in assessing how responsive the economy would be to overall taxes that are perceived as temporarily high or low. The necessary experiment seems not to have been carried out. Policies that involve intertemporal manipulation of aggregate tax rates probably cannot be evaluated with the available data.

Footnotes

[1]Atkinson and Stiglitz (1980, Chapter 12) discuss the limitations of the analysis that focuses on own-elasticities. They also present some more general treatments of the optimal tax problem. Conditions for the optimality of uniform taxation are presented in Sandmo (1974) and Sadka (1977). The difficulty in using these results arises in assessing the quantitative significance of deviations from the precise conditions for ensuring that uniform taxation is optimal.

[2]The theory applies to government spending net of interest payments. The interest payments are determined from the initial debt and the time path of deficits, given the time path of interest rates.

[3]Mobility across governmental jurisdictions may limit the possibilities for a tax-rate-smoothing debt policy--see Benjamin and Kochin (1978). Therefore, the model may fit better for the federal government than for state and local governments. However, the federal government can set a debt policy to smooth total tax rates, rather than federal rates. In this case, the model would apply to total government tax rates.

[4]It also affects Hall's (1978) analysis of consumption, although the problem was not considered there.

[5]A negative coefficient for $D\bar{\tau}_{t-1}$ arises if $|\rho| > \sqrt{2/3}$. The coefficient cannot fall below -1/5, which is attained when $|\rho| = 1$.

[6]I examined also lagged values of public debt expressed relative to GNP. These variables were unimportant for explaining changes in the tax and spending ratios.

[7]The dollar rate of return for each year is the value-weighted total return for all New York Stock Exchange issues, as compiled by the University of Chicago's Center for Research on Security Prices. An inflation rate is subtracted to determine the real rate of return. From 1948 to 1979 the inflation rate is calculated from the seasonally-unadjusted December value of the consumer price index for an urban consumer, measured exclusive of the shelter component. (Shelter was deleted in order to avoid the erroneous measures of mortgage interest costs. For the 1967-79 period, where the CPI net of mortgage interest costs is available, there was a close correspondence between the inflation rate measured net of shelter and that measured net only of mortgage interest costs.) Before 1948 the overall CPI for an urban consumer was used.

[8]The estimated coefficient of CAS_{t-2} in the equation for $D(GF)_t$ is -.23, s.e. = .05. See Table A2.

[9]My previous results on the cyclical behavior of public debt (Barro, 1979, pp. 963, ff.) were based on the relation of current real GNP to an estimated time trend. That analysis should be revised to utilize a measure of current real GNP relative to predicted future values. The temporary federal spending variable from that analysis should be similarly recomputed.

[10]Since CAS $\geq$ 0 applies, the linear specification for this variable is inappropriate. However, the only purpose of this equation is to indicate the significant explanatory value of the lagged variables.

[11]The F-value for CAS remains significant, while that for r is again insignificant.

[12]GNP was retained as the tax base, although the inclusion of "monetary services" would be a possibility.

[13]The proportionate effects are greater in some earlier periods--for example, in 1929, where R = .058 applies, the federal tax rate is revised upward from .0368 to .0408.

[14]The one exception is the significant drift for the total government tax ratio over the 1930-79 period.

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Appendix I

Analysis of the Time-Aggregation Problem

Suppose that observations correspond to "years" as numbered by $t = 1, 2, \ldots$ Each year is composed of underlying segments, $i = 1, 2, \ldots, n$. The basic model dictates a random walk for a variable τ at these underlying time units:

$$\text{(A1)} \qquad \tau_{ti} = \tau_{t,i-1} + u_{ti},$$

for all t and $i = 1, \ldots n$, where $\tau_{t,0} \equiv \tau_{t-1,n}$. The disturbance u_{ti} is i.i.d. with zero mean. The distribution of u_t is assumed to be normal in some of the discussion.

The time-averaged observation for period t is

$$\text{(A2)} \qquad \bar{\tau}_t \equiv \frac{1}{n}\sum_{i=1}^{n} \tau_{ti}.$$

Using equation (A1), the first difference, $D\bar{\tau}_t \equiv \bar{\tau}_t - \bar{\tau}_{t-1}$, can be shown to equal

$$\text{(A3)} \qquad D\bar{\tau}_t = \frac{1}{n}\{[nu_{t,1} + (n-1)u_{t,2} + \ldots + u_{t,n}] + [u_{t-1,2} + 2u_{t-1,3} + \ldots + (n-1)u_{t-1,n}]\}.$$

That is, $D\bar{\tau}_t$ is a moving-average process, involving disturbances applicable to years t and $t-1$.

From equation (A3) it follows (as in Working (1960)) that the simple correlation between $D\bar{\tau}_t$ and $D\bar{\tau}_{t-1}$ is

$$\text{(A4)} \quad \text{CORR}(D\bar{\tau}_t, D\bar{\tau}_{t-1}) = \frac{\text{COV}(D\bar{\tau}_t, D\bar{\tau}_{t-1})}{\text{VAR}(D\bar{\tau}_t)} = \frac{(n^2-1)}{2(2n^2+1)}.$$

As the underlying interval becomes infinitesimal, $n \to \infty$ and

(A5) $$\lim_{n \to \infty} \text{CORR}(D\bar{\tau}_t, D\bar{\tau}_{t-1}) = 1/4.$$

It follows from inspection of equation (A3) that the simple correlation of $D\bar{\tau}_t$ with $D\bar{\tau}_{t-i}$, where $i \geq 2$, is zero. With $D\bar{\tau}_{t-1}$ omitted, $D\bar{\tau}_t$ is independent of the set of lagged variables, $D\bar{\tau}_{t-2}$, $D\bar{\tau}_{t-3}$, ...

Equation (A3) can be used also to evaluate a string of partial correlations involving $D\bar{\tau}_t$ and a set of lagged values $D\bar{\tau}_{t-i}$, where i = 1, 2, ... With four lags included, the pattern of partial correlations turns out to be 56/193 (.29), -15/193 (-.08), 4/193 (.02), and -2/193 (-.01).

Consider another time-averaged, random-walk variable in first-difference form,

(A6) $$D\bar{X}_t = \frac{1}{n}\{(nv_{t,1} + \ldots + v_{t,n}) + [v_{t-1,2} + \ldots + (n-1)v_{t-1,n}]\}.$$

The underlying interval length, as determined by n, coincides with that for τ. The disturbances, (u_{ti}, v_{ti}), are now treated as bivariate normal with zero mean, serial independence and contemporaneous correlation ρ.

It can be shown that the partial correlation of $D\bar{\tau}_t$ with $D\bar{X}_{t-1}$, given $D\bar{\tau}_t$, is zero. Similarly, given the string of lagged values, $D\bar{\tau}_{t-i}$, the partial correlation of $D\bar{\tau}_t$ with $D\bar{X}_{t-i}$ is zero.

Suppose now that X is observed directly, rather than in time-averaged form. The first difference is then

(A7) $$DX_t = v_{t,1} + \ldots + v_{t,n}.$$

Given that $(u_{t,i}, v_{t,i})$ are bivariate normal and taking the case where $n \to \infty$, the mean of $D\bar{\tau}_t$, conditioned on observations for $D\bar{\tau}_{t-1}$ and DX_{t-1}, can be shown (using the general formula for the conditional normal density from Graybill, 1961, p. 63) to be

$$E[D\bar{\tau}_t | D\bar{\tau}_{t-1}, DX_{t-1}] = \frac{1}{4}\left[\frac{1 - (3/2)\rho^2}{1 - (3/8)\rho^2}\right] D\bar{\tau}_{t-1}$$

(A8)

$$+ \frac{3}{8}\left(\rho\frac{\sigma_u}{\sigma_v}\right)\left[\frac{1}{1 - (3/8)\rho^2}\right] DX_{t-1}.$$

Recall that ρ is the correlation between u_{ti} (the τ-innovation) and v_{ti} (the X-innovation). σ_u and σ_v are the standard deviations for u_{ti} and v_{ti}, respectively. When $\rho = 0$ the coefficients in equation (A8) reduce to (1/4, 0). The coefficient of DX_{t-1} has the same sign as ρ. The coefficient of $D\bar{\tau}_{t-1}$ is positive if $\rho^2 < 2/3$--that is, if $|\rho| < .82$. Otherwise, the coefficient is negative. The magnitude of this coefficient is no greater than 1/4--the value approaches -1/5 as $|\rho| \to 1$.

Appendix II

Regression Results

Table A1

Univariate Autoregressions for Federal Taxes and Spending

(1) Dependent Variable	(2) Sample	(3) Constant	(4) Lag 1	(5) Lag 2	(6) Lag 3	(7) Lag 4	(8) R^2	(9) $\hat{\sigma}$
D(TAXF)	1884-1979	.0017(.0012)	.22(.10)	.08(.11)	-.18(.11)	-.02(.10)	.09	.011
"	"	.0020(.0012)		.13(.10)	-.16(.11)	-.06(.11)	.04	.011
D(GF)	"	.0021(.0035)	.44(.10)	-.30(.11)	-.03(.11)	-.22(.10)	.29	.035
"	"	.0029(.0039)		-.09(.11)	-.14(.12)	-.29(.11)	.14	.038
D(TAXF)	1884-1929	.0002(.0011)	.31(.15)	-.04(.16)	-.15(.16)	-.21(.15)	.21	.007
"	"	.0003(.0011)		.07(.15)	-.16(.16)	-.28(.15)	.13	.008
D(GF)	"	.0002(.0034)	.45(.15)	-.77(.15)	.29(.15)	-.37(.15)	.41	.023
"	"	.0003(.0037)		-.59(.16)	.04(.14)	-.30(.16)	.26	.025
D(TAXF)	1930-1979	.0031(.0021)	.18(.15)	.09(.15)	-.18(.15)	.01(.15)	.07	.014
"	"	.0036(.0021)		.12(.15)	-.17(.15)	-.02(.15)	.04	.014
D(GF)	"	.0039(.0059)	.44(.15)	-.12(.16)	-.18(.16)	-.20(.15)	.34	.041
"	"	.0053(.0063)		.09(.15)	-.23(.17)	-.33(.15)	.21	.045
D(TAXF)	1948-1979	.0004(.0018)	-.07(.19)	-.37(.18)	-.24(.18)	-.22(.18)	.19	.010
"	"	.0004(.0018)		-.37(.17)	-.22(.17)	-.20(.17)	.19	.010
D(GF)	"	.0020(.0024)	.15(.19)	-.05(.07)	-.10(.06)	.07(.06)	.17	.013
"	"	.0022(.0024)		-.02(.06)	-.11(.06)	.06(.06)	.15	.013

Notes: The dependent variable for each regression is noted in column 1 as either the first difference of TAXF or GF. See Table 1 for definitions of variables. Estimated coefficients and standard errors for the constant and four own lags are indicated in columns 3-7. $\hat{\sigma}$ is the standard error of estimate. F-statistics are shown in Table 3 of the text.

Table A2

Multivariate Autoregressions for Federal Taxes and Spending

Dependent Variable Sample	D(TAXF) 1930-79	D(TAXF) 1930-79	D(TAXF) 1948-79	D(TAXF) 1948-79	D(GF) 1930-79	D(GF) 1930-79	D(GF) 1948-79	D(GF) 1948-79
Constant	.004 (.003)	.007 (.003)	.001 (.006)	.001 (.005)	.012 (.006)	.015 (.008)	.005 (.007)	-.003 (.007)
$D(TAXF)_{t-1}$	.02 (.21)	--	-.61 (.38)	--	1.70 (.44)	--	-.21 (.47)	--
" $t-2$	-.66 (.26)	-.06 (.22)	-.46 (.38)	-.43 (.35)	-.23 (.53)	.15 (.55)	-.84 (.47)	-.27 (.42)
" $t-3$	-.09 (.23)	.06 (.24)	-.41 (.32)	-.52 (.29)	-.05 (.48)	-.60 (.61)	-.43 (.40)	-.63 (.35)
" $t-4$	.09 (.22)	-.04 (.24)	-.49 (.32)	-.31 (.28)	.48 (.46)	-.40 (.61)	-.69 (.40)	-.84 (.34)
$D(GF)_{t-1}$	.29 (.09)	--	.06 (.23)	--	.24 (.19)	--	.35 (.29)	--
" $t-2$	-.15 (.10)	-.13 (.10)	.19 (.17)	.12 (.18)	-.32 (.21)	.15 (.25)	.16 (.21)	.11 (.22)
" $t-3$	-.11 (.11)	.06 (.09)	-.06 (.15)	.00 (.14)	-.47 (.23)	-.26 (.23)	-.03 (.18)	-.13 (.18)
" $t-4$	.05 (.07)	-.02 (.07)	.08 (.11)	-.02 (.08)	.12 (.15)	.32 (.19)	.17 (.14)	.01 (.09)
CAS_{t-1}	.05 (.03)	--	.23 (.18)	--	.10 (.05)	--	.28 (.22)	--
" $t-2$	-.03 (.03)	-.02 (.02)	-.21 (.19)	.00 (.12)	-.22 (.06)	-.23 (.05)	.04 (.23)	.20 (.15)
" $t-3$	.10 (.03)	.03 (.02)	.10 (.13)	.08 (.13)	.19 (.06)	.12 (.06)	-.11 (.16)	-.15 (.16)
" $t-4$	-.10 (.03)	-.04 (.02)	-.03 (.07)	-.03 (.07)	-.20 (.06)	-.02 (.06)	.04 (.09)	.06 (.08)
DY_{t-1}	.07 (.07)	--	-.04 (.14)	--	.20 (.14)	--	.00 (.17)	--
" $t-2$	.06 (.07)	.16 (.07)	.02 (.15)	.03 (.14)	.01 (.14)	.23 (.18)	-.23 (.19)	-.22 (.17)
" $t-3$	-.07 (.07)	-.07 (.08)	.03 (.14)	.01 (.15)	-.18 (.14)	.06 (.20)	.01 (.18)	.17 (.18)
" $t-4$	.00 (.04)	-.02 (.05)	-.01 (.09)	.00 (.08)	-.05 (.09)	-.18 (.13)	.02 (.11)	.12 (.10)

(continued)

Table A2 (continued)

Multivariate Autoregressions for Federal Taxes and Spending

Dependent Variable Sample	D(TAXF) 1930-79	D(TAXF) 1930-79	D(TAXF) 1948-79	D(TAXF) 1948-79	D(GF) 1930-79	D(GF) 1930-79	D(GF) 1948-79	D(GF) 1948-79
r_{t-1}	.011(.009)	--	.015(.012)	--	-.03 (.02)	--	-.04 (.01)	--
" $_{t-2}$	-.015(.013)	-.01 (.01)	.009(.017)	-.01 (.01)	-.08 (.03)	-.04 (.03)	-.01 (.02)	.00 (.02)
" $_{t-3}$	-.007(.014)	-.04 (.01)	-.004(.021)	-.02 (.02)	.00 (.03)	-.03 (.04)	.05 (.03)	.04 (.02)
" $_{t-4}$	-.005(.014)	.00 (.02)	-.018(.019)	.00 (.02)	.02 (.03)	-.02 (.04)	-.01 (.02)	-.02 (.02)
R^2	.63	.36	.81	.61	.87	.66	.82	.64
$\hat{\sigma}$	.011	.013	.008	.009	.023	.034	.010	.011

Notes: The dependent variable is noted in the first row as either the first difference of TAXF or GF. Each column reports the array of estimated coefficients and standard errors for a single regression. The independent variables are a constant and four lags of D(TAXF), D(GF), CAS, DY, and r. See Table 1 for definitions of variables. $\hat{\sigma}$ is the standard error of estimate. F-statistics are shown in Tables 4-7 of the text.