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Are Tax Rates Too Volatile?

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I. Introduction

The way in which a government chooses to raise tax revenue over time has attracted considerable attention both in the tax literature, and the political business cycle literature. The tax literature has emphasized planning problems where the government chooses taxes and a path for government debt to minimize the excess burden of taxes over time (see Barro [2] and Lucas and Stokey [15]). Alternatively, political business cycle models focus on the fiscal policies pursued by incumbent governments to either improve their reelection prospects or to constrain the policies that future governments in power will pursue (see Alesina and Tabellini [1], Hess [11], Persson and Svensson [21], Rogoff and Sibert [23]).

This paper addresses the question of whether tax rates fluctuate "in excess" of movements in economic fundamentals. I consider, below, a simple theory of optimal taxation which implies that tax rates should follow a random walk. Under this null hypothesis, variance bounds on the intertemporal government budget constraint are derived. The methodology of evaluating these variance bounds corresponds to the stock market volatility literature pioneered by Leroy and Porter [13] and Shiller [28].

Using the methodology of Mankiw, Romer and Shapiro (hereafter M-R-S) [16; 17], these bounds are calculated for United States data from 1870–1989. There are two main benefits to using the M-R-S methodology. First, it uses non-central rather than central variances which eliminates the bias due to estimating the sample means. Second, the M-R-S methodology allows the forcing variables (government expenditures and seignorage) to be potentially non-stationary series. The inability of earlier volatility tests literature to allow for non-stationarity in the forcing variables was a considerable drawback.

It is found that broad movements in tax rates that correspond to relatively large permanent changes in government expenditures are adequately "smoothed". However, it appears that tax rates have been excessively volatile in the United States both in the time period before World War I and after World War II. This suggests that either governments in power have manipulated taxes to fulfill political objective or that the random walk theory of taxation is an over-simplification of optimal taxation.

The outline of the paper is as follows. Section II presents the simple linear-quadratic model

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of taxation and derives the inequality bounds for the volatility tests. Section III presents the calculation of the inequality bounds and discusses the results. In section IV, results from Monte Carlo simulations of the model, under a range of specifications, show the robustness of the empirical results. Section V explores both business cycle and political business cycle explanations for the excess volatility of taxes. I conclude in section VI.

II. The Linear-Quadratic Model

The linear-quadratic model of intertemporal taxation assumes there exists an infinitely lived Benevolent Social Planner (BSP) who chooses taxes to smooth over time the excess burden of taxation. The BSP chooses tax rates and a path for government debt to minimize the expected discounted value of tax distortions, subject to a sequence of budget constraints, an initial condition, and a transversality condition:

$$\min_{\{\tau_t, b_t\}} E_t\{\sum_{k=0}^{\infty} (a_1\tau_{t+k} + (a_2/2)\tau_{t+k}^2)\beta^k|I_t\} \tag{1}$$

$$b_t = R[g_t - \tau_t - s_t + b_{t-1}] \tag{2}$$

$$b_t > 0 \tag{3}$$

$$\lim_{k\to\infty} \beta^k b_{t+k} = 0 \tag{4}$$

where a_1 and $a_2 \leq 0$. τ_t, g_t, s_t and b_t are tax revenue, government expenditures, seignorage, and government debt outstanding at the end of time t, respectively, as ratios of national output. The time discount factor and the real interest rate factor are β and R, respectively. I_t is the information set available to the Benevolent social planner at time t. Among other things, I_t contains $\{g_j\}_{j=-\infty}^{t}$, $\{s_j\}_{j=-\infty}^{t}$ and b_{t-1}. Assuming $E[\beta R] \approx 1$, the sequence of optimality conditions is:

$$E_t\{\tau_{t+1}|I_t\} = \tau_t. \tag{5}$$

Expression (5) is the null hypothesis that tax rates should follow a random walk.[1] Bizer and Durlauf [4], and Sahasakul [24] have explored this relationship and have found it to be violated. In order to analyze the fundamental sources of this rejection, I consider the question of whether tax rates are too volatile as compared to the expected present value of the BSP's net obligations.

Substituting expression (2) forward and using expressions (3) and (4), the intertemporal government budget constraint is:

$$E_t\{\sum_{k=0}^{\infty} g_{t+k}\beta^k|I_t\} + b_{t-1} = E_t\{\sum_{k=0}^{\infty} s_{t+k}\beta^k|I_t\} + E_t\{\sum_{k=0}^{\infty} \tau_{t+k}\beta^k|I_t\}. \tag{6}$$

The left hand side of (6) is the present value of expected current and future government expenditures and the right hand side is the present value of expected current and future tax revenue.[2] Under the null hypothesis that tax rates are optimal, expression (5) is substituted into (6) to obtain

1. The random walk implication for optimal taxation also relies upon the assumption that the elasticity of output with respect to taxation is constant across time.

2. Hamilton and Flavin [9], Hakkio and Rush [8], and Wilcox [29] consider the implications of intertemporal budget balance. Rather, I impose the further restriction on intertemporal budget balance that tax rates follow an optimal tax rule, namely a random walk.

the optimal tax rate at time t as a function of the ratios of the amount of debt outstanding and the expected present value of current and future government spending less seignorage to national output:

$$\tau_t = (1-\beta)[E_t\{b_{t-1} + \sum_{k=0}^{\infty} g_{t+k}\beta^k | I_t\} - E_t\{\sum_{k=0}^{\infty} s_{t+k}\beta^k | I_t\}]. \tag{7}$$

Define τ_t^P to be the "perfect foresight" or "ex-post rational" tax rate. This is the tax rate that should have prevailed if taxes were optimal and the BSP had perfect foresight over government expenditures and seignorage. Since expectations are a linear operator, the perfect foresight tax rate is:

$$\tau_t^P = (1-\beta)[b_{t-1} + \{\sum_{k=0}^{\infty} g_{t+k}\beta^k\} - \{\sum_{k=0}^{\infty} s_{t+k}\beta^k\}]. \tag{8}$$

In contrast to the perfect foresight tax rate, let the "naive" tax rate be a tax rate that is based upon an ad hoc forecast of the model's forcing variables. This "rule of thumb" uses an information set at time t, H_t, that is a strict subset of the information set at time t, I_t, that rational agents actually possess. For purposes of this exercise, the "naive" processes for $\{g_t\}$ and $\{s_t\}$ are:

$$E_t\{g_{t+k}|H_t\} = g_t \quad k = 1, 2, \ldots \tag{9a}$$

$$E_t\{s_{t+k}|H_t\} = s_t \quad k = 1, 2, \ldots. \tag{9b}$$

Substituting these ad hoc processes into expression (7) yields the "naive" tax rate:

$$\tau_t^N = g_t - s_t + (1-\beta)b_{t-1}. \tag{10}$$

Following M-R-S, expressions (7), (8), and (10) are related as follows. First the identity:

$$(\tau_t^P - \tau_t^N) = (\tau_t^P - \tau_t) + (\tau_t - \tau_t^N). \tag{11}$$

Squaring both sides and taking expectations with respect to the appropriate conditioning information sets yields:

$$E_t[(\tau_t^P - \tau_t^N)/W_t]^2 = E_t[(\tau_t^P - \tau_t)/W_t]^2 + E_t[(\tau_t - \tau^N)/W_t]^2 \tag{12}$$

where use is made of $(\tau_t^P - \tau_t)$ being uncorrelated with I_t, and hence is uncorrelated with $(\tau_t - \tau_t^N)$. W_t is any scale variable that is known at time t, and is included primarily to deal with trending in the series which can lead to heteroskedasticity problems in estimation. Since both right hand side terms of (12) are positive, the left hand side term must be greater than each right hand side component. Using the law of iterated expectations, the model's theoretical implications are summarized as follows:

$$S_1 \equiv E_t[(\tau_t^P - \tau_t^N)/W_t]^2 - E_t[(\tau_t^P - \tau_t)/W_t]^2 \geq 0 \tag{13a}$$

$$S_2 \equiv E_t[(\tau_t^P - \tau_t^N)/W_t]^2 - E_t[(\tau_t - \tau^N)/W_t]^2 \geq 0 \tag{13b}$$

$$S_3 \equiv E_t[(\tau_t^P - \tau_t^N)/W_t]^2 - E_t[(\tau_t^P - \tau_t)/W_t]^2 - E_t[(\tau_t - \tau^N)/W_t]^2 = 0. \tag{13c}$$

From expression (13a), the actual tax rate better reflects the economic fundamentals of optimal taxation than a tax rate based upon a naive forecast of the future forcing variables. From

expression (13b), the naive forecast better predicts the actual tax rate than the perfect foresight tax rate. This is because the naive tax rate is based on H_t and the realized tax rate is based upon I_t, where $H_t \subset I_t$. However, the perfect foresight tax rate is based upon the true path of realized forcing variables which supercedes the information contained in I_t. Expression (13c) is a restatement of expression (12). A rejection of equality (13c) would be due to the non-orthogonality of $(\tau_t^P - \tau_t)$ and $(\tau_t^N - \tau_t)$, namely that the forecast errors using the perfect foresight tax rate to predict the actual tax rate and the forecast errors using the naive tax rate to predict the actual tax rate are correlated. If, for example, this correlation were positive, then S_3 would be negative.

To make the perfect foresight tax rate operational, expression (8) must be augmented to reflect that the infinite path of government expenditures and seignorage is unobservable. To circumvent this problem, the future forcing variables that are as yet unrealized are substituted out. This is achieved by using (8) to solve for τ_T^P, which under the null hypothesis of optimal taxation, allows one to solve out $\sum_{k=T-t}^{\infty} g_{t+k}\beta^k - \sum_{k=T-t}^{\infty} s_{t+k}\beta^k$. After algebraic manipulations, the perfect foresight tax rate, is re-written as:

$$\tau_t^P = (1-\beta)\Big[\sum_{k=0}^{T-1-t} g_{t+k}\beta^k - \sum_{k=0}^{T-1-t} s_{t+k}\beta^k + b_{t-1}\Big] + [\tau_T - (1-\beta)b_{T-1}]\beta^{T-t}. \tag{14}$$

III. Results

Figure 1 presents plots of the tax rate, government spending ratio, the end of period government debt outstanding ratio and the seignorage ratio. The plot of government expenditures reveals the impact of the major wars on the series, the rising level of government spending between World War I and World War II due to New Deal policies, and the higher level of expenditures in the post World War II era. As well, the public debt series reflects the build-up of debt after the World War II and the gradual reduction of the debt up until the early 1980s. Remarkably, the mean value of the seignorage ratio is negligible as compared to the other series of interest.

A time series plot of the tax rate, the "perfect foresight" tax rate and the "naive" tax rate, for $\beta = .96$, is presented in Figure 2. The tax rate series remains well below 5% from 1870 until the beginning of World War I, at which point it rises to 8.5% in 1919. The realized tax rate series declines throughout the 1920's until 1933 when it begins to rise in correspondence to the permanent increase in government spending attributable to New Deal policies. Again, it rises at the beginning of World War II to a high of 20.5% in 1943. The realized tax rate series since the end of the Korean War is less volatile than in the preceding time period. In fact, since 1953 the tax rate series has fluctuated within the band widths of 3.4%, from a high of 20.7% in 1969 to a low of 17.3% in 1954. However, as shown in Figure 1, the government spending ratio has been less volatile as well during this time period.

The perfect foresight tax rate is extremely smooth with a positive trend that peaks in 1943 at 22.3%, and thereafter stabilizes at around 20%. The fundamentals driving this series are government spending since the mean value of the ratio of seignorage to output is quite small relative to the government spending ratio. The perfect foresight tax rate smooths over the effects of both World Wars by keeping the series well above the actual tax rate series until the mid-1940s. In fact, the perfect foresight tax rate exceeds the actual tax rate series with the exception of the years 1979 and 1981. The naive tax rate, surprisingly, mimics the actual tax rate series with the exception of the major war years when it systematically overpredicts the actual tax rate. This is due to the fact

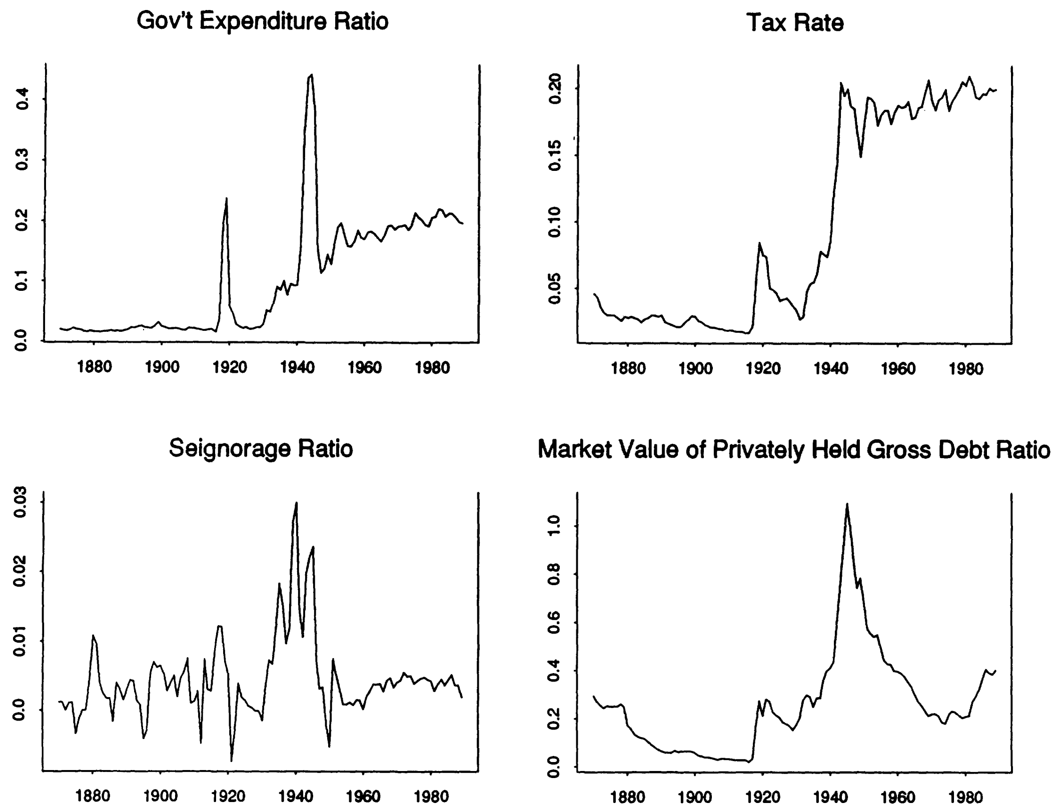

Figure 1

that public debt was quite large during the war, and from expression (10), this raises the naive tax rate substantially.

Unfortunately, when the perfect foresight tax rate is calculated using a horizon of $T - t$, where T is the final period and t is the current period, the calculation of the variance bounds is overly influenced by a large singular event in the forcing variables—namely the permanent increase in government expenditures after World War II. To examine the sensitivity of the perfect foresight approximation, I consider a modification to expression (14) first introduced by Shea [25]. It allows the final year value to be calculated on a rolling basis that uses data only j steps ahead. This method does come with a cost, however, as it consumes j data points at the end of the series. Using this methodology, the perfect foresight tax rate is calculated as:

$$\tau_t^P = (1-\beta)\left[\sum_{k=0}^{j-1} g_{t+k}\beta^k - \sum_{k=0}^{j-1} s_{t+k}\beta^k + b_{t-1}\right] + [\tau_{t+j} - (1-\beta)b_{t+j-1}]\beta^j. \tag{14'}$$

Figures 3 and 4 present such a plot of these series using values of j equal to 5 and 10 years, respectively, for $\beta = .96$. Of course, the actual and naive tax series are unchanged. In Figure 3, the perfect foresight tax rate does not systematically overpredict the actual tax series as above, however it is much less smooth. In fact, the figure implies two steady state levels of taxes, one before World War I, and the other after the Korean War. This is primarily due to the shorter horizon

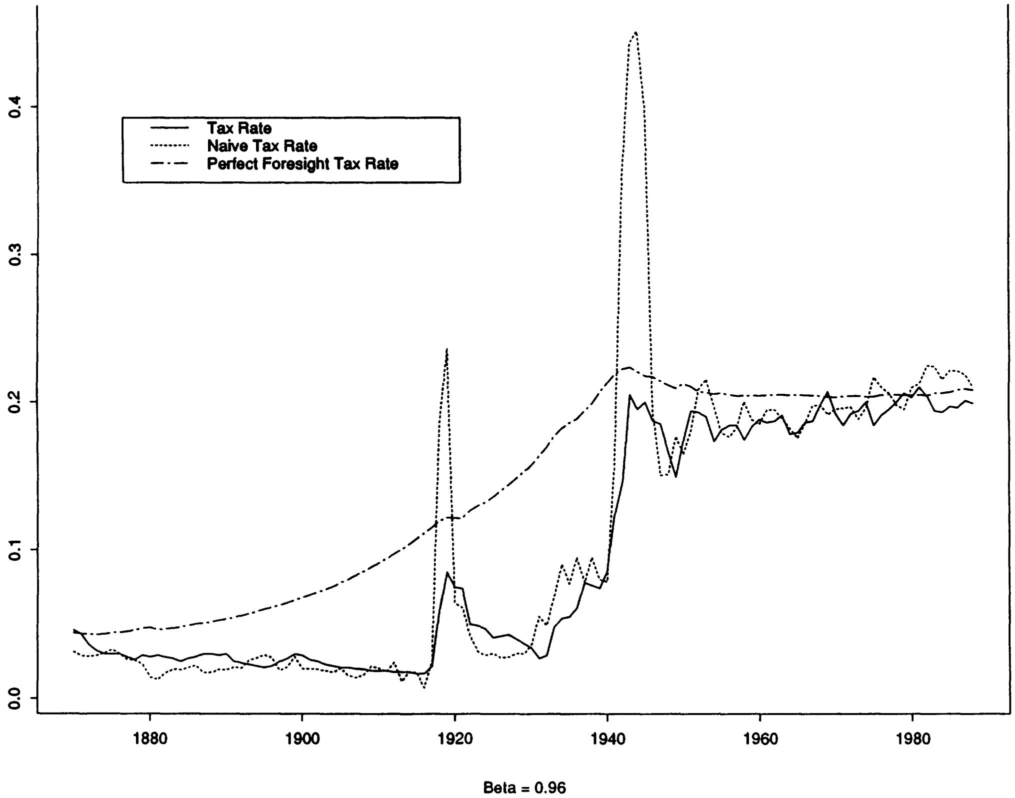

Figure 2

of expression (14′) as compared to (14), since the higher level of government expenditures after World War II does not affect the series before World War I, as it does in Figure 2. In Figure 4, the longer horizon raises the perfect foresight tax rate during the major war years as compared to the case of $j = 5$ in Figure 3, without affecting the apparent steady state properties of the series before and after the World Wars.

Table I presents the calculation of the t-statistics for S_1, S_2 and S_3, which I refer to as t–S_1, t–S_2 and t–S_3, respectively. The asymptotic standard errors for these t-statistics are calculated using the Newey-West [20] correction for possible heteroskedasticity and serial correlation of unknown form. The asymptotic standard error is cast in a generalized method of moments framework that allows us to state the estimators distribution under fairly general conditions.[3,4] For the simple tests considered in this paper, the asymptotic standard error of standardized estimators, $T^{1/2}(\hat{S}_i - s_i)$, is estimated by:

$$\hat{\Omega} = \hat{\Omega}_0 + \sum_{j=1}^{m(T)} w(j, m(T)) 2\Omega_j \tag{15}$$

3. See Mattey and Meese [18] for a detailed presentation of this approach in their examination of the stock market volatility literature.

4. Although theory implies that S_1 and S_2 are non-negative, for empirical purposes the null hypothesis is taken to be that S_1 and S_2 are zero, and the alternative is that S_1 and S_2 are negative. This is the approach suggested by Mood, Graybill and Boes [20, 429].

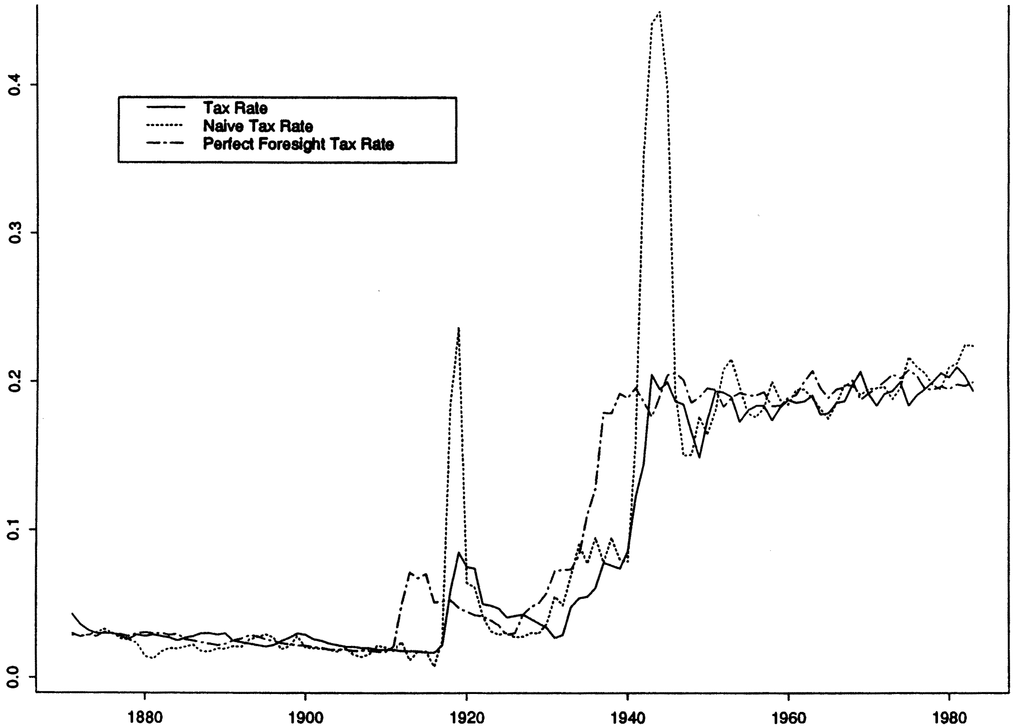

Figure 3

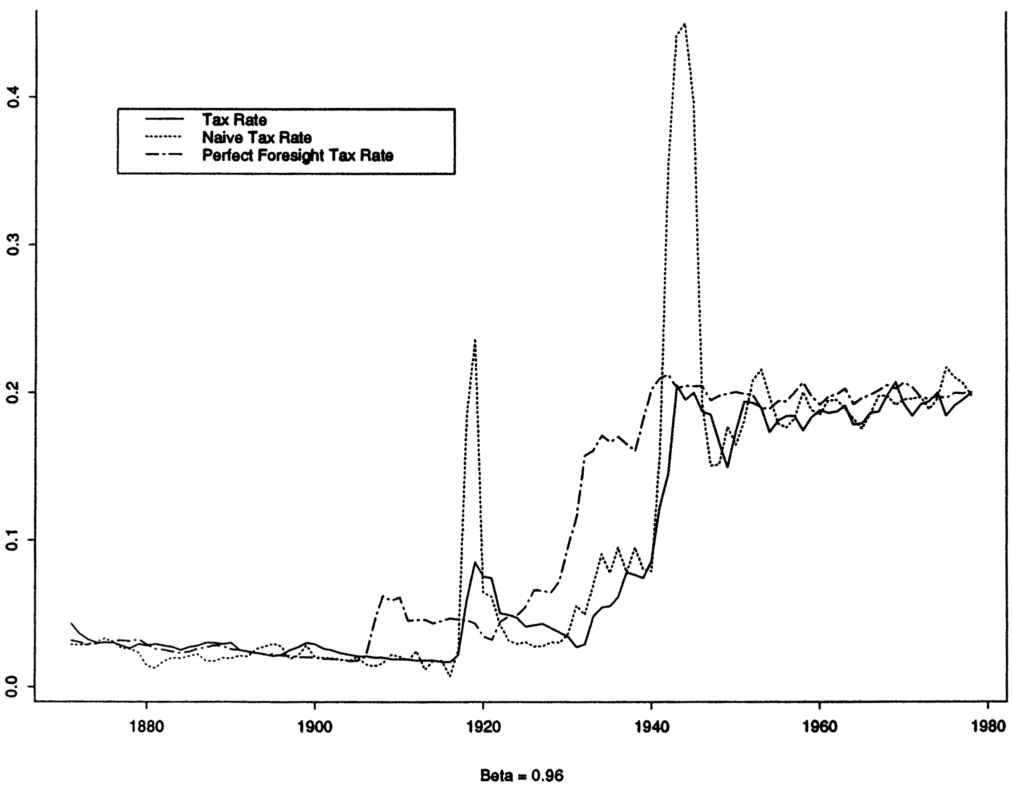

Figure 4

Table I.

		$T - t$			$t + 5$			$t + 10$		
Horizon Period	β	t–S_1	t–S_2	t–S_3	t–S_1	t–S_2	t–S_3	t–S_1	t–S_2	t–S_3
1870–1989	.98	1.98	3.15	1.22	1.21	1.47	−0.77	0.35	2.18	−0.89
	.97	1.13	2.91	0.29	1.06	1.43	−0.97	0.18	2.25	−1.01
	.96	0.43	2.75	−0.43	0.92	1.39	−1.14	0.03	2.32	−1.13
	.95	−0.76	2.63	−0.93	0.80	1.33	−1.30	−0.10	2.35	−1.25
	.94	−0.83	2.01	−1.26	0.69	1.27	−1.47	−0.23	2.35	−1.37
1916–1952	.98	0.35	2.33	−0.42	1.10	2.21	−0.68	−0.05	2.24	−0.96
	.97	0.07	2.42	−0.75	0.99	2.00	−0.90	−0.17	2.40	−1.11
	.96	−0.17	2.48	−1.03	0.90	1.76	−1.11	−0.27	2.58	−1.23
	.95	−0.38	2.51	−1.26	0.81	1.55	−1.31	−0.37	2.77	−1.35
	.94	−0.56	2.51	−1.46	0.72	1.32	−1.51	−0.47	2.96	−1.48
1870–1915	.98	−1.74	−2.89	−4.05	0.99	−2.17	−2.90	1.16	−3.20	−3.59
	.97	−0.97	−2.81	−3.97	0.80	−1.96	−2.78	1.04	−3.14	−3.61
	.96	−0.17	−2.75	−3.73	0.66	−1.66	−2.63	1.02	−3.06	−3.71
	.95	0.55	−2.85	−3.54	0.57	−1.38	−2.55	1.05	−3.15	−4.21
	.94	1.10	−3.39	−3.92	0.53	−1.23	−2.60	1.05	−3.21	−5.11
1953–1989	.98	2.09	1.25	−1.27	1.44	0.42	−1.37	1.84	1.40	−1.08
	.97	0.15	0.67	−3.11	1.04	−0.12	−2.05	0.55	0.58	−2.19
	.96	−1.60	−0.15	−4.13	0.61	−0.91	−2.87	−0.55	−0.59	−3.56
	.95	−2.23	−1.14	−4.36	0.25	−1.82	−3.57	−1.42	−1.89	−4.10
	.94	−2.54	−2.10	−4.34	−0.63	−2.59	−3.92	−2.15	−2.84	−4.35

For the one tailed test applicable for t–S_1 and t–S_2, the 1%, and 5% critical values (asymptotically) are −2.326, and −1.645, respectively. For the two tailed test applicable for t–S_3, the 1%, and 5% critical values (asymptotically) are |2.576|, and |1.960|, respectively. t–S_1, t–S_2 and t–S_3 are the asymptotic t-statistics associated with S_1, S_2 and S_3, respectively.

$$w(j,m) = 1 - [j/(m+1)]$$
$$\Omega_j = \sum_{t=j+1}^{T} \hat{h}_t \hat{h}_{t-j}$$
$$m(T) = \text{integer}(T^{1/3}).$$

For purposes of statistical inference, the estimated statistic divided by its standard error is normally distributed with mean zero and variance equal to one.

The estimates of the bounds using three alternative time horizons for calculating the perfect foresight tax path are presented in Table I. As mentioned above, these horizons are $T - t$, where T is the end of the data sample and t is the current period, and two rolling horizons, $t + 5$ and $t + 10$. Each estimate is calculated for the entire sample, and for three non-overlapping sub-samples, 1870–1915, 1916–1952 and 1953–1989. The selection of the three sub-samples is meant to separate out the movements in tax rates due to major wars and depressions from the time periods when the driving variables are relatively smooth. One should expect, ceteris paribus, that since the magnitude of shocks to government expenditures differs between the sub-samples, an interesting comparison can be drawn between the three periods. The scaling factor, W_t, is set equal to the current tax rate, τ_t, in order to account for trending in the tax rate variable. The results are virtually unchanged when g_t is used in place of W_t.

The results in Table I have three main implications. First, when considering the full sample, there appears to be no systematic rejection of the inequalities, especially for higher values of

the discount factor. In fact, in no case are S_1, S_2 or S_3 significantly less than zero at the 5% level. Therefore, considering the entire time series data in its entirety, the null hypothesis of tax smoothing cannot be rejected.

Secondly, for the 1916–1952 sub-sample (the second panel of Table I), there is again no evidence against the hypothesis that the government did not smooth the distortionary impact of shocks to government expenditures when the environment was extremely volatile. What is particularly interesting about this finding is that the underlying assumptions of the tax smoothing model presented are most likely to be violated during these periods of major wars and depressions—namely that the elasticity of output with respect to taxation is constant, that tax rates should not depend on business cycle conditions, and that the government can issue as much debt as it wants at a constant real interest rate. However, since government expenditures fluctuate greatly during this time period, tax rates would have to have been astronomically volatile in order to reject the theory.

Finally, in contrast to the results for the entire sample and the period dominated by the major world wars, both the pre- and post-war samples display strong evidence against the tax rate smoothing hypothesis (the third and fourth panels of Table I). In fact, for almost every combination of β and horizon considered, S_3 is significantly less than zero at the 5% level, and typically less than zero at the 1% level. The source of this rejection of the implied variance bounds are, as argued above, due to the failures of the perfect foresight and naive tax rates to forecast the actual tax rate, and that these forecast errors are positively correlated. This causes S_3 to be significantly negative.

Corroborating evidence that movements in taxes have been excessive relative to the smooth path of government expenditures both before and after the major wars is seen in the plots of the perfect foresight tax rate in Figures 2, 3 and 4. The perfect foresight tax rate for the post war years is extremely smooth, indicating that the ex-post rational path the present value of government spending less seignorage must also be smooth. Clearly, the actual tax rate moves in excess of fundamentals. Potentially, the tax rates over-react to temporary changes in government spending or political whim. Alternatively, the random walk theory of taxation may not adequately capture the fundamentals of intertemporal optimal taxation, even when the fundamentals are not excessively volatile, if real interest rate movements and or changes in the elasticity of output with respect to taxation are important.

IV. Monte-Carlo Simulations of the Volatility Bounds

Following both Mankiw, Romer and Shapiro [17] and Mattey and Meese [18], Monte-Carlo simulations are performed to assess the finite sample properties of the estimators. For simplicity, only the finite sample properties of t–S_3 are presented since this is the hypothesis that is most often rejected by the data.[5] The Monte-Carlo simulations are intended to investigate whether the theory is rejected because the asymptotic critical values having the incorrect size. In other words, do the tests reject the truth too frequently because the asymptotic critical values are too small (in absolute value) for the finite sample sizes under consideration?

5. The Monte-Carlo results for t–S_1 and t–S_2 differ from those for t–S_3 in that the simulated finite sample distribution of the t-statistic is shifted to the right (i.e., their means were significantly greater than zero). However, this shift becomes much smaller as the sample size is increased from $T = 50$ to $T = 100$. These finite sample results do not overturn our asymptotic results for t–S_1 and t–S_2 as reported in Table I since for the 1870–1915 and 1953–1989 sub-samples, many of the values (especially for t–S_2) were significantly negative.

Table II presents the results from Monte-Carlo simulations of the model under the null hypothesis that taxes are in fact optimal. Two sample sizes, which roughly correspond to the sample sizes in the data ($T = 50$ and $T = 100$), and four processes for government expenditures were considered.[6] The government expenditure series were generated as first order autoregressive processes with different autoregressive coefficients, $\rho = .25$ and $\rho = .75$, to reflect the persistence of random shocks to the series. To proxy the abrupt change in government expenditures due to wars, I also allow for a positive shift in the mean of the series. For each random process used to generate government expenditures, the corresponding actual tax rate series (under the null hypothesis of optimal taxation) and the naive tax rate series were calculated using equations (7) and (10), respectively. The perfect foresight tax rate series were calculated using either equation (14) or (14′), depending on the experiment.[7] For each of the 1,000 replications t–S_3 was calculated as described in the prior section, and from these estimates the empirical distribution of the statistic was created. Estimated moments of the empirical distribution are also presented and are contrasted to the results for the Normal distribution, which is the asymptotic distribution of t–S_3.

The Monte-Carlo simulations reveal that although I consider a variety of processes for government expenditures, the finite sample properties of the distribution of t–S_3 do not change the conclusions that tax rates are excessively volatile during peacetime. Table III presents the most stringent 1% critical values from Table II for horizon's of $T - t$, $t + 5$ and ($T = 50$),[8] as well as the corresponding estimated values of t–S_3 for the sample periods 1870–1915 and 1953–1989 from Table I ($\beta = .96$). From Table III, the rejections of the variance bounds at approximately the 1% level of significance are not due to the finite sample properties of the estimation procedure.

Finally, three additional points worth mentioning about the Monte-Carlo results are that: (1) For more persistent shocks ($\rho = .75$), the mean of the distribution is shifted to the right, implying that the asymptotic significance levels used in Table I for testing $S_3 \leq 0$ may in fact be too conservative. (2) As the sample size increases, the critical values of the empirical distribution of t–S_3 generally approach those for N(0, 1). (3) In most instances, the presence of a shift in the mean of the government expenditure process does not adversely affect the critical regions for testing $S_3 \leq 0$.

V. Sources of Excess Volatility

As has been shown above, the random walk theory of taxation can be rejected for time periods when there are not major wars. In this section, therefore, the potential sources of excess volatility are explored for the time periods 1870–1915 and 1953–1989. Both business cycle and political business cycle explanations are pursued in the next two sub-sections.

Business Cycle Effects

Extensions of the Linear-Quadratic model that do not imply the random walk behavior of tax rates are found in Hess [10], Lowell [14], Poterba and Rotemberg [22], and Trehan and Walsh [28]. Together, these models possess the common feature that tax policy should be more pro-

6. Since the level of seignorage is empirically quite small, I do not replicate it in our empirical work.

7. These constructed series used $\beta = .96$ for the simulations, although the results from this section do not depend upon this selection.

8. Most stringent in the sense that these are the 1% critical values that are the most negative, and hence are the most difficult to accept.

Table II. Finite Sample Simulated Critical Values for t–$S3$.

	Shift								
	$T = 50$				$T = 100$				
	$\rho = .25$		$\rho = .75$		$\rho = .25$		$\rho = .75$		
P	No	Yes	No	Yes	No	Yes	No	Yes	$N(0, 1)$
Horizon = $T - t$									
.010	−2.71	−2.85	−2.20	−1.74	−2.61	−2.55	−3.02	−2.84	−2.33
.025	−2.05	−2.11	−1.97	−1.56	−2.01	−2.08	−2.67	−2.37	−1.96
.050	−1.67	−1.76	−1.62	−1.32	−1.72	−1.76	−2.08	−2.00	−1.65
.100	−1.27	−1.36	−1.25	−0.99	−1.26	−1.31	−1.56	−1.61	−1.28
.900	1.57	1.52	2.17	2.43	1.68	1.55	2.01	2.00	1.28
.950	1.86	1.82	2.64	2.88	2.03	1.92	2.26	2.21	1.65
.975	2.05	2.11	2.82	3.17	2.21	2.12	2.55	2.45	1.96
.990	2.26	2.35	3.17	3.39	2.42	2.25	2.83	2.73	2.33
μ–t	0.11	0.05	0.51	0.71	0.21	0.15	0.26	0.23	0.00
var–t	1.18	1.21	1.73	1.63	1.28	1.25	1.88	1.79	1.00
skw–t	−0.22	−0.19	−0.13	0.05	−0.18	−0.17	−0.27	−0.20	0.00
krt–t	0.30	0.22	−0.12	−0.44	−0.44	−0.52	−0.49	−0.67	0.00
Horizon = $t + 5$									
.010	−2.65	−2.65	−2.09	−0.65	−2.69	−2.70	−2.71	−2.84	−2.33
.025	−2.43	−2.44	−1.47	−0.32	−2.45	−2.48	−1.90	−2.37	−1.96
.050	−1.99	−2.00	−0.78	0.08	−2.05	−2.06	−1.63	−2.00	−1.65
.100	−1.53	−1.54	−0.35	0.48	−1.46	−1.46	−0.96	−1.61	−1.28
.900	1.31	1.34	2.63	2.51	1.43	1.43	2.40	2.00	1.28
.950	1.86	1.87	2.96	2.86	1.80	1.79	2.91	2.21	1.65
.975	2.06	2.08	3.53	3.12	2.28	2.27	3.34	2.45	1.96
.990	2.20	2.29	3.79	3.50	2.38	2.38	3.90	2.73	2.33
μ–t	−0.09	−0.09	1.15	1.44	0.01	0.00	0.78	1.10	0.00
var–t	1.26	1.27	1.46	0.72	1.29	1.29	1.75	1.16	1.00
skw–t	−0.05	−0.03	−0.23	0.14	−0.23	−0.23	−0.11	0.01	0.00
krt–t	0.10	−0.09	1.06	0.48	0.19	0.18	0.55	0.84	0.00
Horizon = $t + 10$									
.010	−3.46	−3.47	−2.28	−0.60	−3.11	−3.13	−2.28	−1.39	−2.33
.025	−2.82	−2.84	−1.29	−0.18	−2.45	−2.46	−1.74	−0.93	−1.96
.050	−2.03	−2.04	−0.84	0.12	−1.98	−1.98	−1.21	−0.52	−1.65
.100	−1.58	−1.60	−0.36	0.45	−1.43	−1.44	−0.83	−0.22	−1.28
.900	1.52	1.55	2.76	2.61	1.41	1.39	2.37	2.37	1.28
.950	2.10	2.11	3.24	2.88	1.81	1.79	2.82	2.73	1.65
.975	2.35	2.34	3.45	3.06	2.18	2.18	3.11	3.05	1.96
.990	2.56	2.56	3.92	3.36	2.36	2.35	3.60	3.20	2.33
μ–t	−0.03	−0.03	1.29	1.54	−0.05	−0.05	0.75	1.04	0.00
var–t	1.58	1.59	1.53	0.72	1.27	1.28	1.56	1.04	1.00
skw–t	−0.19	−0.19	−0.31	−0.16	−0.13	−0.14	−0.04	0.03	0.00
krt–t	0.00	0.00	0.23	0.14	0.05	0.05	−0.17	−0.25	0.00

Notes:
T is the number of observations.
P is the probability of observing a value less than the critical value.
μ–t, var–t, skw–t and krt–t are the sample mean, variance, skewness and kurtosis of the empirical t-distribution, respectively.
Shift is a dummy variable that takes the value of 1 in the second half of the sample.

Table II. Continued

As above, the weighting matrix is the current tax rate.
When Shift = No, $g(t) = .2 + \rho g(t-1) + \varepsilon(t)$.
When Shift = Yes, $g(t) = .1 + .2^{*}Shift(t) + \rho g(t-1) + \varepsilon(t)$.
Initial values for the simulation are $\text{var}(\varepsilon_t) = .01$, $b_0 = .2$, $\beta = .96$.
The empirical distributions are based upon 1000 replications each.
$N(0, 1)$ is the Normal random variable with zero mean and variance equal to one.
For Horizon = $T - t$, the perfect foresight tax rate was calculated using expression (14).
For Horizon = $t + k$, $k = 5, 10$, the perfect foresight tax rate was calculated using expression (14).

Table III.

Horizon	$T - t$	$t + 5$	$t + 10$
Empirical 1% critical value	−2.85	−2.65	−3.47
t–$S3$ 1870–1915	−3.73	−2.63	−3.71
t–$S3$ 1953–1989	−4.13	−4.13	−3.56

cyclical—namely, for any path of expected future government expenditures and for any amount of debt outstanding, tax rates should be relatively higher during economic expansions as compared to economic contractions.

To test whether tax rate changes are related to the business cycle, I employed the following methodology. According to the Linear-Quadratic model of taxation, tax rate changes should be white noise. If, however, the simple random walk hypothesis is incorrect due to its exclusion of business cycle effects, then one would expect that positive (negative) tax rate changes would be associated with lagged changes in output above (below) normal. Using a Goldfeld and Quandt [7] switching regime model, I test whether tax rate changes were positive when lagged changes in real per-capita GNP were high as compared to when they were relatively low. The following model was estimated:

$$\Delta\tau_t = \alpha 1 \cdot I_t + \alpha 2 \cdot (1 - I_t) + \varepsilon_{1t} \cdot I_t + \varepsilon_{2t} \cdot (1 - I_t) \tag{16}$$

where $I_t \in [0, 1]$ is an indicator variable which is equal to the value of the Normal cumulative density function evaluated from $(-\infty, \Delta Y_{t-1} - \mu - \gamma]$, μ is the mean of ΔY, and σ_1 and σ_2 are the standard deviations of ε_{1t} and ε_{2t}, respectively. The Goldfeld-Quandt model places more (less) weight on being in state 1 the higher (lower) is ΔY_{t-1} relative to $\mu + \gamma$. Therefore, if there is a significant business cycle component in tax rate changes, then α_1 should be greater than α_2. Moreover, if the business cycle affects the variability of tax rate changes, then σ_1 may differ from σ_2.

Table IV presents the results from the switching regime model for the time periods 1870–1915 (upper panel) and 1953–1989 (lower panel). The parameters α_1, α_2, σ_1, σ_2 and γ were estimated using maximum likelihood (see Goldfeld and Quandt [7]). There are three main results from the switching regime estimates. First, for both time periods, the estimates for α_1 are greater than that for α_2.[9] This implies that lower than average changes in per-capita real GNP are

9. Interestingly, for the 1870–1915 time period the estimates for the constants are both negative. The mean tax rate change during this time period was −.00059 with a standard deviation of the mean of .00029, which is significantly different from zero at the .050 percent level.

Table IV. Sources of Excess Volatility: Business Cycle Effects, $\Delta\tau_t = \alpha_1 \cdot I_t + \alpha_2 \cdot (1 - I_t) + \varepsilon_{1t} \cdot I_t + \varepsilon_{2t} \cdot (1 - I_t)$ (Switching Regime Model)

	α_1	α_2	σ_1	σ_2	γ	χ^2
1870–1915						
ΔY_{t-1}	−.0003***	−.0007***	.0006**	.0022***	.9572***	.043
	(.0001)	(.0002)	(.0003)	(.0002)	(.2391)	
1953–1989						
ΔY_{t-1}	.0039***	−.0028**	.0019***	.0091***	.7546***	.001
	(.0004)	(.0011)	(.0006)	(.0012)	(.2365)	

Heteroskedasticity robust standard errors in parentheses.
***, **, *: significantly different from zero at below the 1%, 5% and 10% level, respectively.
Y is real per-capita GNP measured in 1982 dollars.
χ^2 is the significance level for the likelihood ratio test that $\alpha_1 = \alpha_2, \sigma_1 = \sigma_2$ and $\gamma = 0$.
I_t is an indicator function which is equal to the value of the Normal cumulative density function evaluated from $(-\infty, \Delta Y_{t-1} - \mu - \gamma]$, μ is the mean of ΔY, and σ_1 and σ_2 are the standard deviations of ε_{1t} and ε_{2t}, respectively.

associated with lower future taxes than otherwise, suggesting a cyclical aspect to tax rates that is absent from the simple random walk hypothesis. Second, the conditional standard deviation of tax changes is greater when output is below normal as compared to when output is above normal. Finally, as shown in the far right column of the table, the joint test of the null hypothesis that $\alpha_1 = \alpha_2$, $\sigma_1 = \sigma_2$ and $\gamma = 0$ is rejected at below the 5% level of statistical significance for both time periods examined. Therefore, the random walk model can be rejected in favor a model of tax rate changes based upon switching business cycle conditions.

Political Business Cycle Effects

In addition to business cycle effects, political factors may also provide an explanation for the rejection of the optimal tax model. Broadly speaking, political business cycle models can be divided into those where the government in power undertakes actions solely to maximize its reelection probability, and those where the government is driven by ideology when choosing among different policy options. Representative of the former view of government policy, Rogoff and Sibert [23] present a model where government's signal their competency in providing government services at a low cost by lowering tax rates prior to elections. Alternatively, Alesina and Tabellini [1] and Persson and Svensson [21] focus on ideologically motivated parties that choose tax plans to manipulate, to their liking, either the level or composition of future government spending. Hess [11] presents a model where governments are driven to pursue both their ideologically favored tax paths and to maximize their probability of reelection. Accordingly, the model predicts that governments are more likely to compromise their ideology and adhere to optimal policies if they were subsequently reelected. To date, the most significant finding of political cycles in tax changes is found in Bizer and Durlauf [4] who discover an approximate eight year cycle in tax changes which corresponds to a significant decrease in taxes two years before a political party's successful control of the presidency. This finding lends support to models that emphasize a government's desire to obtain reelection.

To test these political business cycle models, the following methodology was employed. From the Euler equation describing the optimal path of taxes, equation (5), tax rates should follow a random walk. Following Bizer and Durlauf's test of this theory, I test for whether the changes in the tax rate are correlated with political business cycle variables in the following regression:

$$\Delta\tau_t = \delta + \phi \cdot Z_t + \varepsilon_t. \tag{17}$$

Under the null hypothesis of optimal taxation, no political variable should predict tax rate changes. To test whether political business cycle models can predict tax rate changes, the following dummy variables were constructed at an annual frequency:

- *EY* — Equal to one if it is an election year and zero otherwise;
- *DEM* — Equal to one if the current president is a Democrat and zero otherwise;
- *REP* — Equal to one if the current president is a Republican and zero otherwise;
- *PRES-V* — Equal to one if the current president is subsequently reelected (victorious) and zero otherwise;
- *PRES-L* — Equal to one if the current president is not subsequently reelected (loses) and zero otherwise;
- *PRTY-V* — Equal to one if the current party of the president is subsequently re-elected (victorious) and zero otherwise;
- *PRTY-L* — Equal to one if the current party of the president is subsequently not reelected (loses) and zero otherwise.

These dummy variables, either alone or combined, are meant to capture the different aspects of political business cycle models.[10] For example, the variable ($PRTY\text{-}V_t \cdot EY_{t-2}$) is the variable discovered by Bizer and Durlauf [4] to explain changes in the tax rate. This type of variable accords with models that emphasize a government's desire to obtain reelection [23]. The variables representing the political party of the president, *DEM* and *REP*, when used individually or in combination with the variable *PRTY-L*, is meant to uncover the possible strategic selection of fiscal policy due to ideological differences over either the composition or level of government expenditure [1; 21]. Finally, the variable *PRES-L*, when combined with the political party variables *DEM* or *REP*, is used to test whether presidents who were not returned to office, either due to being a lame duck or losing a reelection, were more likely to have pursued extreme fiscal policy driven by ideology rather than pursue optimal policies [11].

Table V presents the results for the regression of tax changes on political business cycle dummy variables. The top panel of the table shows the results for the 1870–1915 time period. Throughout this time period, the results show that there was an ideological division between Republican and Democratic presidents. From the results for the dummy variable *DEM*, republican presidents were associated with significant negative tax changes (δ) as compared to democratic presidents ($\delta + \phi$). Moreover, this effect also holds for democratic presidents who were subsequently not reelected ($PRES\text{-}L \cdot DEM$) and when the democratic party lost control of the presidency ($PRTY\text{-}L \cdot DEM$). However, these latter two effects are, in practice, difficult to distinguish from the results for the dummy variable for Democratic presidents (*DEM*) since in this sub-sample only in President Wilson's first term did a Democratic president (and party) subsequently maintain control of the presidency. The corresponding dummy variables for Republican Presidents, ($PRES\text{-}L \cdot REP$) and ($PRTY\text{-}L \cdot REP$), are both insignificantly different from zero.

The bottom panel of Table V presents the results for the 1953–1989 sample. As in the earlier sample, there appears to be an ideological division between the major political parties—both the variables ($PRTY\text{-}L \cdot DEM$) and ($PRES\text{-}L \cdot DEM$) are positive and different from zero at the 5

10. The exact dates for each variable are reported in the data appendix.

Table V. Sources of Excess Volatility: Political Business Cycle Effects, $\Delta\tau_t = \delta + \phi \cdot Z_t + \varepsilon_t$

	1870–1915			1953–1989		
Z_t	δ	ϕ	R^2	δ	ϕ	R^2
DEM_t	−.0009** (.0004)	.0011** (.0005)	.059	−.0006 (.0016)	.0024 (.0023)	.024
$PRTY\text{-}L_t \cdot REP_t$	−.0005 (.0004)	−.0004 (.0005)	.008	.0001 (.0014)	.0003 (.0029)	.001
$PRTY\text{-}L_t \cdot DEM_t$	−.0009** (.0003)	.0012** (.0005)	.060	−.0009 (.0014)	.0049** (.0020)	.073
$PRTY\text{-}V_t \cdot EY_{t-1}$	−.0005 (.0003)	−.0006 (.0010)	.011	−.0003 (.0014)	.0033 (.0025)	.022
$PRTY\text{-}V_t \cdot EY_{t-2}$	−.0006* (.0003)	.0001 (.0006)	.001	.0014 (.0012)	−.0091** (.0035)	.172
$PRES\text{-}L_t \cdot REP_t$	−.0004 (.0005)	−.0005 (.0006)	.016	−.0001 (.0015)	.0008 (.0025)	.003
$PRES\text{-}L_t \cdot DEM_t$	−.0009** (.0003)	.0012** (.0005)	.060	−.0009 (.0014)	.0049** (.0020)	.073

Notes:
Heteroskedasticity robust standard errors in parentheses.
***, **, *: significantly different from zero at below the 1%, 5% and 10% levels, respectively.

percent level of statistical significance.[11] However, unlike the earlier sample, the dummy variable for all years with a Democratic president, *DEM*, is insignificantly different from zero. Finally, the dummy variable discovered by Bizer and Durlauf [4] to explain tax changes, ($PRTY\text{-}V \cdot EY_{t-2}$), is also different from zero at the 5% level of statistical significance. More importantly, however, this simple regression has an R-squared of .172 which represents a very powerful effect.

In summary, the results that distinguish Republican from Democratic presidents provide support for the view expressed by Persson and Svensson, Alesina and Tabellini and Hess—namely that presidents that were not returned to office, either due to being a lame duck or losing reelection, were more likely to have pursued extreme fiscal policy driven by ideology rather than pursue optimal policies, in order to "bind the hands of their successors". For the 1953–1989 sub-sample, the finding that there is a significant negative drop in taxes two years before a party maintains control of the presidency (first discovered by Bizer and Durlauf), lends support to the normative view of fiscal policy that emphasizes a president's reelection motive [23].

VI. Conclusion

The results of this paper suggest that tax rates have been excessively volatile in the time periods both before and after the World Wars, despite the relative smoothness of government expenditures. The variance bounds for optimal taxation cannot be rejected for the sample period 1916–1952, even though this is the time period when the assumptions underlying the simple tax hypothesis are most likely not to hold. The reason is that since government expenditures fluctuate tremendously

11. Again, these two dummy variables are equal throughout this sample since there were no cases where the Democratic party successfully transferred power from one president to the other.

during this time period, tax rates would have to have been astronomically volatile in order to reject the theory.

The rejection of the model's variance bounds for the non-war eras implies that researchers should consider the role of political business cycle models and more flexible optimal tax models when modeling tax changes. Extensions of the optimal tax model that do not imply random walk taxation are found in Poterba and Rotemberg [22], Trehan and Walsh [28], Hess [10] and Lowell [14]. Using a switching regime model, I show that for the time periods identified as excessively volatile, the simple random walk hypothesis omits a significant business cycle effect in the tax changes. In addition, for both sub-samples, I uncover a political business cycle effect which suggests that democratic presidents that subsequently were not returned to power, either because they lost or were lame ducks, were associated with higher taxes. This provides evidence for the normative view of fiscal policy advocated by Alesina and Tabellini [1], Hess [11], and Persson and Svensson [21]—namely that presidents that were not returned to office, either due to losing an election or being a lame duck were more likely to have pursued fiscal policy driven by ideology in order to "bind the hands of their successors". Finally, I re-confirm the finding by Bizer and Durlauf [4], who discovered an approximate eight year cycle in tax changes which coincides with significant tax decreases two years before a political party's successful control of the presidency. This conforms to the normative view of fiscal policy that emphasizes a president's reelection motive [23].

Data Appendix

The data for tax rates are from Barro [3] who presents data from 1879–1979. The data for 1869–1878 are taken from Kremers [12], and the years 1980–1989 were calculated from the *Economic Report of the President*. The data is the tax revenue raised by the government in the calendar year net of transfers from the Federal Reserve, divided by the gross national product. The ratio of government expenditures to gross national product is from Kremers [12], Barro [3] and several editions of the *Economic Report of the President*. The data for seignorage has been obtained from Friedman and Schwartz's [6] money base series augmented by data from the *Economic Report of the President*. Data for the market value of privately held gross debt is from Cox and Lown [5], Kremers [12], and Seater [27].

The dates for the political dummy variables are as follows: R, the Republican President dummy variable is equal to one during the years 1869–1884, 1889–1892, 1897–1912, 1953–1960, 1969–1976, 1981–1989, and zero otherwise. D, the Democratic President dummy variable, is simply one minus R. EY, the election year dummy, is equal to one in 1880, 1884, . . . , 1988. *PRTY-V*, the dummy variable for subsequent victory of the presidency by the incumbent party is equal to one during the years 1870–1880, 1897–1908, 1913–1916, 1953–1956, 1961–1964, 1969–1972, 1981–1988, and zero otherwise. *PRTY-L* is simply one minus *PRTY-V*, *PRES-V*, the dummy variable for subsequent victory by the incumbent president is equal to one during the years 1870–1872, 1897–1904, 1913–1916, 1953–1956, 1961–1964, 1969–1972, 1981–1984, and zero otherwise. *PRES-L* is simply one minus *PRES-V*.

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