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THE WELFARE COST OF UNCERTAIN TAX POLICY

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ABSTRACT

Frequent shifts in tax policy can increase uncertainty about future net-of-tax wages and interest income. This paper measures the impact of uncertain tax policy on savings, labor supply, and welfare in the United States. A vector autoregression model with six variables was estimated which found the standard error of the one-year-ahead forecast for the wage tax to be 1.8 percentage points, and for the interest income tax 3.3 percentage points. Furthermore, the negative correlation between unanticipated shifts in the real interest rate and changes in the interest income tax amplifies the variability in the real after-tax return.

A two-period model of consumption and labor supply is developed that measures the effect of uncertain taxes on savings, work hours, and taxpayer welfare. Using plausible empirical parameters, it is shown that removing all uncertainty about future tax policy can lead to a welfare gain of 0.4 percent of national income, or about 12 billion dollars in 1985.

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It is as inevitable as death and taxes that Congress will tinker with the tax code.

-- Senator Daniel Quayle[1]

I. Introduction

Traditional studies that measure the excess burden of taxation assume that tax rates are certain and unchanging, at least until the government decides to change them. However, recent experience in the United States has emphasized that taxpayers are justified in treating taxes as another unpredictable factor in an uncertain world. For example, following the passage of the Economic Recovery Act of 1981, a number of provisions, such as the controversial rule allowing the trading of corporate tax credits, immediately came under attack. The threat of repeal discouraged many firms from taking advantage of the tax cuts; the chairman of one corporation, able to sell benefits for less than half their estimated value, attributed the low price to the "risk of losing the tax benefits through a change in the tax law or other contingencies." (Clark, 1981). Currently, few agree on the final outcome of the President's tax reform efforts, leading to considerable uncertainty about the future marginal tax rate (which may range between 27 and 38 percent under Senate and House proposals), as well as the tax treatment of specific investment classes.

The potential dangers of uncertain taxes have been recognized since Adam Smith, who observed that "The certainty of what each individual ought to pay is, in taxation, a matter of so great importance, that a very considerable degree of inequality,...is not near so great an evil as a very

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[1]Quoted in Clark (1983).

small degree of uncertainty." (Smith, 1976; II: 351)[2] This view suggests that the proper role for the government is to reduce uncertainty about future tax rates. However, there are two reasons why unexpected variations in tax rates may increase, rather than decrease, economic welfare. First, if the income fluctuation is positively correlated with the tax rate, the variance of net-of-tax income may be reduced, thereby benefitting the risk-averse taxpayer. In a progressive tax system, for example, a rise in income is partially offset by a rise in tax rates, while a fall in income is cushioned by a decline in tax rates. The second reason was suggested by Stiglitz (1982) and Weiss (1976), who argued that random taxation can increase social welfare in the presence of existing taxes. The idea is that the tax uncertainty can cause consumers to work more and save more, thereby increasing revenues and partly offsetting the distortion caused by the initial labor and capital income taxation.[3]

This paper measures the uncertain component of wage and interest income taxes during the period 1929-75. Marginal tax rates calculated by Joines (1981) are used in a vector autoregression (VAR) model which includes government expenditure and debt, interest rates, and earnings. The

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[2]Smith's concern was that the uncertainty of taxation "encourages the insolence and favors the corruption" of the tax collection agents. Currently, those who write the code, rather than those who collect taxes, might be more subject to lobbying efforts. See also the 1982 Economic Report of the President, p.111.

[3]Even if labor supply and savings increases, the consumer may still be worse off owing to the additional uncertainty introduced by the random taxes. The result depends on the strong convexity of the marginal utility function and a weak degree of risk aversion. Also see Chang and Wildasin (1985).

estimated coefficients indicate that the one-year-ahead forecast error of the wage tax is 1.8 percentage points, and for the capital income tax 3.3 percent. While unexpected shifts in the wage rate are positively correlated with the wage tax, unexpected shifts in the interest income tax are negatively correlated with the interest rate. One reason for this negative correlation is that unexpected jumps in inflation rates tend to both decrease real ex post interest rates and increase the real tax on interest income. The interest income tax therefore accentuates interest rate uncertainty. Using empirical parameters in a two period model, the annual cost of uncertain taxes is estimated to be 0.4 percent of national income, or 12 billion dollars in 1985.[4]

The remainder of the paper is organized as follows. Section II discusses recent studies of tax uncertainty and presents a simple general-equilibrium model of consumer, government, and production sectors which jointly determine labor supply, savings, taxes, government expenditures, and debt. In Section III, a VAR corresponding to the reduced form of this model is estimated. Section IV provides a numerically computable model of individual consumption and labor supply decisions solved subject to the VAR estimates, while Section V concludes.

II. A Simple Model of Uncertain Tax Policy

There has been recent interest in the implications of uncertain or unpredictable tax policy. Judd (1984) focused on how the timing of future tax increases affects current labor supply and consumption in a general

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[4]This result is not a test of the Stiglitz-Weiss hypothesis, which may hold for some (e.g., intertemporally nonseparable) utility functions.

equilibrium model. He found that for plausible parameters, increased uncertainty about when a future capital income tax would occur led to rising current labor supply and savings. Auerbach and Hines (1986) emphasized the dramatic variations in investment tax incentives during the postwar period, leading to effective tax rates for myopic investors ranging from -19 percent in 1982 to 61 percent in 1953. They compared optimal investment patterns of individuals with myopic expectations and those with perfect foresight in a model which included adjustment costs.

Most recently, Kaplow (1986 a,b) has argued that the government should not compensate taxpayers for unexpected changes in tax rates. Government compensation introduces moral hazard; firms need not avoid investing in activities which the government later wishes to discourage through taxation. Private insurance companies are thought to be the proper institution for spreading risk.

In the model below, individual taxpayers form rational expectations about future taxes, wages, and interest rates. Unlike Kaplow's analysis, it is assumed that the unexpected tax shifts may not be justified on efficiency grounds, but often reflect unexpected inflation, expenditures, or policy vacilations. The general equilibrium model of wage, interest income, taxation, saving, and labor supply is based on three sectors. The first comprises consumers, who make labor supply and savings choices contingent on expectations about future net-of-tax wage and interest rates. The second is the production sector, which relates the supply of labor and capital to gross-of-tax wage rates and interest rates. Third, the government sector simultaneously determines expenditure, debt, and marginal tax rates necessary to collect tax revenue. The model is used primarily to establish the structure of expectations that rational consumers use to predict future net wage and interest rates.

Utility depends on current and future leisure and consumption,

$$U = U(C_1, \ell_1) + E\{U(C_2, \ell_2)\} \tag{1}$$

where C_i and ℓ_i represent consumption and leisure, respectively, and E is the expectations operator conditional on information at period 1. The timing of the model is that individuals choose labor supply at the outset of the period. At the end of the period, wages and interest rates are realized, taxes are paid, and the consumption decision is made. Labor supply decisions are determined before the net wage is realized to reflect human capital investments and occupational choices made early in the life cycle which affect subsequent work effort.[5] Although there is no specific bequest function, C_2 can be thought of as combining second period consumption and any bequests or assets retained for a later period.[6] The budget constraint is

$$C_1 + \frac{C_2}{(1+r_2^*)} = S_0(1+r_1^*) + h_1 w_1^* - R(y_1^e, y_1^u) + \frac{h_2 w_2^* - R(y_2^e, y_2^u)}{(1+r_2^*)} \tag{2}$$

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[5] Alternatively, labor supply could be chosen after the wage is realized. However, such a model leads to no uncertainty about the marginal tradeoff between C_2 and ℓ_2.

[6] For example, utility $U^*(\tilde{C}_2, B_2)$ can be maximized subject to $C_2 = \tilde{C}_2 + B_2$ where $\tilde{C}_2$ measures actual second period consumption and B_2 bequests or assets passed to the next period. Holding the relative price of bequests and consumption constant, the indirect utility function corresponding to U^* would be $V(C_2)$ which could then be substituted into (1).

where w_i^* and r_i^* are gross-of-tax wages and interest rates, h_i measures hours of work, and $\theta = h_i + \ell_i$, where θ is the total hours available for work and leisure. Tax revenue in a given period is a function R of earned income $y_i^e = w_i^* h_i$ and unearned income $y_i^u = S_{i-1} r_i^*$, where S_0 measures savings at period 0 (or assets at the outset of period 1) and

$$S_1 = S_0(1+r_1^*) + w_1^* h_1 - R(y_1^e, y_1^u) - C_1.$$

The progressive nature of the U.S. tax system leads to a divergence between the average and the marginal rates. Although the actual tax code is complex and non-linear, it can be approximated as a negative income tax, with a guaranteed lump-sum subsidy during the two periods of $\mu > 0$ and marginal tax rates t_i on wage and τ_i on interest income. The present value of revenue is therefore

$$t_1 h_1 w_1^* + \tau_1 S_0 r_1^* - \mu + \frac{t_2 h_2 w_2^* + \tau_2 S_1 r_2^* - \mu}{(1+r_2^*)} \quad (3)$$

Substituting (3) into (2) and rearranging yields

$$C_1 + \frac{C_2}{1+r_2} = X + h_1 w_1 + \frac{h_2 w_2}{1+r_2} \quad (4)$$

where $r_i = r_i^*(1-\tau_i)$, $w_i = w_i^*(1-t_i)$, so that r_i and w_i represent marginal after-tax interest rates and wages, while X measures "virtual" nonwage income $S_0(1+r_1) + \mu[1+(1+r_2)^{-1}]$.[7]

A linear homogenous production function is specified of the form

$$y_i = f_i(k_i, h_i)$$

where y_i, output, depends on capital k_i and labor h_i, and all variables are expressed in per capita terms. The production function f_i is allowed to

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[7]While μ is assumed constant, if the extent of income redistribution were uncertain, μ would be random as well.

move randomly over time, leading to unpredictable variations in the marginal product of capital $\partial f_i/\partial k_i$ or the marginal product of labor $\partial f_i/\partial h_i$, holding k_i and h_i constant. This degree of randomness ensures uncertainty about final factor prices, $w_i^* = \partial f_i/\partial h_i$, and $r_i^* = \partial f_i/\partial k_i$.

Note finally that aggregate capital stock is a function of current savings and government debt D_i; $k_i = S_i - D_i$. One could expand the definition of the capital stock and of labor supply to include savings and work choices of other generations, but such an assumption complicates the model and will not affect the results.

The government sector is assumed to maximize a time-specific objective function of the form

$$V_i = V_i(g_i, d_i, t_i, \tau_i) \tag{5}$$

where g_i is the ratio of government spending to GNP, and d_i the ratio of privately held government debt to GNP.[8] The restrictions on the derivatives of V are that governments will always prefer to spend more, holding debt and taxes constant ($\partial V_i/\partial g_i > 0$) and will always be worse off for a given level of spending with higher marginal tax rates or debt ($\partial V_i/\partial x < 0$, $x = t_i, \tau_i, d_i$). The determination of overall expenditures, tax rates, and debt will be affected by labor supply and savings choices, since the "price" of an extra unit of g_i financed by increasing the wage tax t_i is simply $y_i/w_i^* h_i$ evaluated at $t_i = 0$.[9] Because the efficiency cost of a tax rises

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[8]Expenditures and debt are expressed as a ratio of GNP rather than per capita to maintain comparability with other studies of government behavior. I abstract from issues of time-inconsistency in this model of government behavior.

[9]Evaluated at $t_i = 0$, $\partial R/\partial t_i$ is simply $w_i^* h_i$, so the price of goverment

approximately by the squared value of the marginal distortion, Barro (1979) has suggested that the optimal solution of the government is to set constant marginal rates over time, and use debt to cushion unexpected expenditures (e.g., during wartime). The formulation presented here, however, suggests a greater degree of variation in taxes and expenditures, as shifts in savings and labor supply affect the "price" of expenditures, and as a new administration leads to a potentially different objective function V_i.

From equations (1) and (4), current labor supply and savings decisions depend on the expected value and the distribution of future net wages and interest rates. We therefore presume that individuals making these choices in period i-1 use the information set available at that time to forecast future net wage and interest rates in period i. Consider first the general equilibrium solution to the vector of factor prices written as $P_i = \{w_i^*, r_i^*\}'$. Factor prices will depend on the capital-labor ratio, and hence on total debt and on labor supply and savings chosen using information from the previous period. Thus P_i can be expressed as a function of concurrent government policy, lagged labor supply and savings decisions (which in turn depended on lagged values of P and taxes) and an error term. Letting $G_i = \{g_i, d_i, t_i, \tau_i\}'$ and writing in linear form

$$P_i = \Lambda_1 P_{i-1} + \Lambda_2 G_i + \Lambda_3 G_{i-1} + v_{1i} \qquad (6)$$

where Λ_j j = 1,2,3, represents matrices of coefficients, and v_{1i} is a vector of error terms.

The choice of government variables will also depend on past debt and

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spending per GNP is $y_i/w_i^* h_i$.

expenditure commitments (such as entitlement programs), on the size of the tax base (which in turn depends on current and lagged P and taxes), and on an error term measuring unexpected shifts in expenditures or tax rates

$$G_i = \beta_1 G_{i-1} + \beta_2 P_i + \beta_3 P_{i-1} + v_{2i} \tag{7}$$

where v_{2i} represents a vector of error terms. Combining equations (6) and (7), and successively substituting yields the reduced form

$$\tilde{\Gamma}_i = \Psi\tilde{\Gamma}_{i-1} + \nu_i \tag{8}$$

where $\tilde{\Gamma}_i = \{g_i \; d_i \; w_i^* \; r_i^* \; t_i \; \tau_i\}'$, and Ψ is the vector of reduced form coefficients.

The two-period formulation has often been used to characterize "working" and "retirement" stages of the life cycle. In this model, the second period need not correspond to retirement; the essential feature of the prediction problem faced by consumers, however, is that they must make current savings (and human capital) decisions which will subsequently be affected by tax policy for a number of years in the future. Since consumers are making decisions about future consumption and labor supply over a number of years, their goal is to predict average taxes and factor prices (and the variance of those averages) over the future time horizon. In particular, it is assumed that the representative future horizon corresponds to consumption and labor supply at ages 50-59 planned from the perspective of age 35. The forecast relevant to the 35-year old is not simply the value (and variance) of a tax rate in some future year, but the average tax over the entire 10-year period.[10] The next step is to show how the VAR model using annual

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[10] The arithimetic mean approximates the (geometric) effective tax rate on interest income.

data (which we observe) translates into the optimal prediction of average tax rates and factor prices 15-25 years in the future. Using q to denote the year, and Γ_q and Π (without ~) the vector of (annual) dependent variables and the corresponding matrix of VAR coefficients, respectively,

$$\Gamma_{q+1} = \Pi\Gamma_q + \epsilon_q, \tag{9}$$

where ϵ_m is assumed normal and independent over time. Let the forecast period stretch from j-d to j+d years in the future (in the example above, between 15 and 25 years). Then the optimal forecast of $\tilde{\Gamma}_{i+1}$, averaged over N = 2d + 1 years in the future, is[11]

$$\tilde{\Gamma} = \sum_{m=j-d}^{j+d} \bar{\Gamma}_m/N = \Psi\Gamma_0 \tag{10}$$

where $$\bar{\Gamma}_m \equiv E\{\Gamma_m\} = \Pi^m\Gamma_0$$

The optimal prediction of any (yearly) vector Γ at a future year m is $\bar{\Gamma}_m$, while the average of $\bar{\Gamma}_m$ over the N years is simply $\tilde{\Gamma}$. The error of a single year's prediction can be written

$$\Gamma_m - \bar{\Gamma}_m = \Pi^{j-1}\epsilon_1 + \Pi^{j-2}\epsilon_2 + \ldots + \epsilon_m \tag{11}$$

After some rearrangement, the variance of the prediction $\tilde{\Gamma}$ is expressed as[12]

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[11]The notation is slightly different when N is even.

[12]For example, let d = 1 and j = 2. Then

$\Gamma_3 - \bar{\Gamma}_3 = \Pi^2\epsilon_1 + \Pi\epsilon_2 + \epsilon_3$

$\Gamma_2 - \bar{\Gamma}_2 = \Pi\epsilon_1 + \epsilon_2$

$\Gamma_1 - \bar{\Gamma}_1 = \epsilon_1$

The variance of $\tilde{\Gamma}$ is therefore

$\{(I + \Pi + \Pi^2)\Sigma(I + \Pi + \Pi^2)' + (1 + \Pi)\Sigma(I + \Pi)' + \Sigma\}/9.$

$$\Omega \equiv \mathrm{Var}(\tilde{\Gamma}) = N^{-2}\{\sum_{k=0}^{j-d-1} \Pi^k \phi \Sigma \phi' (\Pi^k)' + \sum_{k=0}^{N-1} \sum_{m=0}^{k} \Pi^m \Sigma (\Pi^m)'\} \qquad (12)$$

where $\phi = \sum_{k=0}^{N-1} \Pi^k$, $\Sigma = E(\epsilon\epsilon')$, and $\Pi^0 = I$, the identity matrix.

In the next section, Π and Σ are estimated using U.S. data; these matrices are then transformed into the prediction of $\tilde{\Gamma}$ and its variance-covariance matrix, Ω.

III. A VAR Model of Expenditure, Debt, Income, and Taxes

The estimation of equation (9) uses yearly U.S. data between 1929 and 1975 in real 1972 dollars. The measure of privately held government debt is from Barro (1979), while combined federal and state government expenditures are calculated from the National Income and Product Accounts. Owing to difficulty in measuring wages since 1929, earnings are estimated in the VAR model and subsequently converted to wage rates for the numerical calculations. Earnings are likely to vary more than wage rates if hours of work are positively correlated with wages. However, average earnings will also understate the risk of unemployment. Earnings are defined as the ratio of employee compensation to total non-agricultural employees, while real ex post interest rates are defined as the Moody Aaa bond rate minus the change in the GNP deflator (Economic Report of the President, 1985).

Joines (1981) calculated effective marginal tax rates on capital income and labor income during 1929-75. The labor income tax is the marginal tax on labor income, weighted by the share of labor income in each marginal bracket. Taxes on labor income are defined as state and local (proportional) taxes plus federal wage, salary and social security taxes, plus taxes on miscellaneous income (which is included as earned income).[13] Capital income includes interest and dividend income plus taxable capital gains,[14] while the capital income tax is comprised of state and local proportional taxes, corporate, dividend, interest, and other unearned income taxation.

There are two ways to measure marginal tax rates. The first takes an average of the statutory marginal rates, weighted by taxable income (Barro and Sahasakul, 1983a,b; Estrella and Fuhrer, 1983). This paper uses the second measure of marginal taxes (Joines, 1981; Seater, 1985) which calculates the actual (weighted) change in tax payments as income grows. That is, the marginal tax is defined as $(T-T^*)/(Y-Y^*)$, where T and T^* are actual taxes paid, and Y and Y^* adjusted gross income, in adjacent brackets.[15]

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[13] Miscellaneous income was partnership income plus business income plus farm income. Assuming that miscellaneous income was attributed to capital income generally made less than 1 percentage point difference in the tax rate (Joines, 1981).

[14] An alternative definition of income excluding capital gains leads to only slightly different tax rates. There might have been greater variability in tax rates if the "inflation premium" for interest and dividend income had been excluded from the tax base.

[15] The second measure used in this paper accounts for available deductions and exemptions that tend to rise for higher income taxpayers, and would tend to make the consumer's effective marginal rate less than the statutory rate. It may understate the true marginal rate, since the tax preferred goods will be less highly valued at the margin. See Barro and Sahasakul (1983a) and Seater (1985).

Estimates of the VAR model are presented in Table 1. These coefficients should be interpreted cautiously since they measure the reduced form of the structural model. The coefficient of lagged expenditures on current debt, 0.992 (t-statistic of 6.20), and the insignificance of lagged debt on wage taxes or interest income taxes lends support to Barro's (1979) hypothesis that governments meet shifts in expenditures primarily by issuing debt rather than raising taxes. However, the negative and significant effect of lagged debt on current expenditures also suggests that increasing levels of debt tends to reduce expenditures. Additional lagged variables were not generally significant.[16]

The correlation coefficients for the contemporaneous residuals are also presented in Table 1. The interpretation of the covariance structure is more relevant to the study of how uncertain taxes interact with other factors. For example, the positive correlation (0.457) between earnings and wage taxes means that an unexpected drop in earnings (or holding hours per worker constant, wages) will lead to a lower than expected wage tax. Thus the worker is partially "insured" by the knowledge that net wages will not drop by the full proportional amount of the gross wage decrease. The negative covariance between the interest income tax and real interest rates leads to even more uncertainty in the net-of-tax rate of return; unexpectedly low gross interest rates are associated with high taxes, and conversely. This negative correlation may be caused by unexpected

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[16] The only exception was the interest rate regression, in which the dependent variable lagged 2 years was strongly significant. To preserve computational simplicity, however, a first-order lag structure was assumed for the entire VAR model.

inflation, which tends to reduce ex-post real interest rates and increase effective tax rates. The standard error of the one-year forecast is 1.8 percent for the wage tax and 3.3 percent for the interest income tax.

The Joines data stop at 1975, so that measures of effective tax rates from King and Fullerton (1985) are used for 1980. Weighted effective tax rates for capital income including insurance companies and non-profit institutions were 37.2 percent, and the tax on labor income plus the measure of social security taxes (Barro and Sahasakul, 1983) yields 37.1 percent. The 1980 average wage and interest rates were $5.02 and 2.7 percent, respectively. The coefficents of Ψ used to predict $\tilde{\Gamma}$ are presented in Table 2, along with the initial (1980) variables and the predictions. Assuming stationarity of the model, the optimal prediction is that earnings will rise from $10,040 to $12,160 in real terms, the government will erase its debt, the wage tax will fall to 31.7 percent (3.5 percent standard error) and the interest income tax will rise to 44.2 percent (4.4 percent standard error).

Correlation coefficients of Ω, the variance-covariance matrix of $\tilde{\Gamma}$, are also presented in Table 2. In the long run, there is virtually no correlation between the error terms for gross wages and capital income taxes. The positive covariance between earnings and wage taxes (0.932) and the negative covariance between interest taxes and the interest rate (-0.744) become more pronounced in the 20 year forecasts. The next step is to measure how this uncertainty affects consumer's consumption, labor supply, and utility.

IV. A Model of Consumption and Labor Supply

The utility function in equation (1) is specified as

$$EU = ((\alpha\ell_1^\rho + C_1^\rho)^{\gamma/\rho} + E\{(1+\delta)^{-1}(\alpha\ell_2^\rho + C_2^\rho)^{\gamma/\rho}\})/\gamma \qquad (13)$$

where δ is the time preference rate, and α is a parameter reflecting the relative tradeoff between leisure and consumption in a particular year. The leisure-consumption elasticity of substitution is $\sigma_\ell = 1/(1-\rho)$, while $\sigma_c = 1/(1-\gamma)$ is the elasticity of substitution between household "output" in year 1 and in year 2.[17]

Using the budget constraint from equation (4), the first order conditions for C_1 and ℓ_2 can be shown to be

$$E\{H_1^{\gamma/\rho-1}C_1^{\rho-1} - \left[\frac{1+r_2}{1+\delta}\right]H_2^{\gamma/\rho-1}w_2C_2^{\rho-1}\} = 0 \qquad (14a)$$

$$E\{H_2^{\gamma/\rho-1}[\alpha\ell_2^{\rho-1} - w_2C_2^{\rho-1}]\} = 0 \qquad (14b)$$

where[18]

$$C_2 = [X + (\theta-\ell_1)w_1 - C_1](1+r_2) + (\theta-\ell_2)w_2$$

$$\ell_1 = \left[\frac{w_1}{\alpha}\right]^{-\sigma_\ell} C_1$$

and

$$H_i = \alpha\ell_i^\rho + C_i^\rho$$

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[17] This utility function assumes that the intertemporal elasticity of substitution (σ_c) is equal to the inverse of the Arrow-Pratt relative risk aversion measure. They need not be; a monotonic transformation of EU could imply different values of the (inverse) Arrow Pratt measure and the elasticity of substitution (Hall, 1985).

[18] In general, ℓ_1 is predetermined, since it was chosen at time 0. Assuming that it is freely chosen, as is done here, will tend to understate the true welfare cost of tax uncertainty.

Equations (14a) and (14b) are highly non-linear, and can be solved using numerical methods. Note that the consumption and labor supply decisions depend only on wages, the interest rate r_2 (which is the annual interest rate accumulated over the n-year period), and taxes, but not on government expenditures and debt. Writing wages as earnings divided by 1830 hours (see below), denoting the LHS of (14a) as M_c and the LHS of (14b) as M_ℓ, and assuming normal error terms, the first order conditions take the form

$$\int_{-a_1}^{a_1} \int_{-a_2}^{a_2} \int_{-a_3}^{a_3} \int_{-a_4}^{a_4} \zeta(w_2, r_2, t_2, \tau_2) M_j \, dw_2 dr_2 dt_2 d\tau_2 = 0 \qquad j=c,\ell \qquad (15)$$

where $\zeta(\cdot,\cdot,\cdot,\cdot)$ is the truncated density function of normally distributed random variables with mean $\tilde{\Gamma}$ and variance-covariance matrix given by the corresponding 4x4 submatrix of Ω (Johnson and Kotz, 1972; p. 40). The limits of integration given by a_i prevent explosive solutions (e.g., if $r_2 <$ -1) and reduce computational costs.

The parameters of the utility function were chosen to be consistent with life cycle consumption and labor choices for a representative individual between ages 30 and 40 making decisions about labor supply and consumption for ages 50-60. The Consumer Expenditure Survey of 1972-73 was used to measure household consumption and work hours for both the 30-39 year olds and the 50-59 year olds. Average consumption for the 30-39 year old families was \$9400, while gross-of-tax earnings were \$12,400 and assets (which includes the market value of the house) were \$19,000, or the potential for consuming an additional \$1900 per year over the 10 year period. Using information from the Survey on actual taxes paid, "virtual" income given the linear marginal tax rates was calculated to be $6500. Labor supply was assigned by multiplying the number of weeks worked during the past year times 40 hours (if a full time worker), 20 hours (if part time) or 0 hours (if reported not working). Average hours for the 30-39 year old were approximately 1830 yearly hours, while 50-59 year olds worked an average 1680 hours.

There is substantial evidence about the value of γ. Friend and Blume (1975) in their study of financial portfolio decisions suggested that σ_c was less than 0.5, while Ghez and Becker (1975) placed on σ_c an upper bound of 0.28. Skinner (1985) found estimates between 0.25 and 0.5, although Hansen and Singleton (1983) and Weber (1970,1975) found values generally exceeding 0.5. I assume that $\sigma_c = 0.35$, although the model is tested for higher and lower elasticities.

The evidence on the uncompensated labor supply elasticity in static models suggests an average elasticity of approximately 0.3.[19] The link between the elasticity of substitution σ_ℓ and the conventional labor supply elasticitiy is complex, since changes in the wage rate will also have an impact on the dynamic path of labor supply. If we assume that the wage change is foreseen, it can be shown the implied σ_ℓ corresponding to the 0.3 labor supply response will be approximately 0.5.[20] The time preference rate

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[19] From Killingsworth (1983; pp. 119-124), men's labor supply appears to be at most 0, while for women it is at least 1.0 (although there is considerable variability in coefficient estimates across studies). Weighting the two elasticities by labor force participation yields an average of 0.4. However, other studies of aggregate labor supply (Killingsworth, 1983; p. 125) report elasticities primarily less than 0.2; thus a midpoint of 0.3 is adopted.

δ was chosen to replicate the observed level of consumption in the first period (\$9400), total time endowment θ was set to 4000 hours, and the leisure preference parameter α was adjusted to insure 1830 hours were spent working in the first period.[21]

Comparing a regime with taxes that have a random component and taxes that can be forecast with compelete certainty is problematic, since switching to certain taxes will have general equilibrium effects on the distribution of gross wage and interest rates. However, we can pose the following conceptual experiment -- what are the effects of certain taxes on an individual given the variance-covariance structure of gross wage and interest rates? That is, under the status quo of uncertain taxation, consumption and labor supply are chosen which satisfy (14a) and (14b) integrated over uncertain w_2^*, r_2^*, t_2, τ_2. This outcome is compared to certain taxation, in which savings and labor supply are chosen subject to (14a) and (14b) integrated over uncertain w_2^* and r_2^*, holding t_2 and τ_2 constant (i.e., perfectly foreseeable) at their mean values. The government can expect to raise equal revenue in both cases.

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20 The labor supply parameter can be transformed into σ_ℓ by solving for $-\partial\ell/\partial w(w/(\theta-\ell)$ in the certainty model; the general solution for n-period models of this sort can be found in NBER Working Paper 819, an early version of Auerbach, Kotlikoff, and Skinner (1983).

21 The distribution of uncertain wages, interest rates, and taxes was truncated by a rectangle 2.5 standard deviations above and below the mean for all four variables, encompassing 96.3 percent of the normal distribution. The mean value of the gross interest rate used in the simulation, r', was adjusted to ensure that its expected value $E\{(1+r')^{19}\}$ was equal to the perfect certainty interest rate $(1.077)^{19}$.

The first row of Table 3 presents the results of the model for the baseline parameters of σ_c and σ_ℓ. When certain taxes are imposed, hours of work rise by 0.1 percent in the first period, and fall by 1.8 percent in the second period. The explanation for these changes is that the certain tax regime reduces the variance in net interest rates. Thus providing for C_2 is more easily achieved by saving in the first period, rather than working extra hours in the second period; overall savings rises by a total of 0.8 percent.

The utility gain of certain tax policy is expressed as a proportion of the present value of lifetime income. As Stiglitz (1982) and Weiss (1976) have emphasized, increased revenue from uncertain taxes can potentially raise sufficient revenue to offset the loss in utility of risk averse consumers. Thus the welfare change is measured as the dollar value of the shift in ex ante utility plus the revenue gain (or loss) from certain taxation. Column 6 indicates that for the parameters $\sigma_c = 0.35$ and $\sigma_\ell = 0.50$, the welfare gain of certain tax rates is 0.4 percent of lifetime income. Conversely, the annual loss of uncertain taxation, expressed as a proportion of 1985 U.S. national income, is $12 billion.

This finding is not particularly sensitive to alternative specifications of the utility function. Rows 2-5 present results from the numerically computable model for different values of σ_c and σ_ℓ. Row 2 uses an intertemporal elasticity of 1.35; while savings and labor supply is more responsive to the more certain tax policy, the welfare gain is only 0.2 percent. A high intertemporal elasticity of substitution is also equivalent

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to a low degree of risk aversion in this model; hence the reduction in income variation is less valuable. When the labor elasticity is set to 1.5 (row 3) the results differ slightly from the baseline case in row 1; there is a 0.4 percent welfare gain from certain taxation. The benefits of certain taxation are 0.5 percent of income when $\sigma_c = 0.15$, reflecting the greater degree of risk aversion, while when the labor supply elasticity is 0.15, the efficiency gain of certain taxation is 0.8 percent. The doubling of the welfare gain reflects the modest substitutability between predetermined ℓ_2 and random C_2. Finally, the 6th row describes the welfare gain of uncertain taxes when virtual income is increased from $6500 to $8500. Because the consumer saves a larger fraction of income, and hence is subject to greater uncertainty from the interest income tax, the gain of certainty in tax policy rises from 0.4 percent to 0.6 percent. This calculation provides support for the notion that the interest income tax, both because of its greater variability, and its negative correlation with real interest rates, causes the greatest harm to risk-averse taxpayers.

One extension of this model would be to introduce government expenditures explicitly into the utility function. The assumption of the current model is that expenditures enter utility independently of private consumption goods. However, if government expenditures (e.g., medicare, housing, social security) substitute for private expenditures, then taxpayers would be partially compensated for expenditure increases associated with tax hikes. If government expenditures did substitute for private goods, then the welfare cost of uncertain tax policy would be reduced.

V. Conclusion

The traditional analysis of uncertainty and taxation focused on the beneficial effects of a certain tax on the return from a risky asset (Stiglitz, 1969; Eaton and Rosen, 1980; Kanbur, 1983) The government, by collecting a fixed proportion of the return, or subsidizing a fixed proportion of the loss, shares the risk of the investment. This paper has shown that tax rates in the United States have displayed considerable variability during the period 1929-1975, thereby eroding the potential benefits of taxes in reducing risk. The additional excess burden of uncertain rather than certain tax policy is estimated to be 0.4 percent of GNP, or $12 billion in 1985. The random components of the wage and its tax rate are positively correlated, but the random components of the real interest rate and its tax rate are negatively correlated, suggesting that capital income taxation increases the variability of net interest rates.

Uncertain tax policy may also be harmful if "permanent" tax cuts are perceived by taxpayers as random and unlikely to persist in the future. Although the perceived temporary tax cuts may stimulate short-run investment, the loss in revenue may not be compensated for by an increase in long-term investment (Skinner, 1984).

Tax policy is often unpredictable because of factors beyond the control of the government. However, the cost of extensive tinkering with the tax code should be recognized. Furthermore, the value of tax provisions that are flexible to future economic conditions, such as the indexing of capital gains to inflation, are substantial in an uncertain environment. Neither the government nor the taxpayer gain from tax codes which must constantly be adjusted in light of differing rates of inflation or economic activity. While taxes may be inevitable, they need not be as unpredictable.

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Table 1: Coefficient Matrix of the VAR Model
and Correlation Coefficients of the Residuals

Equation:	(1)	(2)	(3)	(4)	(5)	(6)
Lagged:	Expend.	Debt	Earnings	Int. Rate	Wage Tax	Int. Tax
Expenditures	1.023	0.992	3.729	0.249	-0.014	0.001
	(7.87)	(6.20)	(3.80)	(2.05)	(0.33)	0.01
Debt	-0.261	0.753	-1.773	-0.079	-0.025	0.039
	(6.15)	(14.44)	(5.53)	(1.99)	(1.83)	0.96
Earnings	-0.033	-0.048	0.443	-0.051	0.009	0.012
	(1.95)	(2.32)	(3.46)	(3.24)	(1.62)	0.73
Interest Rate	-0.286	-0.121	-1.228	0.27	0.036	0.239
	(1.87)	(0.64)	(1.06)	(1.89)	(0.74)	1.61
Wage Tax	0.256	-0.079	9.923	1.336	0.631	-0.413
	(0.62)	(0.15)	(2.94)	(3.44)	(4.71)	1.02
Int. Income Tax	0.303	0.049	-0.594	-0.611	0.181	0.987
	(1.52)	(0.20)	(0.40)	(3.29)	(2.82)	5.14
Constant	0.158	0.177	2.578	0.421	-0.071	-0.0237
	(1.51)	(1.40)	(3.23)	(4.28)	(2.09)	0.23
R-Bar Squared	0.816	0.964	0.975	0.576	0.973	0.821
Standard Error	0.034	0.041	0.254	0.031	0.018	0.033

Correlation Coefficients of Residuals

	Expend.	Debt	Earnings	Interest	Wage Tax	Int. Tax
Expenditures	1.000					
Debt	0.759	1.000				
Earnings	0.679	0.333	1.000			
Interest Rates	0.186	0.438	0.419	1.000		
Wage Tax	0.533	0.234	0.457	-0.062	1.000	
Interest Tax	0.416	0.026	0.443	-0.248	0.766	1.000

Note: Earnings are measured in units of 1,000. Absolute values of t-statistics are in parentheses.

Table 2: Matrix of Coefficients and Residual Correlation Coefficients for Predictions 1995-2005

Lagged Vars.	(1) Expend.	(2) Debt	(3) Earnings	(4) Int. Rate	(5) Wage Tax	(6) Int. Tax
Expenditures	-0.040	0.350	-2.299	-0.040	-0.562	0.557
Debt	-0.034	0.214	-1.520	-0.026	-0.370	0.318
Earnings	0.007	-0.049	0.341	0.005	0.008	-0.008
Interest Rate	0.036	-0.262	1.852	0.032	0.051	-0.032
Wage Tax	0.219	-1.651	11.898	0.175	0.304	-0.244
Int. Income Tax	0.057	-0.265	2.144	0.035	0.061	-0.022
Constant	0.222	0.870	4.667	-0.034	0.127	0.592
1980 Baseline	0.364	0.234	10.04	0.027	0.371	0.372
Estimate 1995-04	0.372	-0.160	12.16	0.077	0.317	0.442
S. E. of Estimate	0.039	0.117	0.875	0.023	0.035	0.044

Correlation Coefficients of Residuals

	Expend.	Debt	Earnings	Int. Rate	Wage Tax	Int. Tax
Expenditures	1.000					
Debt	0.152	1.000				
Earnings	0.740	-0.388	1.000			
Interest Rates	-0.502	-0.730	-0.003	1.000		
Wage Tax	0.770	-0.112	0.932	-0.226	1.000	
Int. Income Tax	0.721	0.625	0.365	-0.744	0.622	1.000

Table 3: Savings, Labor Supply, and the Excess Burden of Certain and Uncertain Tax Policies

Row:	(1) Inter-temporal Elasticity (σ_c)	(2) Leisure-Consump. Elasticity (σ_ℓ)	(3) Change in 1st Period Hours of Work	(4) Change in 2nd Period Hours of Work	(5) Change in Savings	(6) Welfare Gain
1	0.35	0.50	0.1	-1.8	0.8	0.4
2	1.35	0.50	0.8	-2.3	3.5	0.2
3	0.35	1.50	0.1	-1.0	0.6	0.4
4	0.15	0.50	-0.1	-0.4	-0.4	0.5
5	0.35	0.15	0.5	-2.5	1.8	0.8
6*	0.35	0.50	0.1	-3.6	0.2	0.6

Notes: The utility parameters are adjusted so that first period consumption is $9400 and first period labor supply is 1830 annual hours in the perfect foresight case for each numerical simulation. All changes are in percentage terms. Welfare gain is expressed as a percentage of lifetime income.

* Non-wage income is $8500 rather than $6500.