Tax Rates, Factor Employment, and Market Production

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INTRODUCTION

An increasing amount of attention has recently been devoted to the effects of alternative tax structures on the pattern of economic activity, on the level of taxable economic activity, and on the aggregate amount of revenue generated by the tax system. In this paper, a static, one-sector, two-factor model is developed in order to analyze the effects of taxes imposed purely for the purpose of generating revenues.[1] For simplicity, these taxes are assumed to be proportional taxes on the incomes of factors of production. We derive some properties of the tax structure needed to maximize output while raising a given level of government revenue. We then examine empirically a specific instance of tax cuts, the Kennedy cuts of the early 1960s, to determine their effect on revenues.

The model we present is a highly simplified one. While we call our two factors of production capital and labor, we do not distinguish one as fixed and the other as variable. Since the model is static, we do not attempt to analyze the process of capital formation.[2] Instead, we assume that at any point there exist fixed stocks of capital and labor and that these stocks must be allocated either to household production or to market sector production.[3]

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[1]More accurately, our model only has one market output. It is in fact a two-sector model in the sense that it has a household production sector which also employs capital and labor in proportions which depend upon their relative cost.

[2]For dynamic models which treat capital formation as the outcome of an intertemporal utility maximization process see Canto (1977) and Joines (1979).

[3]For a discussion of household production see, for example, Becker and Ghez (1975).

THE MODEL

Two factors are combined in the market sector according to a Cobb-Douglas production function to produce the market good Q:

$$(1) \qquad Q = K^{\alpha}L^{(1-\alpha)},$$

where α and $(1-\alpha)$ are the partial output elasticities of capital (K) and labor (L), respectively, and $0 < \alpha < 1$. The market good, capital, and labor are inputs into the household production process. Capital and labor thus have identical analytical properties except that they are not perfect substitutes in either household or market production.

We assume that factors employed in the market sector are paid their marginal products and that the rental rate received by capital (R^*) and the wage rate received by labor (W^*) differ from the rates paid because of the taxation of factor income:

$$(2) \qquad W^* = W(1 - t_L)$$

$$(3) \qquad R^* = R(1 - t_K)$$

where W and R are the gross-of-tax wage and rental rates on labor and capital services, and t_L and t_K are the tax rates on income of labor and capital, respectively. These tax rates are expressed as percentages of the rental and wage rates paid. The gross-of-tax factor payments are denominated in terms of the market good Q.

A change in the ratio of W to R will cause a change in the ratio of capital to labor demanded by firms for production of any level of market goods. One of the characteristics of the Cobb-Douglas production function is the constancy of the shares of the factors of production. Accordingly, the demands for labor and capital and the optimal factor proportions are:

$$(4) \qquad K^d = \frac{\alpha Q}{R}$$

$$(5) \qquad L^d = \frac{(1 - \alpha)Q}{W}$$

$$(6) \qquad \frac{K^d}{L^d} = \frac{\alpha}{(1 - \alpha)} \frac{W}{R} = \frac{\alpha}{(1 - \alpha)} \frac{(1 - t_K)}{(1 - t_L)} \frac{W^*}{R^*}$$

A change in the ratio of W* to R* will cause a change in the ratio of capital to labor demanded by households for production of any level of the household commodity. In addition, an increase in the absolute levels of W* and R*, given the same ratio of W* to R*, will cause households to substitute market goods for capital and labor in the production of a given level of the nonmarket commodity. In other words, an equiproportional increase in W* and R* causes households to supply more of both capital and labor to the market sector. Specifically, we assume that the supply functions for capital and labor take the following form:[4]

$$K^s = \left(\frac{R^*}{W^*}\right)^{\sigma_K}\left(R^*\right)^{\varepsilon} \qquad \varepsilon + \sigma_K > 0 \tag{7}$$

$$L^s = \left(\frac{W^*}{R^*}\right)^{\sigma_L}\left(W^*\right)^{\varepsilon} \qquad \varepsilon + \sigma_L > 0 \tag{8}$$

It is assumed that the government derives its revenue entirely from proportional taxes on factor income, that its budget is always balanced, and that revenue collections are returned to the economy in a neutral fashion so that no income effects are generated.[5]

[4]Notice that these assumptions yield positive own-price factor supply elasticities.

$$\varepsilon^s_{LR} = \frac{W^*}{L}\,\frac{\partial L}{\partial W^*} = (\sigma_L + \varepsilon) > 0$$

$$\varepsilon^s_{KR} = \frac{R^*}{K}\,\frac{\partial K}{\partial R^*} = (\sigma_K + \varepsilon) > 0$$

The cross-price elasticities, however, could be either positive or negative.

$$\varepsilon^s_{KW} = \frac{W^*}{K}\,\frac{\partial K}{\partial W^*} = -\,\sigma_K \gtrless 0$$

$$\varepsilon^s_{LR} = \frac{R^*}{L}\,\frac{\partial L}{\partial R^*} = -\,\sigma_L \gtrless 0$$

[5]For simplicity it is assumed that:

a. government expenditure takes the form of transfer payments to individuals, receipt of which is unrelated to factor supply,

b. there is no waste or inefficiency on the part of the government, and

c. taxes and transfers are costless to collect and distribute, respectively.

Under these conditions government spending will have no net income effect, only a substitution effect due to the relative price changes resulting from the taxes. Joines (1979) and Canto (1977) develop a similar analysis of government fiscal policy in which the possibility of deficit financing is presented. Canto and Miles (1980) consider the possibility of income effects resulting from different types of government expenditure, collection costs, and the government efficiency level.

Combining equations 7 and 8, the ratio of factors supplied to the market sector is:

$$(9) \qquad \frac{K^s}{L^s} = \left(\frac{R^*}{W^*}\right)^{\sigma_s} \qquad \sigma_s > 0$$

where σ_s, the elasticity of substitution in factor supply, is assumed to be positive and defined as $\sigma_K + \sigma_L + \varepsilon$. Equation 9 says that the ratio of capital to labor supplied to the market sector depends only upon the after-tax wage-rental ratio. On the other hand, equation 6 says that the proportion of capital to labor demanded by the market sector depends only upon the gross-of-tax wage-rental ratio. Combining the two equations, one can solve for the equilibrium level of the gross- and net-of-tax wage-rental ratio as a function of the tax rates:

$$(10) \qquad \frac{W^*}{R^*} = \left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{\frac{1}{1+\sigma_s}}$$

$$(11) \qquad \frac{W}{R} = \left(\frac{1-\alpha}{\alpha}\right)\left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{\frac{-\sigma_s}{1+\sigma_s}}$$

Equations 10 and 11 show that both the net-of-tax wage-rental ratio and the gross-of-tax wage-rental ratio depend upon tax rates, factor supply elasticities, and output elasticities of the two factors.

It can be shown that if producers maximize profits, the cost function of the market good will also be of the Cobb-Douglas form:

$$(12) \qquad 1 = \left(\frac{W}{1-\alpha}\right)^{(1-\alpha)} \left(\frac{R}{\alpha}\right)^{\alpha}$$

where the market good has been defined as the numeraire.

Rearranging equation 12 and substituting for the gross-of-tax wage-rental ratio (equation 11), one can solve for the gross-of-tax wage rate:

$$(13) \qquad W = (1-\alpha)\left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{-\frac{\alpha\sigma_s}{1+\sigma_s}}$$

Similarly, the gross-of-tax rental rate can be expressed as:

$$(14) \qquad R = \alpha \left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{\frac{(1-\alpha)\sigma_s}{1+\sigma_s}}$$

Substituting equations 13, 14, 2, and 3 into the factor supply equation, one can determine the equilibrium quantities of each factor and the proportions of capital to labor employed in the market sector:

$$(15) \quad K = (\alpha(1-t_K))^{\varepsilon}\left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{\frac{\varepsilon(1-\alpha)\sigma_s-\sigma_K}{1+\sigma_s}}$$

$$(16) \quad L = [(1-\alpha)(1-t_L)]^{\varepsilon}\left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{\frac{\sigma_L-\alpha\sigma_s\varepsilon}{1+\sigma_s}}$$

$$(17) \quad \frac{K}{L} = \left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{-\frac{\sigma_s}{1+\sigma_s}}$$

The equilibrium level of market output as a function of the tax rates is obtained by substituting equations 15 and 16 into equation 1:

$$(18) \quad Q = ((1-\alpha)(1-t_L))^{\varepsilon}\left[\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-t_L}{1-t_K}\right)\right]^{\frac{\sigma_L-\sigma_s(1+\varepsilon)\alpha}{1+\sigma_s}}$$

Effects of Taxation on Market Activity

Upon inspection of equations 13, 14, and 11, it is apparent that an increase in the labor wedge [i.e., a reduction in $(T_L = \frac{W^*}{W})$] will unambiguously increase the equilibrium levels of the gross-of-tax wage rate (W) and wage-rental ratio (W/R) and decrease the equilibrium levels of the gross-of-tax rental rates.[6]

The increase in the gross-of-tax wage-rental ratio will generate a substitution effect away from labor into capital. The equilibrium level of labor employed in the market sector will unambiguously decline.[7] The effect of the tax on the equilibrium level of capital employed will be ambiguous.[8] However, the capital-labor ratio will

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[6]Defining E as the d log operator, $T_L = (1 - t_L)$ and $T_K = (1 - t_K)$ Differentiating logarithmically Equations 13, 14 and 11 one obtains

$$13)\ EW = \frac{\alpha\sigma_s}{1+\sigma_s} E(T_K/T_L)$$

$$14)\ ER = -\frac{(1-\alpha)\sigma_s}{1+\sigma_s} E(T_K/T_L)$$

$$15)\ E\,(W/R) = \frac{\sigma_s}{1+\sigma_s} E(T_K/T_L)$$

Notice that $ET_K = -\dfrac{dt_K}{T_K}$ and $ET_L = -\dfrac{dt_L}{T_L}$

[7]Differentiating logarithmically equation 16

$$EL = \varepsilon\, ET_L - \frac{\sigma_L - \alpha\sigma_s\varepsilon}{1+\sigma_s} E(T_K/T_L)$$

$$= -\left(\frac{\sigma_L - \alpha\sigma_s\varepsilon}{1+\sigma_s}\right) ET_K + \left[\frac{\varepsilon + \sigma_L + (1-\alpha)\sigma_s\varepsilon}{(1+\sigma_s)}\right] ET_L$$

The coefficient for the ET_K term is clearly ambiguous. This ambiguity is due to two opposing effects. One is the substitution effect generated by an increase in the tax rate on capital which leads to a higher proportion of labor services being used in the production of market goods, and the other is a scale effect (reduction in output) which leads to a lower amount of labor services being demanded. Whether employment of labor increases or not depends on the relative strength of the two effects. On the other hand, since $\varepsilon + \sigma_L > 0$, $\sigma_s > 0$, and $\varepsilon > 0$ by assumption, the coefficient for the ET_L term is unambiguously positive. In this case, the scale and substitution effect reinforce each other.

[8]Differentiating logarithmically equation 15

$$EK = \varepsilon\, ET_K - \frac{\varepsilon(1-\alpha)\sigma_s - \sigma_K}{1+\sigma_s} E(T_K/T_L)$$

$$= \frac{\varepsilon(1-\alpha)\sigma_s - \sigma_K}{1+\sigma_s} ET_L + \frac{\varepsilon + \alpha\varepsilon\sigma_s + \sigma_K}{1+\sigma_s} ET_K$$

As in the previous footnote, the coefficient for the second term is unambiguously positive, while that of the first term is clearly ambiguous. The ambiguity of the first term is due to two opposing effects. One is the substitution effect which leads to a higher proportion of capital per worker and the other is the scale effect (reduction in output) which leads to a lower amount of capital being demanded. Whether employment of capital increases or not depends on the relative strength of the two.

unambiguously increase, resulting in a net reduction of the level of production of the market goods.[9] The effects of an increase in the tax on income from capital can be analyzed in a similar manner.

Using the simplified model developed in the previous section, we derive certain propositions concerning the effects on output and government revenue of changes in the two tax rates. The specific forms taken by the proofs of these propositions depend upon the structure we have assumed for our model. This structure allows us to obtain a closed form solution for the variables of interest. Despite its simplifications, we feel the present model is useful as a pedagogic device for demonstrating the propositions. Most of these propositions can be proved using less restrictive models which derive the factor supply decisions as explicit results of utility maximization, treat capital accumulation in a dynamic framework of intertemporal choice, and allow for the possibility of government debt.

Proposition 1. There exists a trade-off between taxes on labor and capital necessary to maintain output at a given level.

The percentage change in output is:

$$EQ = \varepsilon\, ET_L - \left(\frac{\sigma_L - \sigma_s(1+\varepsilon)\alpha}{(1+\sigma_s)}\right) E(T_K/T_L) \tag{19}$$

At a given level of output (i.e., on an isoquant), $EQ = 0$. Thus, the previous equation implies that:

[9]For a Cobb-Douglas production function, $E(K/L) = E(W/R)$. In footnote 6, it was shown that

$$\frac{E(W/R)}{E(T_L/T_K)} = -\frac{\sigma_s}{1+\sigma_s} < 0$$

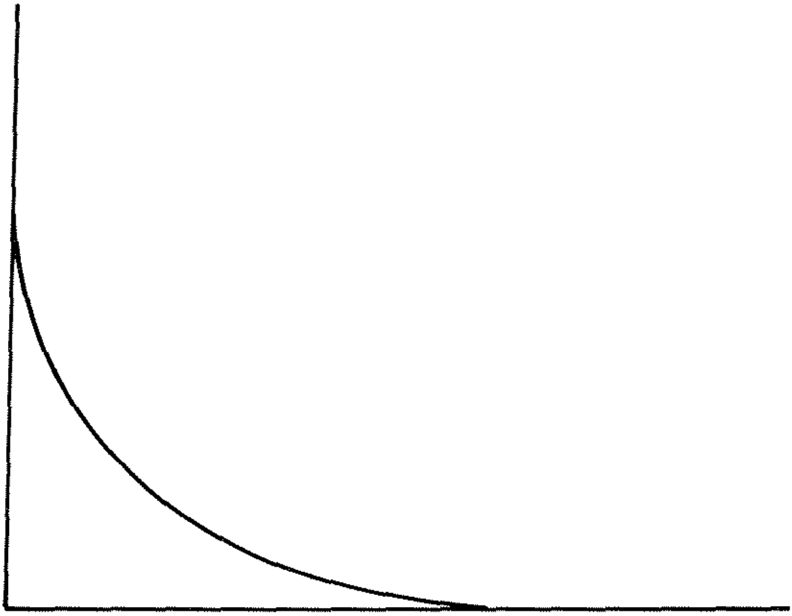
Differentiating equation 18 logarithmically

$$EQ = \varepsilon ET_L - \frac{\sigma_L - \sigma_s(1+\varepsilon)\alpha}{1+\sigma_s} E(T_K/T_L)$$

$$EQ = \frac{(1+\varepsilon)\sigma_s(1-\alpha) - \sigma_K}{1+\sigma_s} ET_L + \frac{\alpha(1+\varepsilon)\sigma_s - \sigma_L}{(1+\sigma_s)} ET_K$$

The signs of the coefficients for T_L and T_K appear to be ambiguous. However, it is apparent that as long as the own price elasticities effects dominate the cross-price elasticities of factor supply, the coefficients will be unambiguously positive. In the remainder of this paper, it is assumed that own effects dominate cross effects. This assumption is consistent with available empirical evidence on factor supply. An implication of this assumption is that an increase in any of the factor tax rates will unambiguously reduce the level of market output.

FIGURE 1



$$\text{(20)} \qquad \frac{ET_K}{ET_L} = 1 + \frac{\varepsilon(1 + \sigma_s)}{\sigma_L - \sigma_s(1 + \varepsilon)\alpha} < 0,$$

from which one can derive the marginal rate of factor tax substitution.[10] This is merely the rate at which the economy can substitute the tax on a given factor of production for a tax on another factor, while keeping output constant. The marginal rate of factor tax substitution is the slope of an isoquant in the $t_L - t_K$ space. Such an isoquant is shown in Figure 1.

The above assumptions ensure that only one isoquant will pass through any point in the tax space. Also, the higher the level of tax rates, the lower will be the level of output. Thus, the closer an isoquant is to the origin, the higher is the level of output to which it corresponds. Within the relevant range, isoquants are concave from above; that is to say, the isoquants exhibit a diminishing marginal rate of factor tax substitution. They are also homothetic

[10]The negative sign is unambiguous given the assumption that own effects dominate cross effects. See n. 9.

in the tax space. Finally, since it is possible to produce some output without one of the factors being taxed, the isoquants will intersect each axis with a finite slope.

Proposition 2. There exists a tax structure that maximizes government revenue.

Here we seek to demonstrate that increases in tax rates are not always accompanied by increases in tax revenues, and the reverse may in fact be the case. Total government receipts can be expressed as:

(21)

$$G = Q[(1 - \alpha)t_L + \alpha t_K] = Q[(1 - \alpha)(1 - T_L) + \alpha(1 - T_K)].$$

Differentiating logarithmically, we have:

(22)

$$EG = \left[\frac{(1 + \varepsilon)(1 - \alpha)\,\sigma_s - \sigma_K}{1 + \sigma_s}\right] ET_L \quad \frac{(1 - \alpha)(T_L)}{1 - [(1 - \alpha)T_L + \alpha T_K]} ET_L$$

$$+ \left[\frac{(1 + \varepsilon)\,\alpha\sigma_s - \sigma_L}{1 + \sigma_s}\right] ET_K - \frac{\alpha T_K}{1 - [(1 - \alpha)\,T_L + \alpha T_K]} ET_K.$$

Equation 22 shows that the percentage change in tax revenue induced by changes in tax rates depends on the output elasticity with respect to tax rates (the first and third terms) and the levels of the tax rates on capital and labor. The equation implies that the government tax revenue will increase initially with increases in the tax rates, but at a decreasing rate. Thus, the marginal tax revenue raised decreases with increases in tax rates, finally reaching some point where the marginal tax revenue raised is zero. Beyond this point, any tax rate increases will reduce revenue collection. Tax revenue is maximized at the point at which the marginal tax revenue is zero. Figures 2 and 3 illustrate government tax revenues as functions of the tax rates on labor and capital, respectively, assuming that the tax rate on the other factor remains constant.

In Figures 2 and 3, two distinct stages can be identified. In Stage I, the normal range,

$$\frac{\partial G}{\partial t_L} > 0 \text{ and } \frac{\partial G}{\partial t_K} > 0\,.$$

FIGURE 2

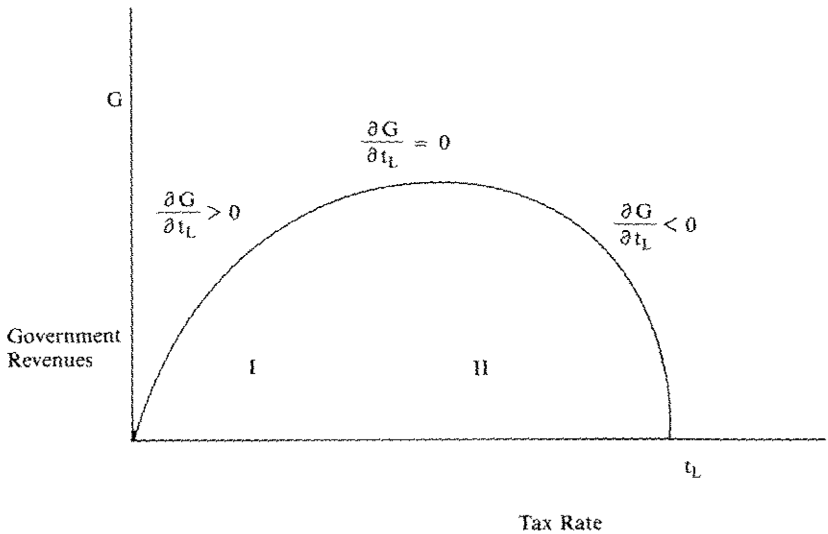
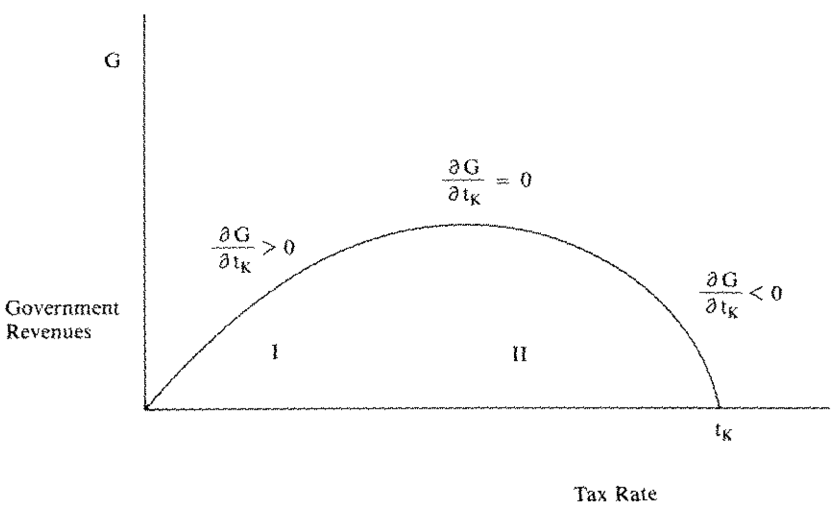


FIGURE 3



In other words, lowering tax rates lowers government receipts and vice versa. In Stage II, the prohibitive range,

$$\frac{\partial G}{\partial t_L} < 0 \text{ and } \frac{\partial G}{\partial t_K} < 0 ,$$

and increases in tax rates on labor and capital decrease government revenues, and vice versa.

In all the stages, the change in government revenues arising from changes in the tax rates depends on the elasticities of the factor supply curves, the output elasticities of the factors, and the level of the taxes. The foregoing analysis shows that there exists a tax structure at which government tax receipts are maximized.

The first-order conditions imply that G is maximized when

$$-A + (1 - \alpha)(A + 1)T_L + \alpha A T_K = 0 \tag{23}$$

$$-B + (1 - \alpha)BT_L + (B + 1)\alpha\, T_K = 0 \tag{24}$$

where

$$A = \frac{(1 + \varepsilon)(1 - \alpha)\sigma_s - \sigma_K}{1 + \sigma_s} \tag{25}$$

$$B = \frac{(1 + \varepsilon)\, \alpha\sigma_s - \sigma_L}{1 + \sigma_s} \tag{26}$$

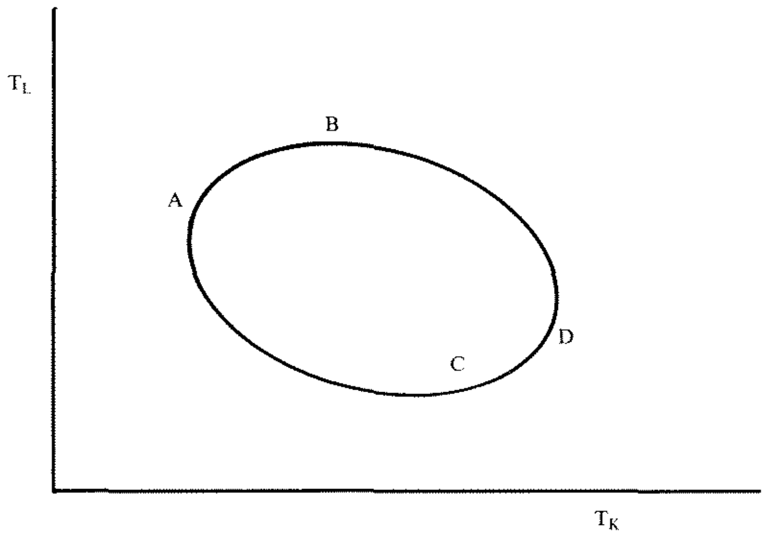
From equations 23 and 24, one can solve for the factor wedge:

$$T_L = \frac{A}{(1 - \alpha)(A + B + 1)} = \frac{(1 + \varepsilon)(1 - \alpha)\sigma_s - \sigma_K}{(1 + \varepsilon)(1 - \alpha)(1 + \sigma_s)} \tag{27}$$

$$T_K = \frac{B}{\alpha(A + B + 1)} = \frac{(1 + \varepsilon)\alpha\sigma_s - \sigma_L}{(1 + \varepsilon)\alpha(1 + \sigma_s)} \tag{28}$$

quations 27 and 28 illustrate the marginal wedges which maximize vernment tax revenues. Using these results, one can then solve licitly for the tax rates, the maximum amount of revenue that government can produce, and the corresponding level of output. apparent also that these results depend on the supply and ut elasticities of the factors of production.

FIGURE 4



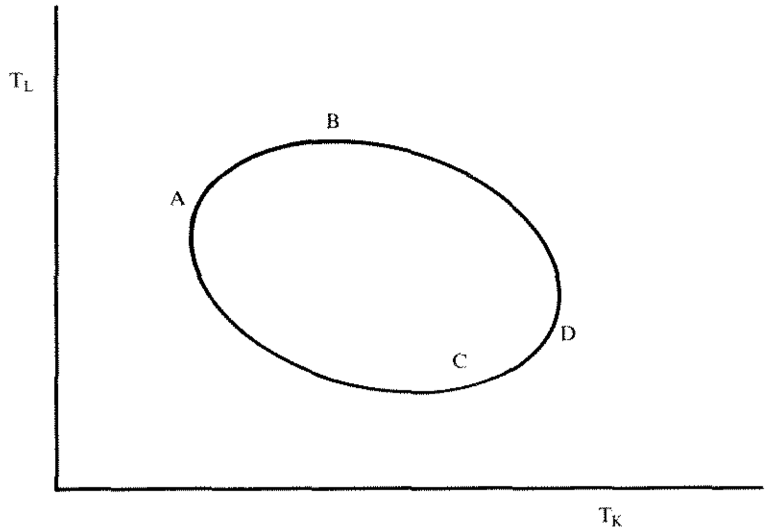
If both factor income tax rates are in the prohibitive range, an increase in either tax rate, the other rate constant, leads to a reduction in total revenue collected. Since both tax rates are in the prohibitive range, the other factor tax rate must be reduced if revenue is to remain unchanged. Hence the iso-revenue curve is also downward sloping in this region, which corresponds to segment BC in Figure 4.

In Case 3, one of the factor tax rates is in the prohibitive range while the other is in the normal range. An increase in the prohibitive tax rate leads to a reduction in revenue. If revenue is to remain unchanged, the tax rate in the normal range must increase, and the iso-revenue curve is therefore upward sloping. Case 3 corresponds to segments AB and CD in figure 4.

Higher valued iso-revenue curves lie inside lower valued curves. In the limit, the iso-revenue curve shrinks to a point, the maximum revenue point (Proposition 2).

Proposition 3: There exists a tax structure that maximizes output at a given level of government expenditures.

FIGURE 4



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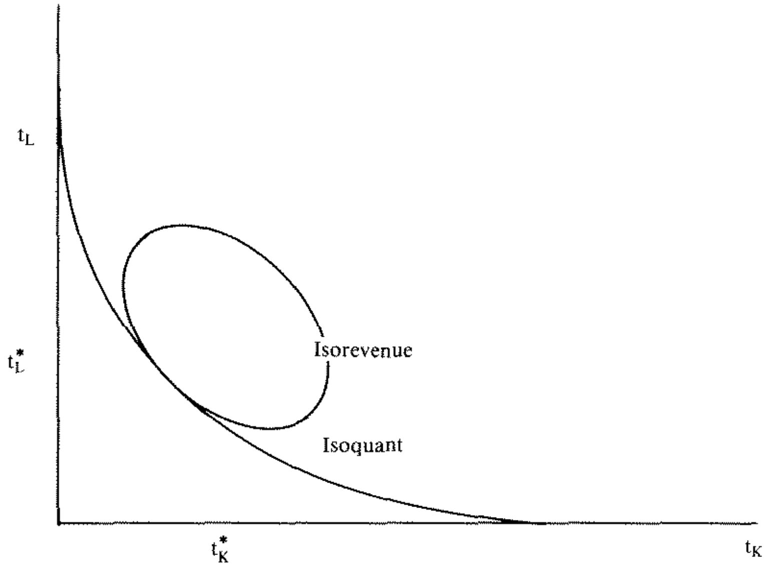

The graphical solution to this problem is quite simple.[11] The level of revenue collection determines the iso-revenue curve. Once this is known, the objective becomes to find the lowest possible isoquant that satisfies the revenue constraint. At this point the two curves are tangent. The question becomes which of the two loci has the largest curvature at the tangency point. It is obvious that the iso-revenue curve can never be below the isoquant. If it were, a lower isoquant (higher output level) could be found that yields the same amount of revenue. The graphical solution is presented in Figure 5.

The design of an optimal tax system has long been a matter of concern to economists.[12] In order to design an optimal tax system (since value judgments must be made as to the objective function to be maximized), some sort of social welfare function has to be specified. Our discussion of Proposition 3 implicitly assumes that

[11] For a formal derivation of this proposition, see Canto, Laffer, and Odogwu (1978).

[12] For an illustration see Harberger (1974), Mirlees (1971), Stiglitz (1972), Cooter (1978).

policymakers have somehow arrived at a social welfare function into which both transfer payments and market output enter with positive signs. In order to finance the transfers, some cost in terms of market output is incurred. Thus, a trade-off exists and the optimum will be at a point where the marginal social gain from the government expenditure equals the marginal social loss from the fall in output.

Empirical Evidence from the Kennedy Tax Cuts

In the previous section, we demonstrated that there is a tax structure which maximizes government revenue (Proposition 2) and that it is possible for tax rates to be so high as to generate less revenue than would be raised from lower tax rates. Whether any real-world governments have ever operated in the prohibitive range, however, is an empirical issue. There are several ways of analyzing this question, the most common of which is what might be called the "elasticities" approach. This approach consists of examining existing estimates of, for example, factor supply elasticities and tax rates. These estimates are applied to some theoretical model in order to simulate the revenue effects of tax rate changes. In general, the higher the elasticities and the tax rates, the more likely it is that the tax rates are in the prohibitive range. One recent study conducted along these lines is that of Fullerton (1980).

While this approach can undoubtedly provide valuable information on the revenue effects of tax cuts, it has several shortcomings. The first of these is that the effective tax base may be smaller than total economic activity. Some economic activity may escape taxation because it is legally exempt from taxation or because of outright tax evasion. The factor supply elasticities relevant for an analysis of revenue effects are the elasticities of supply of factors to *taxable* activities. If there is a reasonable degree of substitutability between taxable and nontaxable activities, then these elasticities may well be higher than the conventionally measured overall factor supply elasticities. This problem can be quite severe as concerns saving, since there are many uses to which saving can be put which involve a partial or complete tax exemption of the resulting income. Notable among these are residential capital and municipal bonds. Recent discussions of the "underground economy" suggest that under-reporting of income may well make the distinction between taxable and nontaxable activity important for labor supply as well.[13]

Another difficulty with employing this elasticities approach in a highly aggregated model is that there are in fact many tax rates which apply to different types of economic activity and also many categories of productive factors, each of which potentially has a different elasticity of supply to taxable economic activity. Given this multiplicity of tax rates and of types of factors, it seems quite likely that some tax rates somewhere in the system are in the prohibitive range. This, in fact, is the very essence of certain tariffs on international transactions which are imposed for protectionist purposes rather than for revenue generation. Certain features of the domestic U.S. tax system may also result in a high tax rate being imposed on an elastically supplied factor. For example, the federal personal income tax imposes a "marriage penalty" which taxes the income of a secondary worker at the marginal rate of the primary worker in the family. This fact, combined with evidence that married women have substantially higher labor supply elasticities than do prime-age males, makes it at least reasonable to conjecture that some features of the current tax system result in prohibitive taxation. Also, recent evidence indicates that proprietors of small businesses, who have more control over hours worked than do most employees, may have a considerably higher supply elasticity than do males in general.[14] Finally, effective marginal tax rates can be quite high for those in upper income brackets and can be even higher for

[13]The factor supply functions (equations 7 and 8) attempt to take these effects into account. As tax rates alter the relative price of factors of production, they also alter the relative price of the nonmarket (i.e., nontaxed) activities. The change in the factor supply to the market sector thus depends on two effects, a substitution effect in household production and a scale effect. The substitution effect is captured by the ε term in both factor supply equations.

These effects give rise to own and cross factor supply elasticities, as shown in n. 4. The own effects are always positive, and the cross effects are ambiguous.

It can be shown that if the product of the own-price elasticities is larger than that of the cross-price elasticities ($\varepsilon^s_{LW}\varepsilon^s_{KR} > \varepsilon^s_{LR}\varepsilon^s_{KW}$), the effects of taxes on output are qualitatively similar to those that neglect the cross effects. However, the magnitude of the change will be different. Whether the total effect is larger or smaller depends upon whether or not the cross-price elasticities offset or reinforce the own-price effects. In the latter case, it is easily shown that the market-output price elasticity will be larger than the case in which the cross-price elasticities are zero. Thus, the neglect of these cross elasticities (the interaction between the factor markets) could lead one to underestimate the economy's responsiveness to tax rate changes. See Canto (1977) and Joines (1979).

[14]See Wales (1973).

the poorest workers and those receiving Social Security, who stand to lose benefit payments as their earnings increase.

The relevant question to ask is thus not whether the United States or some other real-world economy is operating in the prohibitive range. It is quite likely that somewhere in the system there exists a tax rate on some type of activity which results in less revenue than would a lower tax rate. The relevant issue concerns the revenue effects of a specific set of tax rate changes.[15] Of particular interest are recent proposals for broad-based cuts in federal personal and corporate income tax rates. While the elasticities approach might be employed to simulate the effects of such a tax cut, another method suggests itself.[16] This method consists of examining past instances of similar tax cuts to determine their effects on revenue.

The Kennedy tax cuts of 1962 and 1964 offer a natural experiment. Following their enactment, the economy experienced a greater than normal expansion of real economic activity. A comparison between measures of economic activity prevailing before (1961) and after (1966) the tax cuts were enacted indicates that unemployment declined from 6.7 percent to 3.8 percent and capacity utilization as measured by the Federal Reserve Board increased from 77.3 percent to 91.9 percent. During this period, real GNP grew at an average annual rate of 5.9 percent. The average annual growth rate in nominal GNP was 7.5 percent, while federal government expenditures grew at a rate of 6.2 percent. Consequently, the ratio of government expenditures to GNP fell. It thus seems unlikely that the increase in economic activity can be attributed entirely to the stimulus of increased government spending.

Another issue concerns whether the apparent expansion of economic activity was sufficiently large to offset the negative effect on tax revenues of the tax rate reductions themselves. Alternatively stated, the issue concerns whether the economy was in the normal or the prohibitive range of the Laffer curve. Michael K. Evans'

[15]Fullerton recognizes the multiplicity of tax rates and factor supply elasticities to which we refer. He is also careful to simulate the effects of a specific tax cut—a broad-based cut in tax rates on labor income.

[16]In using the elasticities approach to simulate the effects of proposals such as the Kemp-Roth bill, one must be careful not to treat them as cuts only in labor income tax rates. They also entail reductions in personal tax rates on income from capital. The elasticity of supply of saving and factor demand elasticities, as well as labor supply elasticities, are important in such a model. In addition, there may be important cross elasticities of factor supply, as discussed in n. 13 above.

(1978) examination of revenue data for this time period indicates that revenues from individuals with taxable incomes in excess of $100,000 increased from $2.3 billion in 1962 to $2.5 billion in 1963, to $3 billion in 1964, and to $3.8 billion in 1965. Total personal income tax revenues, however, declined between 1963 and 1964. Although high-income individuals would appear to have been in the prohibitive range of the Laffer curve, the evidence concerning overall personal tax revenue suggests that the weighted average of the individual personal income tax rates was in the normal range. That is, a reduction in the overall personal tax rate led to a reduction in revenues. This can be attributed to a loss in tax revenues from individuals at low income levels in excess of the gain in tax revenues from individuals at high income levels.

Other casual evidence on the revenue effects of the Kennedy tax cuts exists, but there is some dispute as to the interpretation of this evidence. Representative Kemp and Senator Roth have asserted that federal tax revenues during the fiscal years 1963 through 1968 showed a cumulative increase of $54 billion over the 1962 level of annual receipts, whereas the Treasury Department had estimated a cumulative revenue loss of $89 billion over the same period as a result of the tax cuts.[17] Heller (1978) and others have pointed out that these two numbers are not comparable, however. The $54 billion refers to the increase in actual revenues between the earlier and later years. The $89 billion figure is the Treasury Department's estimate of the difference between actual revenues during the later period and what they would have been during the same period if the tax reduction had not occurred. That there is no necessary inconsistency between these two numbers can be seen by examining a similar set of estimates reported by Pechman (1965). Pechman forecast that actual individual income tax liability on returns filed for 1965 would be $46.4 billion, or $10.7 billion lower than his estimate of 1965 liability with no tax cut, but $1.6 billion higher than actual liability on 1962 returns. Furthermore, if the $89 billion figure cited by Kemp and Roth were adjusted to include similar Treasury estimates of the effects of the Tax Adjustment Act of 1966, the Treasury's cumulative revenue loss estimate would be only $83 billion.

It is quite possible that the Pechman and Treasury estimates overstate the size of the actual revenue loss resulting from the tax cuts of the early 1960s. These estimates are derived by comparing

[17]See Kemp (1977).

the revenues which would result from applying alternative tax structures to a *given* level of economic activity. Such "static" estimates thus ignore any feedback effects of tax rates on economic activity and revenues. If these feedback effects are quantitatively important, then the static estimates may considerably overstate the true revenue loss.

It would be desirable to obtain an alternative set of revenue loss estimates which allow for any actual feedback of tax rates on economic activity. Such estimates would not be based on any prescribed level of economic activity. In the next section, we report such a set of estimates derived from univariate time series analysis of various revenue series and reported in Canto, Joines, and Webb (1980).

TIME SERIES ESTIMATES

There are several ways of obtaining revenue estimates without first prescribing a level of aggregate economic activity. The desirability of these estimates rests on the belief that the true structure of the economy is such that tax rate changes affect economic activity. An obvious way of incorporating any existing feedback effects would be to estimate a structural model which includes such effects. This model could be used to obtain forecasts of what revenues would have been in the absence of tax rate cuts, and these forecasts could in turn be compared with actual revenues. Alternatively, the model could be used to simulate the effects of various tax changes.

There are several difficulties with this approach, however. Aside from the sheer effort required to design and estimate a complete structural model, the resulting forecasts would be subject to certain sources of error in addition to the parameter estimation errors which affect all attempts at statistical inference. The most important of these sources is misspecification of the structural model, either through an incorrect choice of variables to be included in the model or through the imposition of incorrect identifying restrictions. In addition, Lucas (1976) points out that policy simulations based on such structural models are inherently suspect because the parameters of the model will in general be functions of policy variables and will change in response to shifts in those policy variables.

Zellner and Palm (1974) provide an exhaustive taxonomy of the various types of equations associated with dynamic simultaneous equation systems and discuss the uses and limitations of each. It is of particular interest to note that the univariate time series properties of the system's endogenous variables are implied by the structure of the model and the time series properties of the exogenous variables. It is thus meaningful to fit time series models to each of the endogenous series over periods when both the structure of the complete model and the time series properties of the exogenous variables are stable. One of the primary uses of such a simple univariate model is in forecasting the series to which it is fit. In addition, these models make much more modest demands in terms of data requirements and a priori knowledge of the system's structure than would full-blown structural estimation. Furthermore, as Nelson (1973) points out, univariate time series models are not subject to errors in specifying the structure of the complete model, and hence in theory need not yield less accurate forecasts than would structural estimation. The results reported in Nelson (1972) indicate that this conclusion holds in practice as well as in theory.

From 1950 to the early 1960s there existed the most stable federal tax policy of any period of comparable length since the end of World War I. There were no important changes in personal or corporate income tax rates from 1951 to 1964. Compared to the fluctuations in tax rates during the Great Depression, World War II, and the Korean War, the stability during the later period is quite striking. It thus seems reasonable to regard this period as one during which the underlying structure of the economy was fairly stable. Furthermore, the period of stability is long enough to provide a minimal number of observations for estimation of univariate time series models. Canto, Joines, and Webb used this period to fit univariate models to various revenue series of interest and employed these models to forecast revenues into the mid-1960s under the assumption that there would be no changes in tax rates or the underlying structure of the economy. The forecast errors from these models can be regarded as point estimates of the revenue changes resulting from the tax rate cuts of the early 1960s.

The two federal revenue series to which univariate models were fit are denoted FPR and FCR. They represent, respectively, quarterly federal personal income tax receipts and quarterly federal corporate income tax receipts, each deflated by the Consumer Price Index. The base period for the price deflation is the fourth quarter of 1963. None of these series has been seasonally adjusted.

The models which fit these two series are:[18]

$$\nabla\nabla_4 FPR_t = \underset{(0.11)}{0.0026} + \varepsilon_t$$

$$\hat{\sigma}_\varepsilon = 0.60$$

$$t = 1956{:}1 - 1963{:}4$$

and

$$\nabla FCR_t = -\underset{(0.13)}{0.32\delta_1} + \underset{(0.12)}{0.41\delta_2} - \underset{(0.12)}{0.24\delta_3} + \underset{(0.12)}{0.15\delta_4} + \frac{u_t}{[1 + \underset{(0.15)}{0.20}B^4]}$$

$$\hat{\sigma}_u = 0.47$$

$$\delta_i = \begin{cases} 1, & \text{quarter } i,\ i = 1, \ldots, 4 \\ 0, & \text{otherwise} \end{cases}$$

$$t = 1952{:}4 - 1962{:}4$$

Examination of the residuals $\hat{\varepsilon}_t$ and $\hat{u}_t$ yielded no indication of model inadequacy.

The forecast errors which result from applying these models to the immediate post-estimation observations may be regarded as

[18]Standard errors appear in parentheses below parameter estimates. The model for FPR for the longer period 1952:2 to 1963:4 is slightly complicated due to an "intervention" which occurred in the first quarter of 1955. The Internal Revenue Code of 1954 moved the filing deadline for the federal personal income tax from March 15 to April 15 of each year. This change noticeably altered the seasonal pattern of personal income tax receipts, shifting revenues from the first quarter to the second quarter of each calendar year from 1955 onward. Such an intervention could be represented by the model in the differenced series

$$\nabla\nabla_4 FPR_t = \mu_t + [\omega_0 - \omega_1 B - \omega_2 B^2]\, I_t + \varepsilon_t$$

where

$$I_t = \begin{cases} 1, & t = 1955{:}1 \\ 0, & \text{otherwise.} \end{cases}$$

One would expect *a priori* to find $\omega_0, \omega_1 < 0$ and $\omega_2 > 0$. Estimation of this model yielded the equation

$$\nabla\nabla_4 FPR_t = \underset{(0.091)}{-0.049} + [\,-\underset{(0.61)}{2.00} + \underset{(0.61)}{5.99B} - \underset{(0.61)}{2.27B^2}]\, I_t + \varepsilon_t$$

$$\hat{\sigma}_\varepsilon = 0.60$$

Examination of the residuals $\hat{\varepsilon}_t$ gave no indication of model inadequacy. Since the intervention term does not affect forecasts for the post-1963 period, Canto, Joines, and Webb chose to base their analysis on the simpler model reported in the text. See Box and Tiao (1975) for a description of intervention analysis.

TABLE 1
Estimates of Cumulative Change in Federal Personal Income Tax Receipts
(Billions of Dollars)

Cumulative Change Through	Time Series[a,b]	Treasury[b,c,d]	Pechman[c,d]
1964	−2.93 (1.32)	−2.4	−9.9
1965	−9.31 (6.76)	−11.1	−20.6
1966	−14.43 (18.00)	−23.4	

[a]Constant (1963:4) dollars. Standard errors appear in parentheses below estimates.
[b]Fiscal year.
[c]Current dollars.
[d]Source: H. J. Fowler, "Statement Before the Committee on Banking and Currency." *Meetings With Department and Agency Officials: Hearings Before the Committee on Banking and Currency, House of Representatives* Washington: U.S. Government Printing Office, 1967, p. 12.
[e]Cumulative change in tax liability on returns filed for relevant tax year. Source: J. Pechman, "The Individual Income Tax Provisions of the Revenue Act of 1964." *Journal of Finance* 20 (May 1965), p. 259.

point estimates of the revenue changes resulting from the 1962 and 1964 tax reductions. These estimates may then be compared with other published estimates of the revenue changes.

Table 1 contains alternative estimates of the cumulative change in federal personal income tax receipts. The time series and Treasury estimates are for the cumulative change from the time the rate reductions became effective until the end of selected federal government fiscal years. Pechman's estimates are for the cumulative change in tax liability on returns filed for selected tax years, and hence do not cover time periods strictly comparable to those of the other estimates.[19]

Comparison of the time series estimates with the various static estimates shows very little discrepancy for 1964. Furthermore, while

[19]The time series estimates which correspond most closely to the periods covered by Pechman are −9.07 (with standard error of 4.81) for 1964 and −14.77 (with standard error of 14.50) for 1965.

TABLE 2
Estimates of Cumulative Change in Federal Corporate Income Tax Receipts
(Billions of Dollars)

Cumulative Change Through Fiscal Year	[a]Time Series	[b]Treasury
1963	−0.06 (1.06)	−2.4
1964	1.70 (4.34)	−4.1
1965	4.77 (8.47)	−6.9
1966	10.74 (13.43)	−9.5

[a]Constant (1963:4) dollars. Standard errors appear in parentheses below estimates.
[b]Current dollars. Source: H. J. Fowler, "Statement Before the Committee on Banking and Currency." *Meetings With Department and Agency Officials: Hearings Before the Committee on Banking and Currency, House of Representatives.* Washington: U.S. Government Printing Office, 1967, p. 12.

the point estimates are indistinguishable from the various static estimates for that year, they are more than two standard errors below zero. This would seem to indicate that the initial feedback effects on the tax base were negligible.

Examination of Table 1 shows that for years after 1964, the time series estimates show smaller revenue losses than do the static estimates, and by 1966 the difference between the time series and Treasury estimates is considerable. It should be noted that the standard error associated with the time series estimate for 1966 is quite large. Nevertheless, these results, if taken at face value, indicate that there is only about a twenty percent probability that the cumulative change through 1966 was positive. They also indicate, however, that there is only about a thirty percent chance that the cumulative loss was as large as the Treasury estimated.

Table 2 contains alternative estimates of the cumulative change in federal corporate income tax receipts resulting from the various corporate tax changes legislated in 1962 and 1964. Whereas the

Treasury estimates show a steadily growing revenue loss between 1963 and 1966, the time series estimates show a negligible revenue loss in 1963 followed by a steadily increasing revenue gain between 1964 and 1966. As was the case with federal personal income tax receipts, the standard error associated with the cumulative revenue change through 1966 is somewhat large. Nevertheless, these results indicate that there is only a twenty-five percent chance that there was a cumulative revenue loss, and less than a ten percent probability that there was a loss as great as the Treasury estimated.

Thus far we have examined only federal government receipts from the taxes which were actually reduced in the early 1960s. As Bronfenbrenner (1942, p. 701) points out, however, the notion that reduction in tax rates may increase revenues takes two forms.

> A direct form limits attention to the specific levy under consideration. As applied in direct form, the argument applied to the tax on beer states simply that an increased rate would decrease revenues from the tax on beer, and vice versa. An indirect form applies to the general . . . tax system. As applied to the beer tax, it states that even though an increased rate may increase receipts from beer, it will decrease receipts from other taxes by more than enough to offset the gross increase.

If the federal personal and corporate income tax cuts did in fact expand economic activity, if the base for other taxes is positively related to economic activity, and if the rates of these other taxes remained constant, then one should observe higher than expected revenues from these other taxes during the years immediately following the federal income tax reductions. Furthermore, if such indirect effects do exist, they should be taken explicitly into account in estimating the revenue effects of proposed tax changes.

In order to determine whether any indirect revenue increases resulted from the federal income tax cuts, Canto, Joines, and Webb fit a univariate time series model to quarterly state and local income tax receipts deflated by the Consumer Price Index, neither of which had been seasonally adjusted. The model appropriate to this variable, denoted SLI, is

$$\nabla_4 SLI_t = \underset{(0.020)}{0.11} + [1 + \underset{(0.11)}{0.25B} + \underset{(0.11)}{0.54B^2}]e_t$$

$$\hat{\sigma}_e = 0.089$$

$$t = 1948{:}1 - 1963{:}4$$

Examination of the residuals $\hat{e}_t$ gave no indication of model inadequacy.

TABLE 3
Estimates of Cumulative Change in State And Local Income Tax Receipts
(Billions of Dollars)

Cumulative Change Through Fiscal Year	[a]Time Series Estimate	Standard Error
1964	0.49	0.14
1965	1.48	0.45
1966	3.28	0.86

[a]Constant (1963:4) dollars.

Table 3 contains estimates of the cumulative change in state and local income tax receipts for selected fiscal years. For each year the point estimate is positive and large relative to its standard error. It is possible that part of this increase could have arisen because state and local tax rates increased faster between 1964 and 1966 than they did during the period used to construct our forecasts. To check this possibility, we computed a weighted average of state personal income tax rates for years before and after the federal rate cuts. This average actually increased more slowly during the three years after the federal rate cuts than during the preceding three years. This evidence therefore strongly suggests that the federal tax cuts did entail the predicted indirect revenue increases.

In summary, analysis of these three types of revenues yields a point estimate for the cumulative loss in the three types of revenues combined of $0.41 billion through 1966. Given the uncertainty attaching to this estimate, it is virtually indistinguishable from zero. Furthermore, it contrasts sharply with the Treasury's estimate of the federal revenue loss of $33 billion. It thus seems quite likely that the static revenue estimates used by the Treasury greatly overstate the revenue effects of federal tax rate changes. In addition, it seems almost as likely that the federal tax cuts increased revenues as that they reduced them.

If the Kennedy tax cuts did result in revenue losses smaller than those implied by simple static calculations, this suggests that tax rate reductions may in fact be effective in stimulating economic activity. One qualification to this line of reasoning is in order, however. It was noted above that if tax shelters are expensive, a

TABLE 4
Estimates of Cumulative Changes in
Real Gross National Product

Cumulative Change Through Fiscal Year	[a]Time Series Estimate	Standard Error
1964	5.25	4.81
1965	29.05	18.03
1966	84.34	33.68

[a]Constant (1963:4) dollars.

reduction in tax rates might result in a decrease in tax revenues without necessarily being accompanied by an increase in economic activity. The expansion of the tax base might instead occur as people transfer economic activity from nontaxable to taxable forms. Examination of some variable such as real Gross National Product would allow a separate check on the influence of the Kennedy tax cuts on economic activity.

The following multiplicative seasonal time series model was identified and estimated for quarterly data on real Gross National Product:

$$\nabla GNP_T = \underset{(0.652)}{-9.36\delta_{1t}} + \underset{(0.627)}{5.20\delta_{2t}} + \underset{(0.624)}{0.095\delta_{3t}} + \underset{(0.626)}{8.365\delta_{4t}} + [1 - \underset{(0.140)}{0.350}B^3]a_t$$

$$\hat{\sigma}_a = 2.15$$

$$\delta_{it} = \begin{cases} 1, \text{ quarter } i, \; i = 1, \ldots, 4 \\ 0, \text{ otherwise} \end{cases}$$

$$t = 1951{:}2 - 1963{:}4$$

The price index was the Consumer Price Index, and the series was not seasonally adjusted. Diagnostic checks of the residuals did not indicate any significant departures from a white noise process.

This time series model was used to develop forecasts of real output which were then compared with post-sample realized values. The results are summarized in Table 4. The point estimates reported there provide evidence that an unforecast expansion in economic activity followed the tax rate cuts, with most of the effect occurring in fiscal years 1965 and 1966. This is consistent with the evidence from the analysis of tax revenues. The point estimate of the cumulative gain through 1966 is $84 billion and is about two and a half times its standard error.

CONCLUSION

Our analysis shows that increases in taxes reduce the returns to the factors as well as factor employment and market output. A firm's decision to employ a factor is based partly on the total cost to the firm of the factor's services. The more it costs to hire factors, the lower the quantity of factor services the firm will demand. The lower the costs to the firm to hire factors, the more factor services the firm will demand. Increases in tax rates increase the cost of hiring factors. Therefore, increases in tax rates will result in fewer factor services demanded.

For the owners of factors, the decision to offer factor services to the market is based in part on the earnings the factor receives net of taxes. The more the factor receives net, the larger will be the quantity of services offered to the market, and vice versa. Increases in tax rates reduce the net-of-tax returns to factors. Increases in tax rates reduce the quantity of factor services supplied. Thus, both the firms' desire to employ factors and the factors' willingness to work are diminished by increases in tax rates. The foregoing analysis applies equally to either capital or labor employment and their respective returns. The net effect is that the level of factor employment and output fall as tax rates increase.

Our analysis also indicates that increases in tax rates could as well reduce as increase government tax revenues. In fact, there exists a tax rate structure which maximizes government tax receipts. This tax structure depends on the supply and output elasticities of the factors of production. The set of tax rates which creates conditions such that increases in the rates are accompanied by increases in government tax revenues are referred to as the normal range. The tax rates where increases in the rates are accompanied by decreases in tax revenues are said to be in the prohibitive range. Except at a corner solution, whenever tax rates are reduced, total revenue is never reduced in the same proportion as the tax rate reduction. The more elastic factor supplies are, the more likely it is that any given tax rates will fall into the prohibitive range. Also, the higher the level of tax rates, the more likely tax rates are to be in the prohibitive range.

Our simple static model shows the government tax policy affects the market-sector output which can be obtained from a given stock of resources. In particular, increases in tax rates reduce market employment and output. Such a tax rate increase, however, would also have long-term effects on the size of the resource stock. Both human and nonhuman capital are reproducible resources which can be augmented only at some cost. The stocks of such capital at any point in time depend upon past investment decisions, and the future stocks depend upon current investment decisions. A change in after-tax factor rewards will affect not only the intensity of utilization of currently existing factors, but also the decision to invest in new resources, and thus the size of the future stock of factors of production. A dynamic model is required to analyze such questions. We merely note in closing that increases in tax rates are likely to cause reductions in future output potential, which reinforce the reductions in current output predicted by our static model.

The proposition that increases in tax rates beyond a certain level may actually reduce tax revenues and hence market-sector output is an empirical issue. Data on tax revenues and real per capita output before and after the Kennedy tax cuts of 1962 and 1964 were examined in order to ascertain whether this proposition has empirical support. The evidence suggests that a significant expansion of economic activity and no significant loss of revenue occurred as a result of the Kennedy tax cuts. The point estimate of the cumulative unexpected expansion in output through 1966 is $84 billion, which is large relative to its standard error. Our evidence on revenues is less conclusive. The point estimate of the cumulative revenue change is virtually identical to zero, and it is thus almost equally likely that the Kennedy tax cuts increased revenues as it is that they decreased them.

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