PART I: THEORY AND EVIDENCE

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:

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

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:

$$W^* = W(1 - t_L) \tag{2}$$

$$R^* = R(1 - t_K) \tag{3}$$

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:

$$K^d = \frac{\alpha Q}{R} \tag{4}$$

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

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

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]

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[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:

$$\text{EQ} = \varepsilon\,\text{ET}_L - \left(\frac{\sigma_L - \sigma_s(1+\varepsilon)\alpha}{(1+\sigma_s)}\right)\text{E}(\text{T}_K/\text{T}_L) \tag{19}$$

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

$$\frac{\text{E}(\text{W}/\text{R})}{\text{E}(\text{T}_L/\text{T}_K)} = -\frac{\sigma_s}{1+\sigma_s} < 0$$

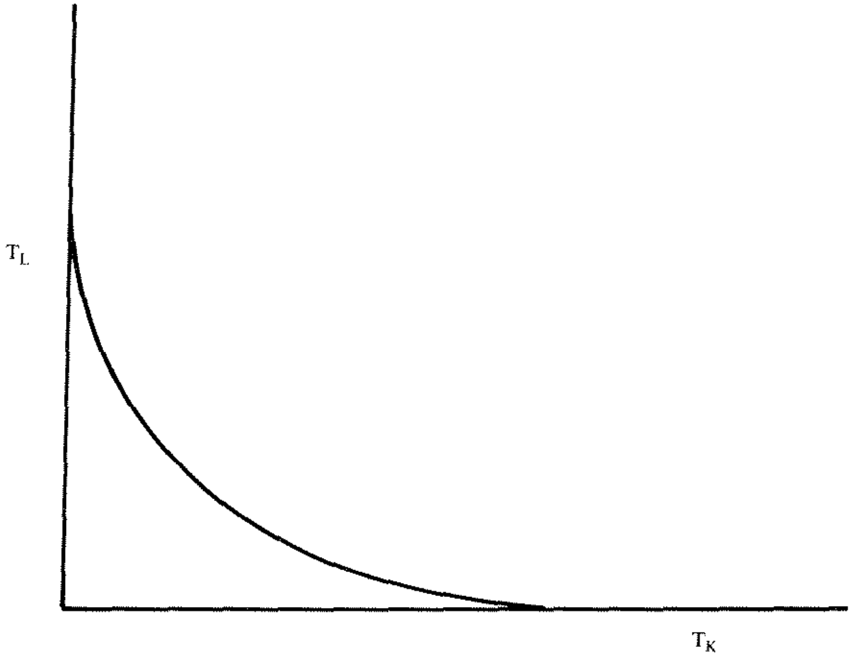
Differentiating equation 18 logarithmically

$$\text{EQ} = \varepsilon\text{ET}_L - \frac{\sigma_L - \sigma_s(1+\varepsilon)\alpha}{1+\sigma_s}\,\text{E}(\text{T}_K/\text{T}_L)$$

$$\text{EQ} = \frac{(1+\varepsilon)\sigma_s(1-\alpha) - \sigma_K}{1+\sigma_s}\,\text{ET}_L + \frac{\alpha(1+\varepsilon)\sigma_s - \sigma_L}{(1+\sigma_s)}\,\text{ET}_K$$

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)

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

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

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

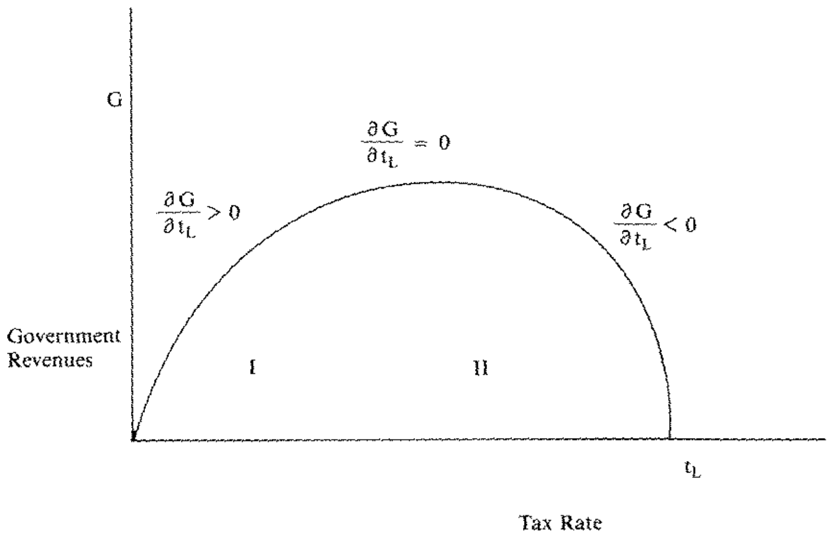
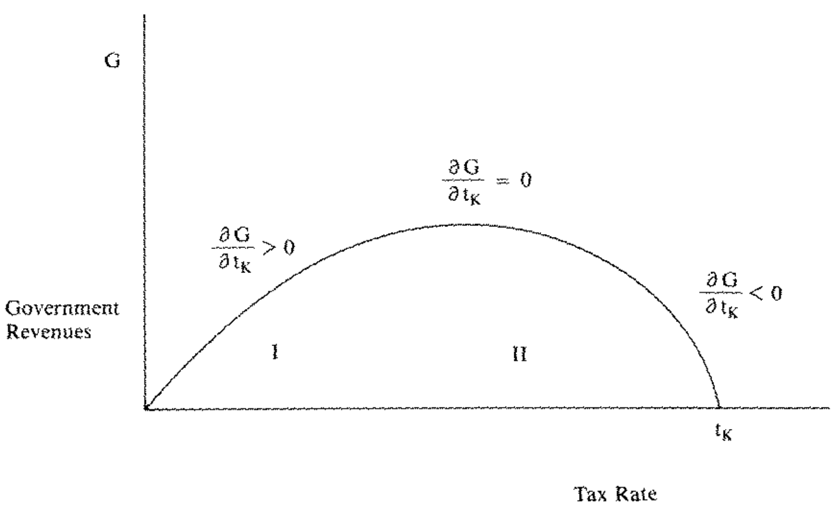


FIGURE 3



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

$$(23) \qquad -A + (1 - \alpha)(A + 1)T_L + \alpha A T_K = 0$$

$$(24) \qquad -B + (1 - \alpha)BT_L + (B + 1)\alpha\, T_K = 0$$

where

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

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

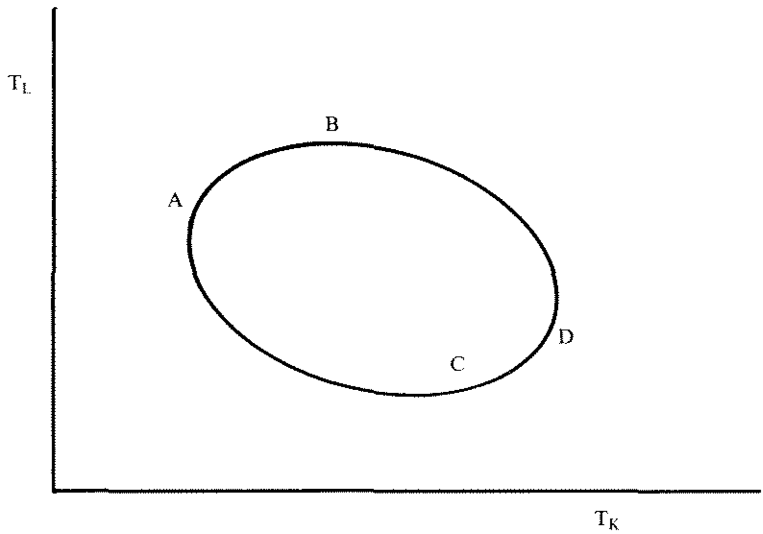
From equations 23 and 24, one can solve for the factor wedge:

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

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

quations 27 and 28 illustrate the marginal wedges which maximize vernment tax revenues. Using these results, one can then solve plicitly 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



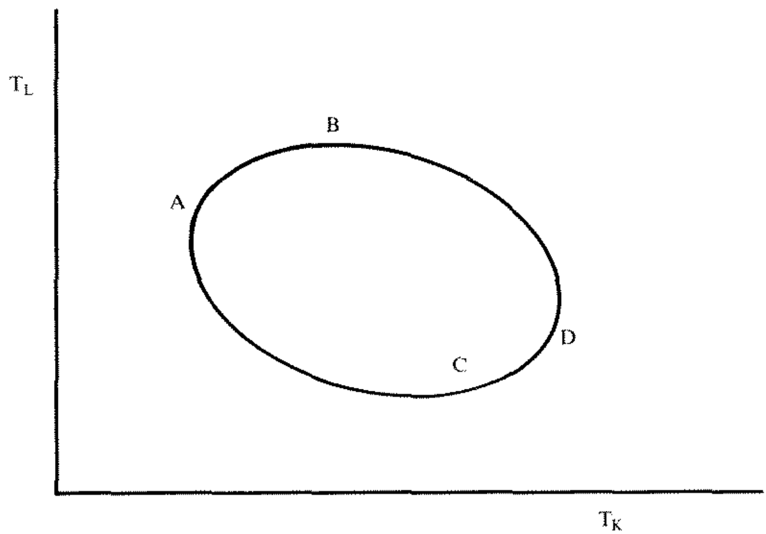
If both factor income tax rates are in the prohibitive range, an increase in either tax rate, the other rate constant, leads to a reduction in total revenue collected. Since both tax rates are in the prohibitive range, the other factor tax rate must be reduced if revenue is to remain unchanged. Hence 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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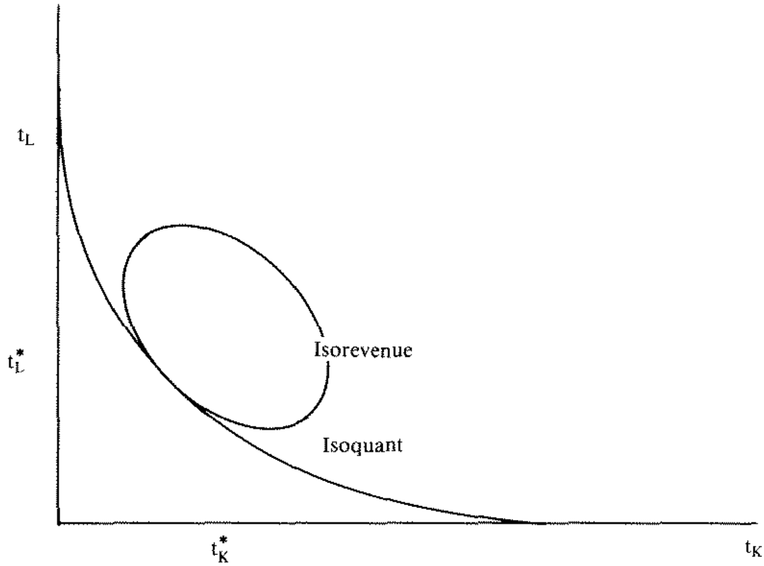

The graphical solution to this problem is quite simple.[11] The level of revenue collection determines the iso-revenue curve. Once this is known, the objective becomes to find the lowest possible isoquant that satisfies the revenue constraint. At this point the two curves are tangent. The question becomes 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

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[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

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[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'

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[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

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

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

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

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

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

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

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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An Econometric Model Incorporating The Supply-Side Effects of Economic Policy

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This paper summarizes the principal findings of the new macroeconomic supply-side model which I have recently completed at Evans Economics. Rather than describe each individual equation or even blocks of equations, I have selected an alternative approach. Since the main thrust of the supply-side model is to examine the ways in which total productive capacity can be increased, I first examine the determinants of productivity, and then show how these determinants are estimated within the confines of the model. The bulk of this paper is devoted to the discussion of the productivity function, the investment functions, and the labor market functions. The concluding section then examines some alternative solutions generated by changes in monetary and fiscal policies. Rather than examine the usual full-scale multiplier tables, I have chosen to concentrate on a specific set of policy alternatives which should be able to increase productive capacity and employment while at the same time reducing inflation.

Determinants of Productivity

As part of the supply-side model, we have estimated an econometric equation to explain changes in productivity on an endogenous basis. Previous attempts to explain productivity reached the conclusion that while some of the decline could be tied to the reduction in the investment ratio and other endogenous factors, part of it could not be explained by economic variables. However, we have found that not to be the case.

The function we have estimated relates the annual percentage change in productivity to two sets of variables: short-term cyclical variables and long-term secular factors. The short-term variables are a) percentage change in real GNP, and b) a nonlinear term of capacity utilization which takes the form $(95 - CP)^{1/2}$. Essentially this term represents the fact that productivity growth slows down as

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the economy approaches full employment and full capacity because of shortages and bottlenecks, more overtime and hence more worker errors, and hiring of less skilled and trained workers.

The long-term secular factors which we consider, together with the weights which we have assigned to each of them, are as follows:

1. Decline in the investment ratio	1%
2. Costs of government regulation	1%
3. Increase in secondary workers in the labor force	½%
4. Increase in relative price of energy	½%
5. Reduction in ratio of R&D expenditures to GNP	(included in #1; not measured separately)

While the last factor was not explicitly included in the function because of the very long lag times involved, it enters the function indirectly through its eventual effect on investment. This point is discussed in more detail in the next section.

The actual equation used in our supply-side model is as follows:

Independent Variable	Estimated Coefficient	Standard Error	T-Statistic	Contribution To R^2
-C-	−7.51592	4.57449	−1.64301	
SECWK01	−0.839850	0.355811	−2.36038	0.698377D-01
INVXC01	0.625840	0.419031	1.49354	0.379613D-01
REG	−0.208791	0.170205	−1.22671	0.188628D-01
ENERGYC	−4.11652	2.49016	−1.65311	0.342554D-01
GNP72	0.524536	0.108446	4.83686	0.293259
CAPUTIL	1.11549	0.440452	2.53261	0.804009D-01

R-Squared = 0.7368
R-Squared (Corrected) = 0.6616
Multicollinearity Effect = 0.2122
Durbin-Watson Statistic = 1.3901
Number of Observations = 28
Sum of Squared Residuals = 17.7071
Standard Error of the Regression = 0.918256

The dependent variable is:

$$PRDT = \frac{\Delta PRD}{PRD_{-1}}$$

where PRD = Private nonfarm business productivity.

The independent variables are:

$$SECWK01 = \frac{1}{2} \sum_{i=0}^{2} SECWORK_{-i}$$

where $SECWORK = \frac{\text{Secondary workers}}{\text{Total employment}}$

$$INVXC01 = \frac{1}{2} \sum_{i=1}^{2} INVXC_{-i}$$

where $INVXC = \frac{\text{Business Fixed Investment less investment in cars and trucks}}{\text{Gross National Product}}$

$$ENERGYC = \Delta \left(\frac{PWIFP}{PGNP} \right)$$

where PWIFP = Producer Price Index, fuel and power
PGNP = Implicit Deflator, Gross National Product

$$GNP72 = \frac{\Delta GNP}{GNP_{-1}}$$

where GNP = Gross National Product, billions of 1972 dollars

$$CAPUTIL = (95 - CP)^{1/2}$$

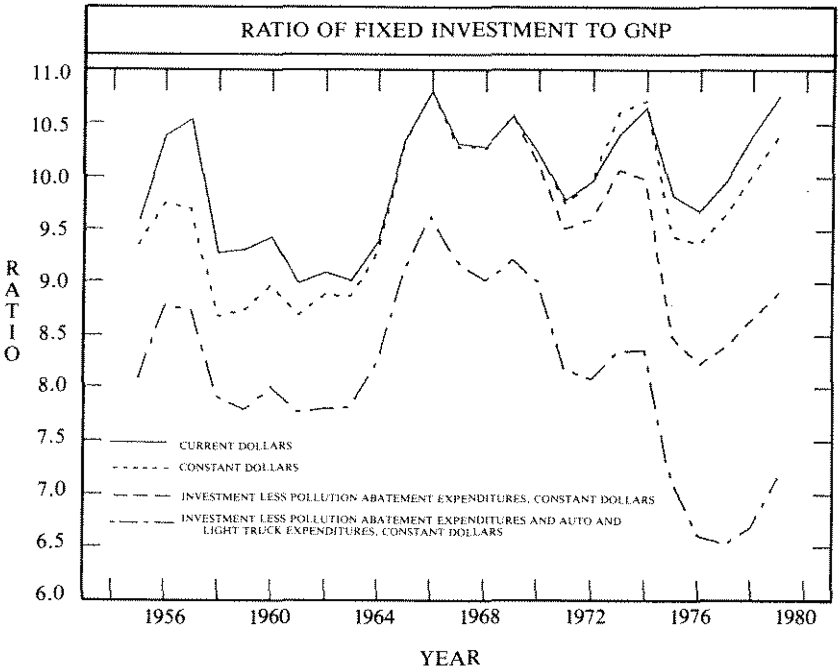
where CP = Index of Capacity Utilization, manufacturing

At first glance, the ratio of fixed business investment to GNP has remained roughly constant over the postwar period and in fact posted an above-average value for 1979. However, this ratio is misleading and must be adjusted for several factors.

First, the ratio should be calculated in constant rather than current dollars. Just because the price of capital goods has increased faster than other prices does not mean that we are devoting more of our resources to capital formation.

Second, the investment figure should exclude capital spending undertaken to meet federally-mandated standards. The only figures available in this category are those for pollution abatement and control, so our estimate obviously understates total capital spending in this area. However, removal of these figures makes a noticeable difference to the investment ratio.

FIGURE 1



Third, "investment" in cars and light trucks should be excluded from the total investment figures. Most of these purchases are made for personal or quasi-business reasons, and do not represent investment in the traditional sense.

We have adjusted the investment ratio for all of these factors, and the very considerable difference which it makes is shown in Figure 1. Thus although the nominal ratio may not have declined, the real ratio of capital spending to GNP properly adjusted exhibits a striking demise for the past five years.

Our productivity equation suggests that a 1% increase in the investment ratio, or a switch of about $25 billion (in 1980 dollars) from consumption to investment would raise productivity by about 0.6% per year and thus lower inflation by about twice that amount. We defer discussion of the ways in which this could be accomplished until the next section, turning now to the other principal determinants of productivity.

The second factor causing reduced growth in productivity, namely increased investment to meet federally-mandated standards, is summarized in Table 1. This table should also include investment

TABLE 1

Fixed Investment and Capital Stock
Adjustment for Inflation and Pollution Control Equipment

Year	Fixed Business Investment (Current $)	[a]Pollution Control	[b]Health and Safety	Productive Fixed Business Investment (Current $)	Productive Fixed Business Investment (Constant $)	[c]Net Capital Stock (Constant $)	Net Productive Capital Stock (Constant $)
1970	100.5	2.2	1.7*	96.6	105.8	833.7	830.0
1971	104.1	2.9	1.8*	99.4	103.2	859.5	851.4
1972	116.8	4.1	2.5	110.2	110.2	889.8	875.8
1973	136.0	5.3	2.6	128.1	123.4	929.5	908.5
1974	150.6	5.8	3.1	141.7	122.7	965.1	936.7
1975	150.2	6.5	2.7	141	106.6	981.2	944.9
1976	164.6	6.8	2.4	155.4	112.2	1000.8	956.1
1977	190.4	7.5	2.9	180	122.9	1029.0	973.7
1978	221.1	6.9	4.3	209.9	143.3	1060.2	993.7
1979	254.9	7.1	2.9	244.9	155.3	1089.3*	1024.8
1980E	264.2	7.7	3.7	252.8	147.6	1110.7*	1044.3

[a]June, 1980 *Survey of Current Business*.
[b]*Annual Survey of Investment in Employee Safety and Health*, McGraw-Hill Publications Company, 1980.
[c]August, 1979 Survey of *Current Business*.
*Extrapolated by Evans Economics, Inc.
All figures are in billions of dollars.

undertaken by the automobile industry to meet pollution, fuel economy, and safety standards, but we were unable to find even approximate estimates for these figures. Even without them, however, we note that adjusted capital stock has grown at an annual rate of only 2.4% since 1970, compared to 3.0% as calculated from the investment figures before adjustment.

Because pollution control costs represent the lion's share of non-productive investment, we have presented them in greater detail in Table 2. As shown there, investment in private sector pollution control for stationary source emissions (i.e., excluding motor vehicles) will average about 4% of investment over the 1973-1984 period. Public sector spending for pollution control will average between 15% and 20% of total public sector investment, while pollution control devices will represent about 10% of the cost of purchasing a new car.

We also repeat the annual costs associated with pollution control investment; they are defined to include interest, depreciation, and operation and maintenance costs. According to Council on Environmental Quality (CEQ) estimates, the total annual costs for the 1975-1984 period will be $486 billion in 1975 dollars, or approximately $750 billion in current dollars. These costs will amount to between 2% and 3% of total GNP during the forthcoming decade, representing a very significant economic burden for the costs of clean air, water, and solid waste.

Two additional comments should be appended to these figures. First, the cost of regulation appearing in the government budgets is only a tiny fraction of the cost imposed on the private sector of the economy; Murray Wiedenbaum and others have estimated that it is only about 5%. Second, while pollution abatement probably does represent the lion's share of these costs, the burden of occupational safety and health standards, consumer product safety, toxic substances control act, and other programs are substantial and should not be assumed to be zero just because no definite figures are available for these categories.

We do not think it is reasonable to expect society to turn back the clock on the massive changes in social policy which produced the federally-mandated standards of the 1970s. Yet it certainly should at least be possible to rationalize these regulations so that firms are charged with attaining the ends rather than the means. If, for example, one national goal is to reduce air pollution, utilities ought to be able to decide on their own whether this is to be accomplished through choice of fuel, use of scrubbers, less

TABLE 2

Total Actual and Expected Investment for Pollution Control, 1970-1984

Year	(1) Capital Investment — [a]Stationary Source Private	(2) Capital Investment — [a]Stationary Source Public	(3) Capital Investment — Mobile Source*	(4) Annual Costs** — [a]Stationary Source Private	(5) Annual Costs** — [a]Stationary Source Public	(6) Annual Costs** — Mobile Source*	(7) Total Fixed Business Investment	(8) Pollution Control Investment (Percent)	(9) Total GNP	(10) Pollution Control Resources (Percent)
1970	2.2	0.1	0.3	1.1	0.0	1.3	100.5	2.2	982	0.2
1971	2.9	0.1	0.4	1.7	0.0	2.0	104.1	2.8	1063	0.3
1972	4.1	0.2	0.4	2.4	0.1	2.8	116.8	3.5	1171	0.5
1973	5.3	0.5	1.1	3.5	0.3	4.1	136.0	3.9	1307	0.6
1974	5.8	3.7	1.2	5.4	1.4	5.3	150.6	3.9	1413	0.9
1975	6.5	6.6	2.3	8.2	3.3	5.7	150.2	4.3	1529	1.1
1976	6.8	8.0	2.9	11.4	7.4	6.0	164.6	4.1	1700	1.5
1977	7.5	6.0	3.5	15.3	10.3	6.4	190.4	3.9	1887	1.7
1978	8.9	6.7	5.6	20.6	14.2	8.2	221.1	4.0	2104	2.0
1979	11.0	7.0	6.3	25.3	17.2	11.3	242.1	4.5	2281	2.4
1980	11.7	7.4	6.6	31.0	20.5	12.1	262.7	4.4	2479	2.6
1981	12.2	7.8	7.2	37.7	25.0	12.2	299.7	4.1	2730	2.7
1982	13.6	8.2	7.8	45.2	29.3	12.1	337.5	4.0	2980	2.9
1983	15.0	8.6	8.4	53.3	37.4	11.7	376.6	4.0	3256	3.1
1984	16.5	9.1	8.9	62.9	42.9	11.3	417.8	4.0	3551	3.3

Source: Figures are interpolated from ten-year totals given in the CEQ Annual Report. All figures are converted from constant to current dollars. Numbers are based on total rather than incremental pollution control expenditures.

**Interest, Depreciation, Operation, and Maintenance Costs of Pollution control.

*Includes additional fuel costs, motor vehicles   [a]Air, water, and solid waste, excludes motor vehicles

(8) = (1) / (7)

production during "air alerts," building plants in new locations, and so forth, rather than by administrative fiat. Our best guess is that the use of common sense in these areas could reduce the loss in productivity growth due to regulation from 1% to ½% per year, thus reducing the overall rate of inflation by about 1% per year. If in addition this reduction from $100 billion to $50 billion per year would free resources for increased capital spending, the gains would be even larger.

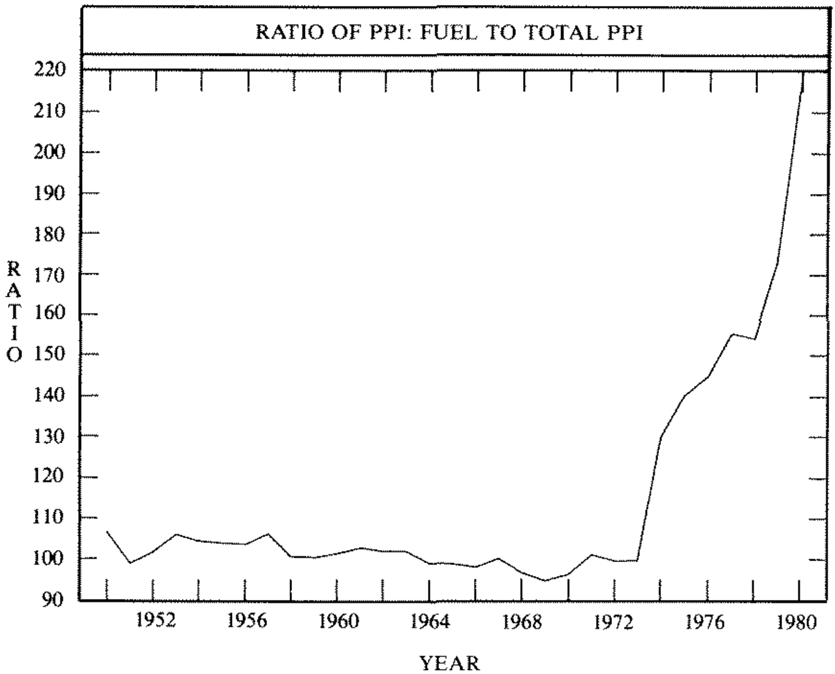
The third factor which has accounted for the slowdown in productivity growth, although it will be reversed during the 1980s, is the sharp growth of secondary workers in the labor force. In 1964, males aged 25 to 54 accounted for 46% of the total labor force; in 1980 the figure will be 38%. The major increases have occurred in women aged 25 to 54 and in teenagers of both sexes. The problem has been compounded not only by rapid increases in labor force participation rates but in the population aged under 25.

Many of these secondary workers have less education, vocational training, or on-the-job experience than their primary counterparts when first hired. As a result, they were initially less productive. This does not necessarily imply that such individuals will continue to have a lower level of productivity over the lifetime of their jobs, but rather that their productivity was lower when they initially entered the labor market.

During the 1980s, however, the size of the population aged 16 to 24 will shrink by a full 6 million persons. Thus even if labor force rates continue to rise for teenage workers, the number of potential employees will decline significantly. Second, many women aged 25 to 54 in the labor force will have had the full complement of education, vocational training, and on-the-job experience as their male counterparts, so they will be just as productive. As a result, we look for this factor to improve, hence raising the growth rate of productivity for the 1980s by about ½% per year.

The fourth factor retarding productivity, the skyrocketing cost of energy, is only too well known to anyone associated with the utility industry, but the increase as shown in Figure 2 is striking nonetheless. Furthermore, we find little if any reason to expect this ratio to reverse course over the next 10 years. In the U.S., consumption of petroleum products remains at a high level, although not as much as previously, and production is stagnant. Under these two sets of circumstances it is clear that the long-run trend for oil imports continues in the upward direction, which gives OPEC all the economic justification they need to continue to raise prices in real terms. In this respect it is noteworthy that OPEC was

FIGURE 2



able to push through yet another price increase in June in spite of the fact that the U.S. is definitely in the midst of a fairly serious recession and the rest of the world economy is also slowing significantly.

The long-run effects of energy prices on productivity are undoubtedly understated. Indeed, it has become increasingly apparent that the long-term effects of changes in energy prices on productivity are greater than had been generally appreciated, and larger than would be determined by empirical techniques which are by nature restricted to the period since 1973. The productivity equation which we have estimated in our supply-side model indicates that the increase in energy costs has lowered productivity growth by ½% per year. While that is probably the appropriate figure for the short run, the long-run figure is considerably greater.

The standard explanation of how higher energy costs reduce productivity is usually confined to the manufacturing sector. With a shift in relative prices, firms use less energy and more labor, raw materials, and capital. This shift is borne out by the increase in employment throughout 1979 during a period of virtually stagnant output, and while some of the excess workers are being disgorged now that we are in a recession, the demand for labor still has shifted to a higher plane.

This shift is an important change and one which cannot be treated lightly. Yet in the longer run it will probably turn out to be less important than the changes in productivity which affect the transportation and distribution network. Some of these changes are already obvious, such as the 1974-75 decline in productivity in the transportation industry when higher fuel prices led to lower speeds by airlines (voluntary) and trucking (mandatory). However, these short-run changes are already included in our measurements of the ½% yearly decline. Here we consider the longer term changes brought about by higher energy prices as they affect the entire production and distribution system of the economy.

Let us first consider a world in which transportation and distribution costs are negligible. If that were the case, the location of manufacturing plants would be largely independent of markets except for those products that gain weight or bulk during manufacturing or those processes which utilize large quantities of raw materials. Most important, all plants would be large enough to take full advantage of economies of scale. Hence there would be relatively few plants in those industries where economies of scale are significant, particularly metals, machinery, transportation equipment, and power generation. Competition would thrive because one firm could not obtain an advantage merely by accident of location. The manufacturing sector would not be the only part of the economy to benefit from this arrangement. Consumers would also benefit; they could comparison shop at several locations since the cost of a reasonable amount of travel to obtain better prices would be small.

While transportation costs have always been a substantial portion of the total price for some goods, such as cement, it is not too farfetched to say that many elements of the economy described above applied to the U.S. before 1973. Indeed, it should be clear in general that cheap transportation and distribution aids productivity and retards inflation. It encourages greater efficiency through economies of scale in manufacturing, and it encourages greater competition through a wider range of choice in retail markets. After all, if consumers had no transportation and were virtually forced to shop only at the closest store, the storekeeper would have far less incentive to cut costs through higher productivity.

Thus the higher cost of energy, through reducing the amount of transportation utilized, raises prices by much more than the cost of the more expensive fuel alone. Furthermore, this is not reflected in higher profits; it is the deadweight loss of productivity which does not benefit anyone. Manufacturing plants gradually become less efficient, and retail outlets become less competitive and less productive.

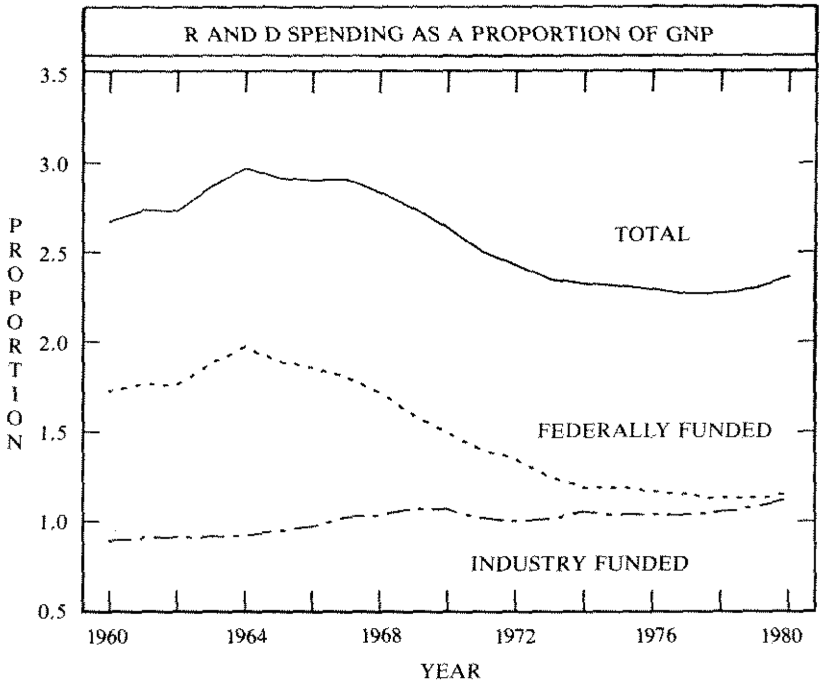
Obviously these events change only very slowly over time, which is precisely why we cannot yet measure them very well. Existing plants do not shrink when energy costs rise, although they may run at lower rates of capacity utilization. Consumers do not change their driving or living habits overnight, and so on. But over time these gradual changes, almost imperceptible within the time frame of a quarter or even a year, cumulate and eventually represent a potent force affecting productivity.

Offsetting this to a certain degree is the fact that if capital spending is stimulated during the 1980s, much of the new investment may be used for energy-saving plant and equipment, thus diminishing our dependence on imported oil. This would eventually cause OPEC to reduce their price in real terms, hence removing one of the major hurdles to higher productivity growth. In other words, higher investment may have benefits far greater than the traditional methods of raising productivity through expanded capital stock; the new mix of capital stock may be more energy-efficient as well, representing savings which would not come about were new investment to proceed at a slower pace. However, the entire relationship between energy prices and investment is a very complicated one, well beyond the scope of this modest report.

The fifth factor which we believe influences the long-term growth rate of productivity is the proportion of resources devoted to R&D compared to GNP. As is shown in Figure 3, from a peak of 3% reached in the mid-1960s at the height of the space program, this ratio has declined to slightly over 2% in 1976, although it has recently improved as private industry has stepped up its R&D spending. The long lags between R&D spending and productivity growth, which average up to five years, mean that this relationship is not quite as precise as the other factors determining productivity. However, as discussed in the next section, it is thought to have an effect on investment, albeit with this very long lag.

To summarize this section, output/manhour in the private sector increased at an annual average rate of 3% for the period from 1948 to 1965, but has declined to almost 0% currently. Table 3 contains the tabulation of the postwar record for increases in output/manhour in the private nonfarm sector. We have taken three-year

FIGURE 3



averages rather than yearly figures in order to smooth out the fluctuations in productivity caused by sharp changes in output. While some traces of recessions still remain in these numbers, the overall swings in productivity emerge much more clearly than is the case in the series for annual changes.

As shown in Table 3, productivity rose very rapidly in the years immediately following World War II (no figures are available before 1948) because of the large proportion of GNP devoted to investment to replace obsolete plant and equipment. Productivity increases then declined to the 2.0% range for the period 1956-1961, considerably below the long-term average. This was due in large part to the severity of the 1958 recession. Productivity then rose rapidly from the period 1962 to 1968, due to the increase in capital spending spurred by the investment tax credit, liberalized depreciation allowances, and the reduction in the corporate income tax rate; productivity gains were also increased by the substantial increases in federal spending for research and development. Beginning in 1969, both of these driving forces toward higher growth were removed. The investment tax credit was cancelled, and

TABLE 3
Long-Term Trends in Productivity Growth

Three-Year Period	Average Annual Growth Rate in Productivity (Private Nonfarm Sector)
1950	4.2
1951	4.0
1952	3.5
1953	2.2
1954	2.0
1955	2.4
1956	1.6
1957	1.6
1958	1.7
1959	2.8
1960	2.3
1961	2.4
1962	2.7
1963	3.5
1964	3.5
1965	3.0
1966	3.1
1967	2.4
1968	2.4
1969	1.3
1970	1.5
1971	2.1
1972	2.3
1973	2.9
1974	0.8
1975	0.2
1976	0.8
1977	2.3
1978	1.9
1979	0.3
1980	−0.6
1981-1990	1.0

recurring financial crises reduced the amount of money available for new investment spending. The reinstatement of the investment tax credit in 1971 did raise investment above the levels which would otherwise have been reached, but this was offset by the substantial expenditures required for environmental and safety standards. As a result, productivity actually declined for the first time in the postwar period in 1974 and for the three-year period 1973-1975 showed virtually no improvement. While the 1977-78 figures indicate a rebound, that was due mainly to cyclical factors, as shown by the subsequent slowdown in 1979 and 1980.

The growth rate of productivity in the 1980s clearly depends on what happens to the factors we enumerated at the beginning of this section.

Determinants of Investment

It is generally agreed that an increase in the production of resources devoted to capital spending will raise productivity, hence increasing real growth and lowering inflation. However, less agreement exists concerning the determinants of investment. Economists are generally divided into two groups: those who believe in the "trickle-down" theory, and those who claim that the primary variable is expected rate of return.

The trickle-down theory states that a rise in consumption is sufficient to increase investment to the desired level. Once the demand for goods increases, businessmen, ever alert and eager for increased opportunities, will expand capacity sufficiently to create the productive capacity for these new goods. In somewhat oversimplified terms, demand creates its own supply.

The rate of return theorists would argue that no such automatic mechanism exists to equilibrate demand and supply. Capital spending will not increase unless the expected rate of return is sufficient to cover the cost of investment. To be sure, an increase in demand does raise the rate of return, other things being equal—but it does not in and of itself guarantee an adequate rate of return. Thus the tax mechanism must be used to insure that demand and supply are kept in balance. Obviously the choice of theory has tremendous implications in determining the appropriate tax policies to stimulate growth and productivity.

The investment functions which we have estimated in the Evans Economics macro model rely heavily on the cost of capital-rate of return variable originally introduced by Jorgenson. However, the approach which we have used permits much greater flexibility than his original construction. By using a two-step procedure in which we estimate equations for orders and investment separately, we are able to measure the separate contributions for a change in the corporate income tax rate, investment tax credit, and depreciation allowances. Furthermore, since the index of stock prices is included as one of the variables in the rental cost of capital term, we can also examine how changes in the capital gains tax rate will affect investment.

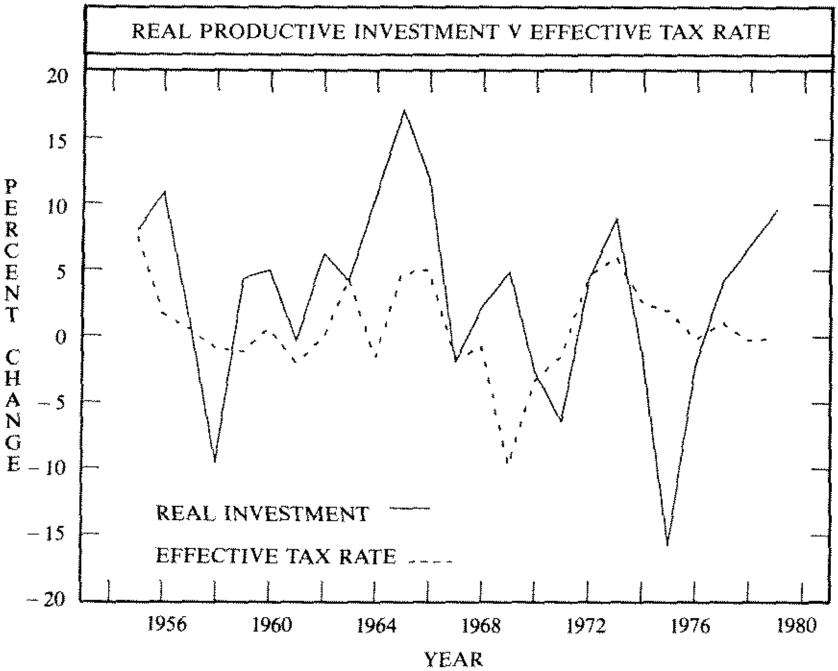
We can summarize the results here by listing the impact effects of changes in these tax laws. By impact effects we mean simply the marginal coefficients times the change in the tax law in question. These coefficients do not take into account the interactive and dynamic effects, for which we need to solve the entire model, but they do give some idea of both the absolute and relative importance of each type of tax change.

Our results in the supply-side model have shown that, for the same revenue-producing change, the corporate income tax rate cut has greater efficacy than a change in depreciation allowances, which in turn has a greater effect than a change in the investment tax credit. Furthermore, a change in the stock prices has a substantially greater effect than a proportional change in interest rates. Since these findings are not universally accepted, a further word of explanation is in order.

We have found that the corporate income tax cut has the highest efficacy because it is a "pure" tax cut; it does not contain any of the restrictions that the other types of tax changes contain. For example, an investment tax credit can be used only for equipment, but not for plant; a certain amount of the credit must be carried over into future years and in certain circumstances companies cannot use all the credit, which means they must find other investors who use the credit as a tax shelter. In addition, at least until recently many investors believed that the investment tax credit was a "gimmick" to be suspended or terminated at will by Congress, and hence they were less willing to use it as a basis for long-term investment planning.

While we do think that these three changes in the tax law will have somewhat differing effects on investment, it should be stressed that all of them will have a significantly positive response. Indeed, the post-war history of capital spending in the U.S. economy is largely tied to changes in the effective tax rate on corporate income. The relationship between changes in capital spending (in constant prices) and the effective corporate income tax rate lagged one year is given in Figure 4.

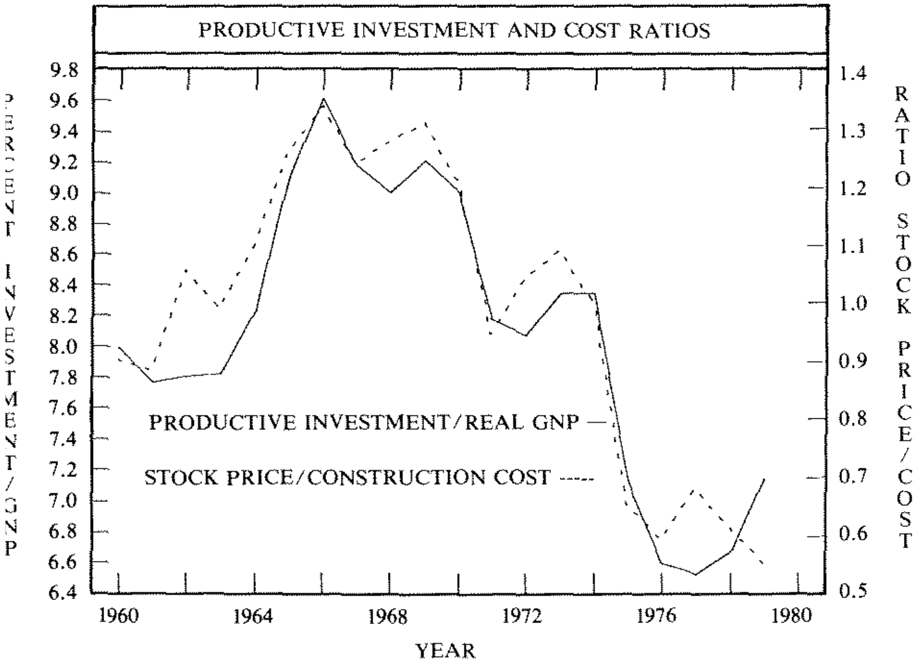
FIGURE 4



To summarize the information given in Figure 4, the U.S. economy has undergone three investment booms in the postwar period: 1955-1956, 1964-1966, and 1972-1973. Each of these booms has a common characteristic: it was preceded in the previous year by a major change in the tax code which was favorable to investment. Hence 1954 marked the end of the excess profits tax from the Korean War and the first liberalization of depreciation allowances. The investment tax credit was introduced at a 7% rate in late 1962 and was accompanied by a 20% reduction in accounting tax lives; when this was followed by a reduction in the corporate income tax rate from 52% to 48% in 1964, capital spending climbed 20% in constant prices in 1965, the only time in the postwar period that has occurred. Finally, in 1972 the investment tax credit was reinstated at 7% and accounting tax lives were reduced by an additional 20%.

We also note that the sharp increase in tax rates in 1969, caused by the imposition of the 10% income tax surtax and the suspension of the investment tax credit, was sufficient to cause a decline in

FIGURE 5



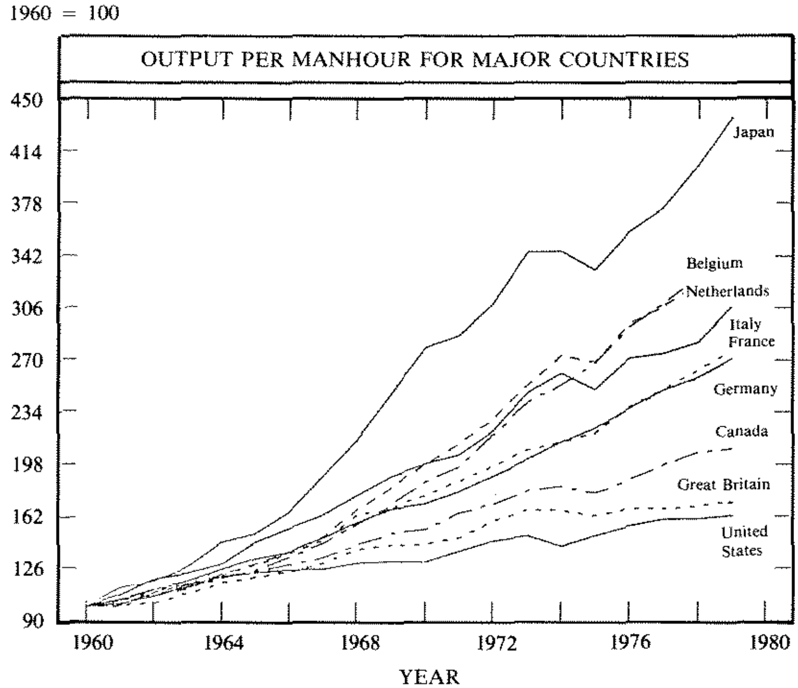
investment in 1970 even though the economy was still operating at high utilization rates.

However, the correlation between changes in investment and changes in the effective corporate income tax rate is not perfect. In particular, the sharp declines in investment in 1958 and 1975 appear to be unrelated to changes in the tax code, and were indeed caused by the severe recessions which occurred in those years.

This anomaly disappears when we correlate the investment ratio and the ratio of stock prices to construction costs, lagged one year. As shown in Figure 5, this ratio captures both the cyclical and secular movements in the investment ratio. This fact has received bipartisan support, as it was prominently discussed in both the 1977 and 1978 issues of the *Economic Report of the President*.

The theory behind this ratio is fairly straightforward. When stock prices are high relative to construction costs and equity capital is relatively inexpensive, businesses will expand by building new plants and filling them with new equipment. However, when stock prices are relatively depressed, businesses will expand by buying smaller

FIGURE 6

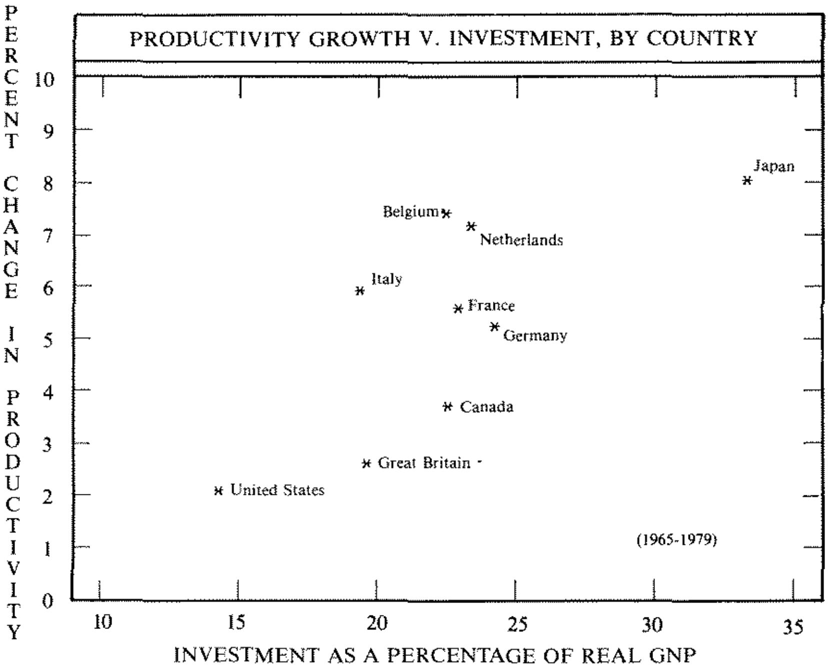


existing businesses, rather than by investing more in new capital assets. The course of the stock market is thus of extreme importance in determining the growth in investment, and explains why this term is relatively more important than the interest rate.

We can never be absolutely positive that the slowdown in productivity after 1966 was due to the reduced rate of growth in investment. However, additional supporting evidence can be gathered by examining the investment and growth patterns of the U.S. economy with those of other leading industrialized countries of the world. These comparisons are provided in the next two graphs. In Figure 6 we find almost a perfect correlation between the proportion of GNP spent on fixed investment and the growth in productivity. Figure 7 documents the extent to which increases in output/manhour in the U.S. have fallen behind growth in the rest of the world. Even when one adjusts these for lower wage gains in this country, the evidence explaining the weakness of the dollar seems compelling.

It often comes as a shock to realize that in the past 15 years the proportion of GNP going to fixed business investment and the rate

FIGURE 7



of increase in productivity for the United States are below even those of the United Kingdom. It is this below-par performance which has been at the root of the weakness of the dollar since 1970.

The oil embargo and subsequent quintupling of OPEC oil prices may result in some relative shift in these relationships during the next decade. As shown in Figure 7, productivity declined in Japan and all major European countries except Germany during 1974, the first time this has occurred in the entire postwar period. Furthermore, wage gains in Europe and Japan have been well above increases in the U.S.; if this continues and is not offset by continuing relative increases in productivity, these areas could lose much of their allure for investors.

So far we have been discussing plans to stimulate investment directly through lower taxes. However, investment can also be stimulated indirectly, namely by increasing personal saving. A decline in the tax rate on income generated from saving—such as interest and dividend income—would result in more personal saving, and eventually more investment.

The vast majority of previous empirical work on the consumption function implies that the interest rate has no significant effect on the proportion of disposable income which is consumed or saved. It is true that a simple correlation between the saving rate and the interest rate reveals no relationship. However, we have found a very strong link between the real after-tax rate of return and personal saving. After substantial testing, we have determined that this rate can best be represented by the long-term bond yield multiplied by (1 − average tax rate on personal income) minus the average rate of inflation over the past four years. Thus defined, this rate of return is found to have an important effect on consumption and saving. Specifically, a 1% increase in the rate of return—e.g., from 3% to 4%—would raise saving by $12 billion. Furthermore, we find that the importance of the after-tax rate of return on savings has been increasing in recent years as interest rates and inflation move to higher levels.

An across-the-board $10 billion personal income tax cut from, say 30% to 29% would have relatively little effect on saving over and above the increase stemming from higher income, although as we note later it would have a much larger effect on labor market behavior. However, the increase in saving from this tax cut due to the increased rate of return would be only about $1 billion. On the other hand, a tax cut of the same size which was targeted only to increase saving through a higher rate of return would result in a rise in saving of some $13 billion. Thus the form of the tax cut is all-important in determining the effect on consumption and saving.

We now consider some of the ways in which saving and investment are stimulated in the high-productivity simulation calculated for this report.

As mentioned above, the simplest and most direct approach is a reduction in the corporate income tax rate. A decrease from the present level of 46% to 40% would cost the Treasury about $11 billion per year before reflows; these figures obviously increase over time as the economy expands and profits rise in nominal terms. The impact effect on investment would be to raise it $9 billion after the lagged effects were fully considered. The multiplier effects are discussed in more detail in the final section.

Changes in depreciation lives could take several different forms, and in general the analysis is somewhat more complicated than for the simple cut in corporate income taxes. The two major plans which have been suggested for changing depreciation allowances are (a) replacement cost accounting, and (b) shortening tax lives, which has recently been popularized as 10-5-3, although clearly other variants of shorter lives are possible.

The theoretical justification to adjust depreciation allowances, in addition to the fact that this would stimulate investment, is that these allowances fall far short of replacement needs in a period of inflation.

Since that is the avowed objective of all such plans, it seems most reasonable to us to meet the ravages of inflation by an adjustment which compensates for inflation. This would be accomplished very simply as follows. Depreciation allowances would be set equal to the appropriate proportion of investment for each year times the ratio of capital goods prices in the present year to capital goods prices in the year during which the investment was originally undertaken. Symbolically this can be expressed by:

$$D_T = \sum_{j=0}^{T-1} \left(\frac{SL_{T-j}}{t_{T-j}} + ACC_{T-j} \left(\frac{2(t_{T-j} - j)}{t^2_{T-j}} \right) \right) * \frac{P_{k_T}}{P_{k_{T-j}}} * I_{T-j}$$

where

P_{k_T} = price of capital goods (implicit deflator, national income accounts, business fixed investment) in year T;

D_T = depreciation allowances in year T;

SL_T = proportion of investment depreciated by the straight line method in year T;

t_T = average length of depreciable life of assets depreciated by the straight line method in year T;

ACC_T = proportion of investment depreciated by accelerated methods in year T; and

I_T = investment in year T.

The drawback to replacement cost accounting, according to the proponents of 10-5-3, is that it is too complicated. However, we feel that such a plan could be implemented very simply by having all depreciation allowances increase by the average rate of inflation of capital goods, as published by the Bureau of Economic Analysis (BEA). Some distinction could be made for equipment and structures, but as a first order of approximation 90% of the inequities caused by inflation would be wiped out by linking to one or two overall indexes.

The reduction in the maximum capital gains tax rate from 49.1%

to 28% in late 1978 brought forth anguished cries from some critics who claimed that it benefited the speculator rather than the long-term investor. While we believe that all capital gains taxes should eventually be abolished, the remaining tax burden could be restructured to benefit more directly those members of society who contribute most to spending on R&D, venture capital, and investment in new companies.

One plan to restructure the capital gains tax laws states that anyone investing venture capital into a new or fledgling company and then holding on to the stock for five years or more would not have to pay any capital gains taxes at all. Furthermore, capital gains would be calculated on an indexed basis, so that investors would not have to pay tax on the phony profits which are due only to inflation. For purposes of calculation, the implicit GNP deflator or some other broad-based price index would be used.

In order to relate the relationship between stock market prices and investment to tax policy, we must determine how much a change in capital gains taxes will affect the stock market. Here we have found a significant relationship, namely that a 1% change in the maximum tax rate on capital gains (i.e., from 48% to 47%) would raise stock prices by approximately 1½%. Hence one of the most important ways to stimulate investment and productivity is to reduce the capital gains tax rate further.

Although no specific figures are available, it is likely that the reduction in capital gains taxes will also contribute to a renaissance of the venture capital industry, which was approximately a $3 billion a year industry in 1968 before higher capital gains taxes and the decline of the stock market combined virtually to wipe out this industry. R&D spending has also been hampered by the lack of venture capital, and while this does not show up immediately in declining productivity, it is thought to have a very substantial effect over a five to 10 year period.

A number of plans have emerged to reduce the burden on the individual saver, and although these are not as far advanced through the Congressional labyrinth, they still merit some discussion and inclusion in our model simulations.

The formation of Individual Retirement Accounts (IRAs) four years ago permitted individuals not covered by pension plans to invest $1,500 each year tax-free, providing the money was not withdrawn before retirement age. Our planned Individual Saving Account (ISAs) would have some elements in common with this general idea, in that they would encourage savings, but the scope would be much more broad-based. Each taxpaying unit could treat up to $1,500 per year in interest income, dividend income, or capital gains rollover as tax-exempt income. Thus, for example, if an individual had a savings account of $10,000 on which he earned an average interest rate of 9% and dividend income of $1,000, $1,500 of that $1,900 income would not be included in his gross taxable income. The plan would have certain strictures; taxpayers would have to keep their principal fully invested, although they could switch assets just as is the case for IRAs now. Any capital gains would have to be reinvested (rolled over) into other similar investments in order for that part of the exemption to qualify. However, the basic idea of an ISA would be that income generated from stocks, bonds, savings accounts, money market funds, or similar assets would be tax exempt as long as the principal remained invested in this class of assets. We estimate that this would cost about $6 billion per year in *ex ante* revenue loss.

Clearly the establishment of ISAs would have many advantages. It would reduce the tax burden for savers, particularly smaller savers, and thus would be politically as well as economically popular with the vast majority of voters. It would stimulate savings and investment, and would pull the U.S. closer to being able to compete with other major industrialized nations in terms of gains in investment and productivity.

The disadvantages which are likely to be raised are threefold. First, such a move would definitely increase the size of the federal budget deficit; no backward-bending supply curves would operate here. Second, it could be argued that most of the tax break would simply go to taxpayers who would save and invest in any case; i.e., it would attract very little new savings. Third, someone is sure to complain that most of the tax breaks will go to the "rich", which to a certain extent cannot be refuted because most of the poor don't save.

These objections suggest an alternative plan which would affect marginal savings more directly. Under this alternative, taxpayers would not receive an exemption or credit unless their savings in any given year were greater than the average savings rate for that income bracket. For example, if the average savings rate was 5% for a $30,000 per year income, taxpayers at that level would not receive any exemption unless they saved over $1,500 in that year. It is difficult to estimate the *ex ante* revenue loss, but it would certainly be under $5 billion per year.

A third alternative plan would be to "start the tax table over" for nonwage income. For example, if a taxpayer had $50,000 in wages and salaries and $10,000 in interest and dividend income, the nonwage income would be taxed at marginal rates applying to $10,000 of income, rather than $60,000. Thus if a wealthy individual had, say, $250,000 of interest and dividend income he would still pay high marginal tax rates—although in this case the top marginal bracket would be limited to 50%, just as it is for wage income, rather than the current top level of 70%. Indeed, we estimate that lowering the top tax bracket from 70% to 50% would actually net the Treasury about $3 billion per year as taxpayers would shift out of tax-sheltered or tax-exempt sources of income.

Other alternative plans are available as well. The original concept of the IRA could be expanded to allow much more of a deduction than $1,500. The principal and interest on money put aside to buy a home could be declared tax-exempt. In any case, all these schemes would have the net effect of reducing the net tax rate on saving. In the model we have assumed that some combination of these reductions would result in lowering the marginal tax rate on savings from its current level of 40% to 30%, which would result in a net loss of revenue to the Treasury of $8 billion per year before reflows.

As a result of these findings, we have also introduced some personal income tax cuts in the high-growth simulations, and some personal tax increases—mainly through bracket creep rather than actual rate hikes—in the low-growth simulation. While the changes in laws affecting investment behavior are the most important movers of the differential rate of growth, we should not ignore the effect of changes in personal income tax rates on labor force participation, the amount of labor offered by those already in the labor force, the level of productivity, and the increase in wage rates. We now examine these relationships in greater detail.

Relationship between Labor and Tax Rates

The theoretical literature of microeconomics has always posited significant relationships between the demand and supply of labor and the cost of that labor, including tax rates. A tax on labor (such as a social security tax) would raise the cost of this labor, thereby reducing its use. Similarly, an increase in taxes would reduce the supply of labor offered, although this effect is sometimes thought to be offset by the so-called backward bending supply curve. However, these linkages have been almost entirely absent from previous macroeconomic models, even though microeconomic studies, including several funded by the federal government, have shown significant elasticities for various classifications of employees, particularly secondary workers in the labor force.

In addition to the beneficial aspects of tax cuts on saving and investment in our new macroeconomic model, we have also found significant relationships between changes in personal income taxes and labor market conditions. These can be subdivided into three areas: labor force participation, amount and quality of work offered, and increase in wage rates.

Typical macroeconomic labor supply functions have been estimated in the form of labor force participation rates by demographic composition, with the principal independent variable being the lagged value of the unemployment rate. Both theory and microeconomic results suggest that the real wage should be included as an additional determinant of labor force participation. However, on an empirical basis the problem of separating out the income and substitution effects has proved baffling. In general we would expect that an increase in the wage rate would have offsetting effects. The higher wage would induce an increase in labor supply, following the usual upward-sloping supply curve for factors of production. However, an increase in income would result in substitution of leisure for work, following the so-called backward-bending supply curve. Furthermore, an increase in prices generally reduces the real income of the wage earner, so that a higher rate of inflation would draw more people into the labor force in an attempt to make ends meet.

The major problem in estimating labor force participation rate equations with the wage rate has always been the difficulty in sorting out the difference between the substitution and income effects, since they should have different signs. Furthermore, most of the theoretical work has been done under assumptions which assume constant prices, whereas in reality fluctuations in the real wage due to inflation are among the major determinants of labor force participation.

Let us first turn to the problem of the income and substitution effects. Musgrave has suggested that this problem can be handled by considering the average and the marginal tax rates separately. He argues that work effort will decline if the marginal rate is raised (substitution effect) but will *increase* if the average rate is raised (income effect). From a theoretical point of view, therefore, the problem is solved by entering both of these tax rates.

From an empirical point of view, however, it is perfectly obvious that these rates move together over time, and that it is not possible to measure the empirical effects separately on a time-series basis. One way around this problem is to introduce an income term together with the marginal tax rate in the labor force participation rate equations. Thus we have included the wage *bill* deflated by the CPI, thus incorporating elements of both the wage rate and income. While not a perfect solution, this combined variable does enable us to estimate more robust estimates of the effect of tax rates on labor force participation, separate the average and marginal tax rate effects, and include the theoretical desirable income term.

Thus the key variable used in the labor force participation rate equation is:

$$\frac{W}{CPI}(1 - t_m)$$

where: W = wage and salaries;
CPI = consumer price index; and
t_m = marginal tax rate as calculated by Evans Economics, Inc. (EEI).

We now turn to the distinction between primary and secondary workers in the labor force. In general economists have found a modest if not insignificant relationship between labor force participation rates for males aged 25 to 54 and either the real wage or the rate of inflation. On the other hand, we would expect both of these variables to be quite significant for secondary workers in the labor force.

We also need to consider the effect of changes in the marginal tax rate on labor supply. Again one can raise the question of whether the substitution or income effect dominates; as tax rates rise, it could be argued, labor supply increases in order to hold real income constant. However, the overwhelming evidence of the microeconomic studies suggest that the substitution effect predominates, and that an increase in tax rates reduces the supply of labor offered. Thus we have combined the tax term with the real wage term in all of these equations.

We thus expect the standardized labor force participation rate equation to contain the following terms: the unemployment rate, the wage bill divided by the price level, the marginal tax rate on personal income, and the rate of inflation.

It is often claimed that the minimum wage has contributed to an increase in the unemployment rate among teenagers, since they are the potential employees whose marginal product is most likely to be lower than the minimum wage. While this is undoubtedly the case, the relationship has another dimension, which is that the existence of the minimum wage barrier also deters many teenagers from entering the labor force in the first place. Thus we find a significant negative correlation between labor force participation rates for those aged 16 to 24 and the minimum wage in real terms. A 1% increase in the minimum wage will reduce labor force participation by approximately 0.2%.

At the other end of the age spectrum, we find a very strong negative correlation between social security benefits in real terms and labor force participation for those 55 and older. Since the benefits are tied to the cost-of-living and in fact are one of the very few types of personal income to outstrip inflation over the past decade, it is clear that an increase in the rate of inflation raises real income for recipients, especially when it is considered that social security benefits are tax-free whereas earned income is subject to personal and social security taxes. Hence the situation for retirement-age individuals is unlike the situation for the rest of the work force, for whom an increase in inflation lowers real income and thus leads to greater labor force participation. One might argue that real income remains constant for those on social security, but actually very few people over 55 are buying or financing new homes, and hence the CPI increase clearly overstates the increase in their cost of living. Also, those over 65 receive medical care free of charge; hence those rapidly rising prices are also not indicative of the costs faced by older citizens.

The empirical results for labor force participation are best divided into primary and secondary members of the work force. The effects on primary workers, defined here as males aged 25 to 54, are significant but small. A one percentage point (p.p.) reduction in the marginal personal income tax rate would result in only a 0.05% increase in the primary labor force. However, it would result in a 0.37% increase in the secondary labor force. However, total increase in the labor force caused by a 1 p.p. reduction in the tax rate would be 0.26%, or approximately 270,000 workers at the present size of the labor force.

The labor force participation equations also indicate that a 1% increase in the real minimum wage (adjusted for inflation) would decrease labor force participation for those aged 16 to 24 by 0.2%. At the other end of the age scale, a 1% increase in real per capital social security benefits would diminish labor force participation of those 55 and over by 0.4%.

The equations relating the amount of utilized labor to output, capital stock, and productivity are usually known as inverted production functions or labor demand functions. However, they are actually a reduced form of labor demand and supply equations, since the amount of labor used depends both on the demand for labor by business and the degree of willingness to offer their labor.

These combined effects are very significant. We find that a 1% increase in the average personal income tax rate including social security taxes will reduce the amount of labor utilized by 0.5%. This decline is caused by several factors. First, an increase in the cost of labor through higher social security taxes will reduce the demand. Second, an increase in tax rates will reduce hours worked per week; we find that this effect accounts for slightly over half of the total reduction in labor offered. Third, higher taxes lead to a rise in vacation time, absenteeism, and unwillingness even to work at all by some members of the labor force.

The results we have found on the effect of changes in taxes on work effort are quite striking. Yet they are corroborated by some cross-section studies which we performed for the years 1962 and 1966. These years were chosen because they bracketed the major 1964 tax cut. We used the IRS tapes and stratified the income tax returns by income classification in order to determine what happened to work effort when taxes were reduced.

Basically the approach we have taken is the following. We know that tax rates were reduced significantly between 1962 and 1966. For any given level of adjusted gross income (AGI), we examined what happened to the proportion of income accounted for by the sum of wages and salaries and business and professional income—in other words, income earned from current work effort. If this proportion remained unchanged we could conclude that the reduction in tax rates had no significant influence on work effort. If it increased, however, we could conclude that the tax reduction heightened work effort. Note that by holding AGI constant in the regressions we have automatically excluded any increase in work effort which might have accrued from the overall growth in the economy or rise in productivity. Our analysis is strictly a marginal one for any given level of income.

We found the following results for a 1% reduction in tax rates. For lower-income workers, such a reduction would raise work effort by about 0.1%. For middle- and upper-middle workers, the increase was about 0.25%. For upper-income workers—those with taxable income of $120,000 or more—we found that elasticities were in excess of 2.0. The upper-income elasticities are probably overstated for the following reason. When the top marginal tax rate dropped from 91% to 70%, many individuals simply shifted some of their compensation from capital gains and stock options back into earned income. As a result, tax revenues in the top bracket more than doubled from 1964 to 1966 after accounting for growth in the economy even though the top bracket rates dropped drastically.

We now consider the wage rate functions in the supply-side model, for they play a critical role in determining the rate of inflation. From the point of view of supply-side economics, the view that we cannot simultaneously have full employment and stable prices is anathema, for it is just this combination which our model shows how to achieve. The problem is that a decline in unemployment is usually triggered by policies which increase aggregate demand but do not raise aggregate supply. When this happens, it is small wonder that inflation eventually rises. However, balanced growth policies, which raise both demand and supply at the same rate, will lead to lower unemployment without increasing inflation.

Yet if we accept the empirical proposition that a strong negative relationship exists between wages and unemployment, how can we then claim that a decline in unemployment will not result in higher wages, unit labor costs, and prices?

Several possibilities can be considered. The main ones are as follows:

1. The decline in unemployment is accompanied by an increase in productivity, thus offsetting higher wage rates. This would occur, for example, if the reduction in unemployment were due to greater capital spending.

2. The decline in unemployment is accompanied by a reduction in personal income tax rates, thereby causing wage earners to accept smaller pre-tax pay increases.

3. The increase in output is accomplished by increasing labor force participation and lengthening the work week, thereby leaving the unemployment rate almost unchanged. This solution is preferable mainly when the economy is near full employment; but as indicated in our previous discussion, that is when the trade-off between wages and unemployment becomes most severe. When slack still exists in the labor markets, the increase in wage rates

stemming from a decline in unemployment is much smaller.

4. An increase in output could be accompanied by declining prices for other factors, such as an improvement in the value of the dollar and hence lower import prices.

To be sure, these changes will not happen automatically. In fact, it is probably the rule rather than the exception that wages, unit labor costs, and prices will rise as unemployment falls. However, to state that this is a general empirical rule because of past experience does not necessarily imply that policies which will offset or mitigate this trade-off cannot be fashioned. In fact, we have just proposed four solutions which would accomplish just that.

It should be stressed that the lags on all of these variables are substantial. The unemployment rate is included with an average lag over the past two years. The lag on the CPI is at least one year in all cases and ranges as far back as three years in the construction equation. Similarly, the personal tax rate is averaged over the past two to three years. Thus the effects which we are describing clearly do not happen instantaneously. They do, however, point out that delayed wage demands may be viewed as somewhat of a "ticking time bomb" in the aftermath of sharp increases in inflation or tax rates. Just because wage demands do not spiral up immediately after inflation and taxes increase does not necessarily mean that they will never catch up, for the lag process can take up to three years to become fully effective.

The generalized wage rate function which we estimate is of the form:

$$\frac{w - \overline{w}}{\overline{w}} = a_0 + a_1\, g(Un) + a_2 \frac{p - \overline{p}}{\overline{p}} + a_3 t_p$$

where: w = average wage rate;

Un = unemployment rate;

p = consumer price index;

t_p = average tax rate on personal income;

$\overline{x} = \frac{1}{4} \sum_{i=1}^{4} X_{-i}$; and

g = a generalized nonlinear function, e.g., $\frac{1}{Un}$

Both the unemployment and inflation terms are in common use in macroeconomic wage rate equations. However, the last major term which we use in these equations, namely the average tax rate on personal income, definitely is not. Yet its inclusion should not be considered particularly surprising. An increase in tax rates will cause workers to bargain for wage increases in excess of the rise in inflation in order to keep their real income constant. Similarly, a tax reduction will permit them to accept gains which are less than the rate of inflation because their take-home pay will still be at the same or higher levels.

The elasticities for the various sectors of the economy, and for total private nonfarm business, are given in Table 4. We see that a 1% increase in the CPI eventually results in a 0.62%, or 5/8%, rise in wage rates. While this figure is high, it is not unity. Even after a lag of up to three years, wage earners do not recoup the full increase in the reported CPI. This fact has been fairly evident ever since 1973, when the real wage was some 10% higher than current levels in spite of two tax cuts in the intervening years.

TABLE 4

Elasticities for Wage Rate Equations

	1% Change in CPI	[a]1% Change in Un	[b]1% Change in Un	[c]1% Change in t_p
Manufacturing	0.58	0.25	0.82	0.50
Construction	0.87	0.67	2.23	0.46
Nonmanufacturing	0.62	0.00	1.17	0.37
Total private nonfarm	0.62	0.11	1.13	0.41

[a]From 8% to 7%
[b]From 5% to 4%
[c]1 p.p. change, i.e., from 30% to 31%

The elasticity with respect to unemployment is nonlinear, as we think it should be. Above 8% unemployment we do not find any effect at all on wage rates from a change in unemployment. The change in each percentage point below 8% then becomes progressively larger. We have selected two points on this unemployment/wage trade-off curve: a change from 8% to 7%, and a change from 5% to 4%. As can be seen, a change in the first case results in a change in wage rates well below 1%, whereas a change in the second case results in a change in wage rates somewhat above 1%.

We finally turn to the change in wage rates resulting from a change in the average tax rate. It is encouraging to find that the coefficients in all of the three equations are bunched closely together. While we might expect differences in the unemployment/ wage rate trade-off in different industries because of varying institutional and union structure, we would expect that workers would respond similarly to changes in tax rates regardless of the particular industry in which they were employed. We find that for the overall economy, a 1 p.p. change in tax rates (i.e., from 30% to 31%) would result in a 0.4% change in wage rates. However, this is only an impact multiplier although it does take place over as much as three years; we also need to consider the total effect after including the interaction between wages and prices.

In order to understand the dynamics of the wage-price-tax interaction, let us aggregate the equations in the wage sector. We then find that a 1 p.p. reduction in personal income tax rates will reduce prices by about 0.45% and wage rates by about 0.70%. Since wage rates rise a full 1% because of lower taxes, the after-tax increase in the real wage rate stemming from the tax reduction is 0.9%.

To summarize the results of this section, we find that:

1. A 1 p.p. change in the tax rate will change labor force participation in the opposite direction for primary workers by a minuscule 0.05% but will change the participation rate for secondary workers by 0.37%.

2. A 1 p.p. change in the tax rate will change employment-hours in the opposite direction by 0.5%. Much of this change stems from the change in hours worked.

3. A 1 p.p. change in the tax rate will change the average wage rate in the same direction by 0.4% on impact, and 0.7% when the interaction between prices and wages is considered.

Thus a reduction in the personal income tax rate would increase the supply of labor, increase the number of hours worked, and reduce the gain in average wage rate. An increase in the demand and supply of labor would expand the maximum productive capacity of the economy. Thus inflation would be reduced both through a lower wage rate and a higher level of maximum capacity, thus widening the gap between actual and maximum capacity.

MAJOR LINKAGES IN THE SUPPLY-SIDE MODEL

One of the reasons that demand-oriented policies have been used almost exclusively in the past 15 years is that all of the current large scale econometric models have indicated that these policies will benefit the economy more than supply-side changes. Embedded in these models is the implicit assumption that an increase in demand will automatically trickle down to increase aggregate supply, thus insuring balanced, noninflationary growth.

However, there is nothing magical about the balance between aggregate demand and supply. If incentives are lacking for investment, capital formation will stagnate. If incentives are lacking for labor, labor force participation will decline, the amount of labor offered by those already in the labor force will be reduced, and productivity will diminish. As a result, total productive capacity of the economy will grow more slowly than total demand, and bottlenecks, shortages and higher inflation will eventually result.

According to Keynesian demand economics, this higher inflation must then be fought by causing a recession and reducing aggregate demand. It is true that the gap between aggregate demand and supply must be widened in order to diminish inflationary pressures. However, surely there are two ways to accomplish this aim. One is indeed to diminish demand, thereby causing higher unemployment. The other is to increase aggregate supply, thereby raising the production possibility curve of the economy and increasing jobs and output at the same time that inflation is being lowered. This is the fundamental hypothesis underlying our supply-side modeling.

As already noted, most fiscal policy analysis of the past 15 years has been based on the belief that an increase in government spending will lead to a larger rise in demand and output than an equivalent reduction in taxes. The reasoning which leads to this conclusion is straightforward if inaccurate. If the government increases its spending, the entire dollar is used to raise aggregate demand. If taxes are cut, however, some of each dollar is used for saving. Since existing Keynesian models do not incorporate the links between saving and investment, demand does not rise as much.

Furthermore, these models also state that a personal income tax cut has a larger effect than a corporate income tax cut, and for much the same reason. Individuals spend a larger proportion of the extra money they receive from reduced taxes than do corporations, and that left-over saving does not contribute to economic growth or prosperity.

The supply-side model which we have built gives exactly the opposite result: an income tax cut has a larger effect on the economy than an increase in government spending. The supply-side mechanisms which support this conclusion can be qualitatively summarized as follows. In particular, a reduction in personal and corporate income taxes will set in motion the following chain of events.

1. An increase in the after-tax rate of return on personal saving occasioned by a reduction in personal income tax rates raises the incentives of individuals to save. This increase in saving leads to lower interest rates and higher investment.

2. A reduction in the effective corporate income tax rate, either through lower tax rates, a higher investment tax credit, or more liberal depreciation allowances, improves capital spending directly by increasing the average rate of return.

3. An increase in both personal and corporate saving leads to greater liquidity and less loan demand, thereby lowering interest rates. These effects help both capital spending and residential investment.

4. A rise in the ratio of investment to GNP leads to higher productivity, which means that more goods and services can be produced per unit of input. As a result, unit costs do not rise as fast and inflation grows more slowly.

5. A reduction in personal income tax rates leads to a rise in labor force participation and work effort, thereby increasing the supply of labor necessary to produce more goods and services.

6. Thus labor supply, capital stock, and productivity are all increased by lower tax rates, thereby expanding the maximum productive capacity of the U.S. economy.

7. As a result of higher maximum capacity the inflationary pressures of shortages and bottlenecks diminish, thereby reducing the rate of inflation.

8. An increase in maximum capacity also permits the production of more goods and services for export markets. This improves our net foreign balance and strengthens the dollar, thus leading to lower inflation because imported goods decline rather than advance in price.

9. Lower personal income tax rates lead to smaller wage gains, since wage bargaining is based at least in part on the level of after-tax income. This in turn reduces inflation further.

10. Thus lower tax rates cause a reduction in inflation through several channels. Inflationary pressures decline as the gap between actual and maximum potential GNP rises; productivity increases, thereby lowering unit labor costs; the dollar strengthens, causing less imported inflation; and wage rates rise more slowly.

11. Lower inflation leads to higher real disposable income, since

bracket inflation is mitigated. The rise in income leads to an increase in consumption, output, and employment.

12. Lower inflation leads to lower interest rates, stimulating investment in both plant and equipment and in housing.

13. The increased demand for goods and services stemming from lower inflation is matched by the rise in the maximum potential capacity of the economy to produce these goods and services, thereby resulting in balanced, noninflationary growth.

One of the most important sets of linkages in the supply-side model is the relationship between saving and investment. For if saving rises and these funds are just used to increase idle cash balances, investment may not expand. However, these links are well documented in our model.

A $10 billion increase in personal saving raises time deposits by $3.0 billion and thrift institution deposits by $1.6 billion. In addition, it reduces loan demand by $3.6 billion.

As a result of these changes in the balance sheet of commercial banks, demand for U.S. government securities by the banks increases by $11.5 billion. This results in approximately a 1% decline in interest rates and a 3.2% increase in stock market prices.

These changes have two related effects on investment. First, lower interest rates and higher stock prices stimulate fixed business investment. Second, easier credit increases housing starts and mobile homes and, to a lesser extent, producers durable equipment.

As would be expected, nonresidential construction is more sensitive to changes in interest rates and stock prices than is equipment. Thus we find a $2.5 billion increase in structures, as compared to a $1.3 billion rise in producers durable equipment from a $10 billion increase in personal saving. Residential construction rises $1.5 billion because of credit easing and $1.2 billion because of lower interest rates. These are, of course, only first-round effects which do not take into account the increase in investment stemming from higher income and output. However, these results do document the strong linkages between saving and investment which exist in the supply-side model. For if these linkages are not strong, the second-round effects will not be observable either.

Another important breakthrough in our supply-side model is the endogenous explanation of productivity, which we have already discussed in the first section.

A 1% increase in productivity will not only expand maximum potential GNP by that amount; it will initially lower prices by 2/3%, since labor costs consist of 2/3 of total factor costs. This is only the first-round effect, since lower prices will lead to lower wages and further declines in unit labor costs and prices. The total effect of a 1% increase in productivity is to reduce prices by about 2%.

We are also able to introduce other innovations into the supply-side model because of the endogenous treatment of maximum capacity. In particular, the model introduces the concept of the cumulative gap, already discussed in the first section, which we define as the cumulative difference between 99% of maximum GNP and the actual level of GNP *when this gap is negative*. When it is positive—i.e., actual GNP is below maximum potential output—inflationary pressures do not build because of bottlenecks and shortages. However, when it is negative, prices start to rise faster than would be indicated by the cost of factor inputs alone.

So far this term does not sound greatly different than an index of capacity utilization, although it is much more inclusive in that it covers all sectors of the economy. However, we have *cumulated* this gap for all periods when the gap is negative. This term therefore indicates that inflationary pressures build up over many years and do not disappear every time a mild recession occurs. The inefficiencies and distortions which occur when the economy is operating near full capacity are not reversed overnight, and remain as a legacy until the cumulative gap once again returns to zero. This term may also represent the gradual buildup of inflationary expectations.

The final area of the model in which supply-side economics has been incorporated is the integration of the international sector with the U.S. economy. Again, this is an area where theoretical economists have long posited strong links, but they have never been empirically documented within the context of a macroeconomic model.

Supply-side effects are important in two specific areas. First, an increase in the gap between actual and maximum potential GNP raises exports, since the greater capacity of the U.S. economy permits the production of more goods and services for export markets as well. A 1% increase in this gap raises net exports by about $0.7 billion per year; since the gap is cumulative, this figure continues to increase linearly and is, for example, $2.1 billion after three years.

The second major effect is the link between the trade-weighted average of the dollar, which is itself closely tied to the size of the net foreign balance, and the overall rate of inflation. We find that a 10% decline in the value of the dollar relative to a trade-weighted average of the Deutschemark, French franc, Belgian franc, Dutch guilder, and Japanese yen raises the producer price index 1.3% and the consumer price index about half that much after a period of two years.

Thus we can document several supply-side relationships that have a significant effect on inflation as well as the rate of growth. All these figures refer to the change in the CPI and are impact estimates only. First, a 1 p.p. decline in the personal income tax rate will lower wage rates and thus prices by about 0.5%. Second, a 1% increase in productivity will lower prices by 2/3%. Third, a 10% improvement in the trade-weighted average of the dollar will reduce inflation by about 0.6%. Fourth, after a three-year period, a 1% increase in the gap between actual and maximum GNP will lower prices by 0.4%. It is worth repeating that all of these figures are impact estimates only and do not take into account the interaction between wages, prices, productivity, and other factors of production. Indeed, the final changes in prices are between two and three times the initial impacts, depending on cyclical conditions at the time.

Thus we find that the nemesis of demand-side economics, namely that output must be reduced and unemployment increased in order to dampen the rate of inflation, is only one of several alternatives. Inflation can also be reduced by increasing productivity, reducing personal and corporate tax rates, and strengthening the value of the dollar. We would not quarrel with the statement that the size of the gap between actual and maximum potential GNP is one of the factors determining the rate of inflation, but do believe that other factors must be considered as well.

The actual reduction in the implicit GNP deflator for the high-growth, high-deficit case is only 1.3% by 1990, although even this represents a marked change from the usual finding that inflation would be higher. The two principal reasons for this discrepancy are a) the lag structure and b) the large deficit. The changes in productivity do not immediately translate into lower prices, since both changes in wages and prices react to change in economic stimuli with a substantial lag. In addition, the benefits to higher productivity from higher investment are not felt immediately.

The second and more important reason is that the huge budget deficit pushes up interest rates, thereby contributing to higher costs of doing business and also raising the CPI through higher mortgage interest rates.

Because of the fact that the implicit GNP deflator declines in this high growth scenario, we find that the reflows are rather modest. Hence the *ex post* deficit in 1990 is approximately $500 billion in spite of the higher growth generated. While such a deficit is economically feasible because the dissaving by the government is funnelled into saving by the private sector, we do not think it would be politically feasible, nor do we consider it the optimal solution.

For this reason we have calculated another high-growth scenario, one with a balanced budget, which is generated by reducing transfer payments. This alternative high-growth scenario, which we then adopt as our preferred run, also provides additional information about the timing and magnitude of government spending multipliers.

GENERATING A HIGH-GROWTH SCENARIO: THE BALANCED BUDGET CASE

To generate this simulation, we made only one change from the previous high-growth run: we reduced transfer payments enough to generate a balanced budget. This resulted in transfer payments increasing only 2.2% per year (current dollars) instead of the 11.4% per year increase which is included in both the baseline and high growth-large deficit scenario. The total reduction in transfer payments by 1990 is approximately $500 billion per year.

Before examining the economic ramifications of such a reduction, it certainly is worth asking whether it would be possible to cut transfer payments by this amount while still retaining the present social fabric of the United States. Figures on the projected growth of transfer payments over the next decade under alternative assumptions are given in Table 5.

For purpose of this analysis, we can divide transfer payments into three categories: retirement benefits, medical care payments, and other transfers, which are largely veterans benefits and welfare payments. Under the baseline case, retirement benefits are expected to grow at a rate equal to the annual average increase in the CPI plus the average increase in the population over 65. A similar formula would apply for medical care benefits, although there we use the increase in the CPI for medical care. Other transfer payments are expected to grow at a rate of increase equal to the

TABLE 5

Projected Growth of Transfer Payments

	1980 (billions)	Annual Increase Due To: Inflation	Pop.	Change in Coverage	Total Annual Change	1990 (billions)
		A. Baseline				
Retirement Benefits	$157	9.9%	2.0%	0.0%	12.1%	$490
Medical Care	38	10.1	2.0	1.0	13.4	134
Other	98	8.3	1.0	0.0	9.4	241
TOTAL	293				11.4	865
		B. Adjustment for Lower Inflation Only				
Retirement Benefits	$157	6.1%	2.0%	0.0%	8.2%	$344
Medical Care	38	7.8	2.0	1.0	11.0	108
Other	98	7.5	1.0	0.0	8.5	222
TOTAL	293				8.7	674
		C. Lower Inflation and Cutbacks in Program				
Retirement Benefits	$157	6.3%	2.0%	−9.0%	−0.7%	$147
Medical Care	38	7.8	2.0	−5.0	5.0	62
Other	98	7.5	1.0	−3.7	4.6	154
TOTAL	293				2.2	363

[a]Implicit Constant Deflator instead of CPI

average rise in the implicit GNP deflator plus the average gain in total population. These figures are all given in Table 5A.

The figures in Table 5B are adjusted for lower inflation, and also incorporate the assumption that retirement benefits would be indexed to the implicit deflator for consumption rather than the CPI, since the tendency of the latter to overstate price increases because of its overdependence on the cost of buying and financing a home is now well known. Thus switching to the higher-growth lower-inflation scenario, plus this one sensible adjustment in the indexation scheme for social security benefits, reduces transfer payments by almost $200 billion per year by 1990.

While this $200 billion is indeed an impressive saving, it is far less than the $500 billion which is needed to balance the budget. Table 5C provides the arithmetic to indicate how these remaining savings are achieved. From an economic point of view, the following changes are instituted:

1. The retirement age is raised from 65 to 70. There is nothing sacrosanct about the number 65 for a retirement age; indeed, if we use the most recent actuarial tables, we find that a retirement age of 65 in the mid-1930s (when social security was originally implemented) now corresponds to an age of almost 70, and that figure will probably rise to 72 by the end of this decade.

As might be expected, the savings in postponing the retirement age are substantial. Each additional year of postponement—e.g., from 65 to 66—saves the government $18 billion at current levels of benefits and population. If we adjust this figure upward for the increase in the implicit consumption deflator and the growth in population over 65, by 1990 this figure amounts to $40 billion for each year the retirement age is postponed. Thus raising the retirement age to 70 would save a whopping $200 billion, in which case retirement benefits would actually be somewhat below present levels.

The other cuts are less drastic. The reduction in medical care benefits could be accomplished, we believe, by simply adding a deductible and coinsurance whereby the patient would pay the first $100 per year of medical expenses and 90% of the remainder up to some fixed limit which might be equal to, say, 10% of his annual income. For example, if an individual had an income of $20,000, he would be required to pay no more than $2,000 in medical premiums that year regardless of the extent of his actual bills. This would provide 100% coverage for catastrophic illness while alerting patients to the substantial cost of medical services which is borne by society at large. We estimate that the deductible and coinsurance as outlined above would cut the growth of medical care payments in half.

The remaining cuts would occur in the phasing back of existing programs, such as food stamps for college students, a cap on black lung payments, reduction in the Aid to Families with Dependent Children as these parents returned to work, and other similar welfare programs. Of the three major areas, these cuts are proportionately the smallest and the most politically feasible.

It should be made quite clear that workers who no longer receive retirement benefits at ages 65 through 69 will remain in the labor force, but the higher growth rates will certainly provide the additional jobs necessary to support these older workers. As we have already mentioned above, the U.S. economy will shift from a labor surplus to a labor shortage economy by 1990, and the jobs which these older workers retain will mitigate the labor shortage problem. Hence the gradual raising of the retirement age—increasing it, for example, six months every year over the next decade—would fit hand in glove with the need for more workers and the redirection of resources from the public to the private sector.

COMPARISON OF THE TWO HIGH-GROWTH SCENARIOS

Based on traditional multiplier analysis, one might expect that the $500 billion decrease in transfer payments would result in a far slower rate of growth because of the resulting decline in consumption. However, this is not at all what happens. The reduction in the federal government budget deficit lowers interest rates, thereby stimulating capital formation. Furthermore, the lower rate of inflation which stems from higher productivity growth also reduces interest rates. Finally, since income is redistributed to those who are working away from those who are not, labor force participation rises, which provides the additional labor inputs needed to complement increased capital spending.

The comparison for several key variables is given in Table 6. In particular we note that while real growth is about ½% per year higher for the largest deficit case in the early 1980s, the pattern is completely reversed in the second half of the decade, and by 1990 real GNP is increasing almost ½% per year faster for the balanced budget case. As can be seen, the rate of inflation is approximately 1% per year lower for the balanced budget case after 1985.

TABLE 6
Comparison of Two High-Growth Scenarios

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Real GNP, % Growth										
Large deficit	2.6	6.2	4.4	1.0	2.1	3.4	3.9	4.4	4.8	5.0
No deficit	2.5	5.9	3.8	0.2	1.6	3.2	4.1	4.7	5.2	5.4
Implicit GNP Deflator, % Growth										
Large deficit	9.2	8.7	8.8	8.6	7.6	6.6	6.1	5.6	5.3	4.9
No deficit	9.2	8.7	8.6	8.2	6.9	5.7	5.0	4.5	4.2	3.8
Federal Budget Surplus or Deficit, billions of $										
Large deficit	-78	-70	-92	-148	-199	-239	-284	-348	-416	-508
No deficit	-65	-19	-2	-15	-16	-2	13	15	16	-4
Government Spending/GNP, ratio										
Large deficit	37.1	35.5	34.5	34.8	35.1	35.2	35.2	35.2	35.2	35.2
No deficit	36.6	34.0	32.2	31.9	31.6	31.1	30.4	29.9	29.4	29.0
AA Utility Bond Rate, %										
Large deficit	11.5	11.3	11.7	13.0	13.6	14.1	14.6	15.5	16.6	18.0
No deficit	11.5	11.0	10.9	11.8	11.5	11.3	11.0	11.2	11.5	12.2

LOW-GROWTH SCENARIO

We have generated a high-growth scenario with a balanced budget by cutting corporate and personal income tax rates dramatically and then balancing the budget through lower transfer payments. The low-growth alternative, however, cannot realistically be generated by raising tax rates the same amount they were cut in the high-growth alternative, for no one expects the statutory tax rates to be raised during the 1980s, although rates may drift up because of bracket creep. Thus we must lower growth directly by reducing growth in the labor force and by lowering the rate of growth in productivity. This can be done by a combination of a) higher tax rates through bracket creep, b) higher costs of government regulation, and c) higher relative energy prices.

Thus we have approached the low-growth scenario in a much different manner, and have changed those variables which impact directly on labor force growth and productivity *other than* income tax rates. The changes which we have introduced to generate this scenario are the following;

1. Energy prices, both imported and domestic, grow at a faster rate.
2. The cost of government regulation doubles over the decade.
3. Labor force participation rates grow more slowly.
4. Transfer payments grow 15.6% per year instead of 11.4%.

The average tax rate increases from 24.9% to 38.3% by 1990—but that is entirely due to bracket creep and does not reflect any rise in the statutory rate.

In addition to these four changes, we have also cancelled any personal or corporate income tax cuts over the decade which are included in the baseline, held depreciable lives at 1980 levels, and terminated the investment tax credit. However, it should be stressed that these do not account for the bulk of the decline in growth which occurs in this scenario—that is due to the four factors listed above.

COMPARISONS OF THE ALTERNATIVE SCENARIOS

We now compare the performance of the economy, on a decade-long average and for year-by-year changes, for the baseline, high growth with balanced budget, and low-growth scenarios. We have not included the high growth with large deficit run, since that is not a feasible alternative; furthermore, we have already discussed the difference between the two high-growth runs in the previous subsection. The principal assumptions and results are presented in Table 7.

While the decade average figures are useful, they really do not convey the full flavor of the differences between the runs; this is best done by examining the differences in the forecast on an annual basis, which is presented in Table 8. Here we note the great divergence which occurs in the saving rate, growth in productivity, and inflation, particularly after 1985. The forecasts are somewhat

TABLE 7
Growth Rates
(1980 - 1990)
Selected Economic Indicators for Alternative Scenarios

	Baseline	High Growth	Low Growth
Real GNP	2.9	3.6	1.6
Labor Input	2.0	1.6	1.3
Labor Productivity	0.9	2.0	0.3
Labor Force Participation	0.6	0.8	0.3
Real GNP per capita	2.0	2.7	0.7
Relative Price of Energy (PPI)	6.6	6.8	7.2
Growth of Transfer Payments	11.4	2.1	15.6
Levels in 1985			
Personal Income Tax Rate	0.227	0.168	0.284
Corporate Income Tax Rate	0.46	0.20	0.46
Investment Tax Credit	10%	10%	0%
Depreciation Lives, Equipment	8.4	5.0	10.5
Depreciation Lives, Structures	18.4	10.0	23.0

similar for the first five years but then differ markedly, which emphasizes the fact that most of the effects of changes in supply-side fiscal policies occur only after the first five years.

The results in Table 8 point out that the effect of higher productivity on higher saving and investment on productivity, growth, and inflation is far from instantaneous. In fact, even if an optimal fiscal policy were to be implemented immediately, we would not expect it to have a noticeable effect on slowing inflation for at least two years. In fact, it is often five years or even more before the full effect of higher saving is translated into benefits for the entire economy.

In fact, it is interesting to note that the initial effect of these tax cuts is to raise inflation, just as would be the case in a traditional demand-side model. This occurs because the demand elements—higher consumption and investment—are activated before the supply elements—higher productivity and lower wage rates—work

TABLE 8
Annual Comparisons of Alternative Scenarios

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Real GNP, % Change										
Baseline	2.0	5.2	3.6	0.0	1.5	3.0	3.6	3.6	3.6	3.5
High Growth	2.5	5.9	3.8	0.2	1.6	3.2	4.1	4.7	5.2	5.4
Low Growth	1.7	3.8	1.7	-0.9	-0.1	1.2	2.4	2.9	3.5	-0.3
Implicit GNP Deflator, % Change										
Baseline	9.1	8.2	8.0	7.9	7.1	6.3	6.2	6.3	6.6	6.9
High Growth	9.2	8.7	8.6	8.2	6.9	5.7	5.0	4.5	4.2	3.8
Low Growth	9.8	9.2	9.2	9.2	8.8	8.4	8.5	9.1	10.0	11.6
Productivity Growth, % Change										
Baseline	1.3	1.4	1.3	0.3	0.0	0.7	0.8	0.9	0.9	0.9
High Growth	1.3	1.7	1.8	1.1	1.2	2.3	2.9	3.4	3.9	4.2
Low Growth	1.2	1.5	1.1	-0.7	-1.4	-1.5	-1.9	-2.4	-2.7	-3.0
Ratio of Fixed Business Investment to GNP										
Baseline	9.3	9.8	10.8	11.2	10.8	10.8	11.0	11.1	11.1	11.0
High Growth	9.4	10.2	11.6	12.1	12.1	12.3	12.5	12.8	12.9	13.0
Low Growth	9.3	9.7	10.4	10.5	10.3	10.1	10.1	10.2	10.0	9.9
Ratio of Government Spending to GNP										
Baseline	36.6	36.1	35.6	36.3	36.8	36.9	36.8	36.6	36.5	36.4
High Growth	36.6	34.0	32.2	31.9	31.6	31.1	30.4	29.9	29.4	29.9
Low Growth	37.2	36.6	36.9	38.1	39.2	39.7	39.7	39.3	38.5	38.9
Personal Saving Rate, %										
Baseline	4.5	5.1	6.6	6.6	6.5	7.6	8.8	9.7	10.3	11.1
High Growth	5.0	5.1	6.1	5.7	5.5	6.5	8.0	9.4	10.7	12.5
Low Growth	3.2	3.2	3.4	2.8	2.5	3.0	3.3	3.0	2.2	0.8

their way through the system. However, by 1985 the situation is reversed and by 1990 the inflation rate in the higher growth scenario is almost 3% below the baseline solution.

It is perhaps not very difficult to convince anyone that a higher rate of growth is preferable to a lower one. However, recently two groups of lower growth advocates have emerged: those who argue that we either cannot or should not produce enough resources necessary to support higher growth, and those who argue that higher growth would be inflationary and hence ultimately destroy that which we set out to accomplish.

The resource question is not a trivial one, but can be solved by an appeal to market economics. The decline in domestic oil production and the huge increases in the volume of oil imports during the past decade has been directly related to the decision by U.S. government officials that we would somehow all be better off if oil prices were not allowed to rise as fast as increasing costs. While the problem with energy reserves is the most virulent, similar problems exist with respect to many other basic industrial commodities. It is imperative that the higher growth scenario be accompanied by adequate supply response in terms of profit margins for those who extract or produce basic materials.

Simulations and Multiplier Estimates

One way to approach this subject would be to give the usual multiplier estimates for small changes in government spending, personal income tax cuts, corporate tax cuts, and similar measures. Even these estimates can be quite instructive; we have already used this model to show that the Carter tax packages are much more inflationary than the Reagan tax packages. However, the full flavor of the supply-side model cannot really be savored unless we introduce massive changes in fiscal policy, and it is these changes which we report in this section. Specifically, we have prepared three simulations: a) the baseline case with moderate tax cuts and essentially a balanced budget after 1982, b) a daring experiment in which we cut personal and corporate tax rates in half, and c) the same tax cuts, but combined with enough reductions in transfer payments to balance the budget.

Generating a High-Growth Scenario: The Large Deficit Case

The high-growth run is generated by changing the following tax parameters:

1. Gradual reduction in the corporate tax rate from 0.46 to 0.20 by 1985. The actual yearly values are:

1980	1981	1982	1983	1984	1985 and later
0.46	0.40	0.35	0.30	0.25	0.20

2. Depreciation lives for equipment reduced from 10.5 presently to eight years in 1981 and five years in 1982 and thereafter.

3. Depreciation lives for structures reduced from 23 presently to 18 years in 1981 and 10 years in 1982 and thereafter.

4. Gradual reduction in the average marginal federal personal income tax rate from 24% to 12% in equal increments by 1990.

The revenue losses from these changes are immense, particularly when calculated in 1990 prices. For example, taxable personal income is estimated to be $3.4 trillion by 1990. Thus a cut from 24% to 12% in the tax rate would result in a static revenue loss of some $410 billion.

The changes in the corporate tax rates are not as great, but they are still substantial. Pre-tax corporate profits are expected to be about $400 million by 1990; hence, cutting the tax rate from 46% to 20% would reduce tax receipts by $100 billion. In addition, shortening depreciation lives would lower pre-tax corporate income by $140 billion, although since the tax rate is reduced to 20%, this only accounts for an additional $30 billion revenue loss per year. In fact, it should be clear that as the corporate tax rate approaches 0%, the length of depreciation lives is no longer of any importance for tax purposes.

These figures indicate a static revenue loss of $540 billion per year. Even when compared with a GNP of almost $7 trillion and a federal budget of $1.7 trillion, the amounts are quite large. This loss amounts to a deficit of 7.7% of GNP, which is far larger than the postwar record of 4.6% posted in the recession year of 1975.

It is usually argued that such static revenue loss estimates are inappropriate, for they fail to consider the higher revenue base raised by faster growth of the economy, higher employment and income, and greater profits. However, this leads to one of the major findings of the supply-side model.

Because lower personal income tax rates generate smaller gains in wage rates and hence smaller increases in unit labor costs and prices, *current* dollar GNP is only slightly larger in the higher growth scenario than in the baseline case. Real GNP is some 8.6% higher, since we have defined the high growth alternative to show real GNP rising approximately 1% per year faster for the nine-year period 1981-1990. However, according to our basic results on the trade-off between productivity and inflation, every 1% increase in productivity results in a 2% reduction in inflation. Hence in steady state equilibrium, we would expect current dollar GNP to grow 1% *less* per year with this higher productivity growth.

The hypothesis that higher growth leads to more inflation is effectively defused by the results given in this report. Indeed, the higher growth scenario is accompanied by lower rather than higher rates of inflation, due to greater productivity and lower wage rate increases both slowing the rise in unit labor costs. Thus we are able to generate realistic alternative scenarios which not only provide for more jobs and greater output, but reduce the rate of inflation as well by redirecting resources toward saving and investment.

Finally, it is clear that one of the major contributors of higher growth in the preferred scenario has been the increase in the investment ratio, which in turn has been brought about through tax incentives for increased saving and investment.

The generalized incentives for investment—lowering the corporate income tax rate and shortening depreciation lives—are well known and have often been suggested for stimulating investment. We have not used an increase in the investment tax credit in this scenario because of our finding that it is not as efficacious. It increases investment only about half as much as an equal reduction in the corporate income tax rate and about ¾ as much as an equal reduction in depreciation allowances. We have also introduced a net reduction in the capital gains tax by increasing the exclusion from 60% to 70% of the total gain, a change which also stimulates investment through raising stock prices and hence lowering the cost of equity capital.

However, one should not neglect the fact that capital markets are fungible—that an increase in saving in any major sector of the economy will result in lower interest rates, greater credit availability, and hence greater investment and productivity. We can achieve these gains not only by stimulating investment directly, but by increasing saving in the personal and governmental sectors. In particular, we believe that capital formation can be stimulated by reducing personal as well as corporate income taxes.

Hence in addition to reducing the corporate tax rate to 20% and restructuring depreciation lives to adjust for inflation, we also favor broad-based personal income tax cuts accompanied by commensurate reduction in government transfer payments. It is the balanced approach—the use of all three legs of the stool—which we feel is essential for balanced low inflationary growth.

Thoughts on the Laffer Curve

ALAN S. BLINDER

. . . the ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed the world is ruled by little else.
—J. M. Keynes

The first part of the paper by Canto, Joines, and Laffer, which is the only part I will discuss, sets up a simple general equilibrium model with two factors (both taxed proportionately) and one output, and proceeds to grind out the solutions. The model, while not entirely unobjectionable, is certainly not outlandish in any important respect. The authors make no claims that the model tells us anything about the U.S. economy; nor do they draw any policy conclusions. They use the model to provide intellectual underpinnings for the celebrated "Laffer Curve"—the notion that the function relating tax receipts to tax rates rises to a peak and then falls. Since, as I will point out shortly, the analytical foundations of the Laffer curve were in fact established centuries ago, and require no economic analysis at all, I will devote my comments to the critical empirical issue: is it possible that taxes in the U.S. have passed the points at which tax receipts cease rising? Is the U.S. tax system over the Laffer hill?

Let me note at the outset why this is an important question. Certainly not because of the implications for the government deficit. Surely what a tax change does to the budget deficit must be one of the *least* important questions to ask. It is important to know which taxes, if any, have reached the downside of the Laffer hill because, in an optimal taxation framework, tax rates should be set to raise whatever revenues are required with minimum deadweight loss.[1] Since a tax that is past this point causes deadweight loss and

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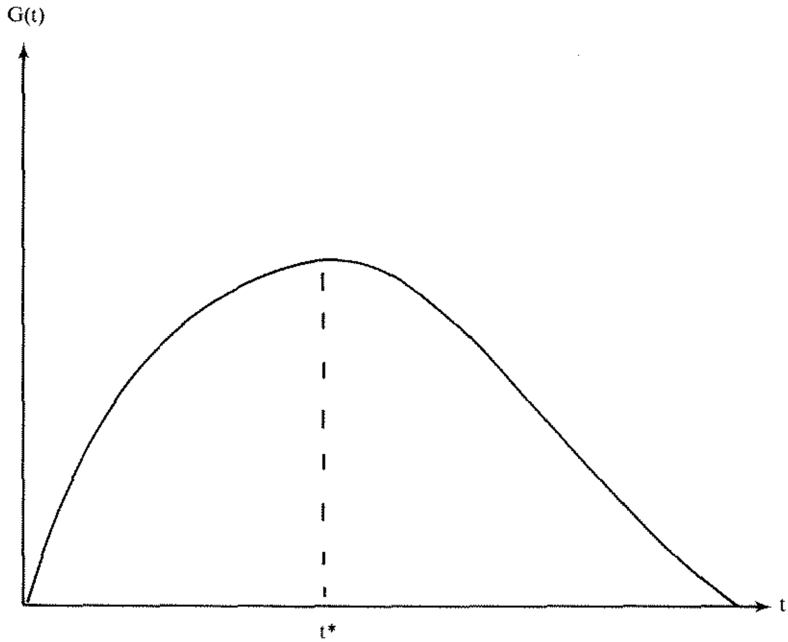
[1]The statement assumes that lump sum taxes are unavailable and ignores distributional objectives.

FIGURE 1



makes a *negative* contribution to revenue, it must be irrationally high, as Canto, Joines and Laffer correctly state.[2]

ORIGINS OF THE LAFFER CURVE

Figure 1 is a Laffer curve relating tax receipts, G, to the tax rate, t. For some types of taxes (example: income taxes), the tax rate has a natural upper bound at 100%, so we may assume that $G(1) = 0$. For others (example: excise taxes) there is no such natural bound at 100%, so we assume instead that G asymptotically approaches zero as t approaches infinity. The distinction is not terribly important so long as we keep in mind that taxes greater than 100% are indeed possible in many cases.[3] The Laffer curve reaches its peak at tax rate t*, which I hereafter call the Laffer point.

[2]Such a tax might be rational if its avowed purpose was to "distort" behavior (e.g., an emissions tax to reduce pollution). A purely redistributive objective is also a potential rationale; but there must be better ways to redistribute income.

[3]Taxes on such items as cigarettes, liquor, and gasoline have exceeded 100% of the producer's price in many times and places.

According to the media, the Laffer curve was born on a napkin in a Washington restaurant in 1974. This, however, I know to be wrong. The Laffer curve should perhaps be called the Dupuit Curve, because Dupuit—a man who was ahead of his times in many respects—wrote in 1844 that:[4]

> *If a tax is gradually increased from zero up to the point where it becomes prohibitive, its yield is at first nil, then increases by small stages until it reaches a maximum, after which it gradually declines until it becomes zero again.*

But Dupuit was just an academic scribbler distilling his frenzy from a politician of a bygone age. In parliament in 1774, Edmund Burke used what was perhaps called the Burke Curve by the journalists of the day to argue against overtaxation of the American colonists:

> Your scheme yields no revenue; it yields nothing but discontent, disorder, disobedience; and such is the state of America, that after wading up to your eyes in blood, you could only end just where you began; *that is, to tax where no revenue is to be found* . . .

But, alas, we cannot credit Burke with the idea either, for the concept goes back even further and is far more basic. One of the first things that freshmen learn in their first course in calculus is Rolle's Theorem. Rolle's Theorem is as follows. Let $G(t)$ be any continuous and differentiable function with $G(a) = 0$ and $G(b) = 0$. Then there must be some point t^* between a and b such that $G'(t^*) = 0$. Let $a = 0$, b be either 1 or infinity, depending on the type of tax under consideration, add the proviso that $G'(0) > 0$, and you have a Laffer curve. The existence of a Laffer curve, in other words, is not a result of economics at all, but rather a result of mathematics. We cannot doubt that there *is* a Laffer hill, i.e., there is a tax rate that maximizes tax receipts, so long as the assumptions of Rolle's Theorem are granted. Are they? I think we do not want to quibble with continuity or differentiability, and it must be true that a tax rate of zero yields no revenue. This leaves only the endpoint condition—either $G(1) = 0$ or $G(\infty) = 0$, depending on the type of tax in question. But I, for one, am willing to accept that a 100% income tax rate or an infinite sales tax rate will, to a first approximation, eliminate the taxed activity entirely. The Laffer curve almost certainly exists.

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[4]This quotation appears in Atkinson and Stern (1980). For other interesting precursors, see Canto, Joines and Webb (1979).

ARE WE OVER THE LAFFER HILL?

I now turn to the question at hand. Is it plausible that the tax rates we observe in the real world are greater than t*, so that we are operating on the down side of the Laffer hill?

First a preliminary point. We all know that the applicability of the Laffer curve hinges on elasticities being "large" in some sense. (I will be more precise in a moment.) Thus the possibility of taxing beyond the Laffer point is much more real for taxes whose bases are narrowly defined—either in time, or in geographical space, or in commodity space—than it is for taxes that are broadly based. Let me illustrate. A sales tax on pastrami is much more likely to have a negative marginal revenue yield than a sales tax on all food, simply because of the much greater substitution possibilities on both the demand side and the supply side of the market for pastrami, as compared to the market for all food. Similarly, I rather doubt that an income tax on earnings between noon and 2 p.m. on Wednesdays would bring in much revenue. As a final example, I have heard it claimed that if New York City raised its sales tax, but the surrounding states and counties did not, revenues would actually decline. The possibility of being over the Laffer hill, I submit, is a very real one for very narrowly defined taxes. This, of course, merely strengthens the argument—which economists have been making for eons, it seems—for using broadly-based taxes rather than narrow ones.

The important question for current public policy debates, as I understand it, is: Can it be that some of our broadly-based taxes—like the personal and corporate income taxes—have passed the Laffer point? This seems to me highly implausible, and let me explain why.

Tax receipts are the product of the tax rate times the tax base. For *ad valorem* taxes, the latter is itself the product of a price (the net-of-tax price) and a quantity.[5] Thus:

$$G = tpQ. \tag{1}$$

Since t affects both p and Q, the derivative $\frac{dG}{dt}$ has three terms.

The first term:

$$pQ$$

might be called (with some unfairness to the Treasury) the naive

[5] I assume markets clear so quantity demanded and quantity supplied are equal.

Treasury term. It would be a good estimate of marginal tax yield if there were no behavioral responses. The second term:

$$tp \frac{dQ}{dt}$$

is the effect of the celebrated tax "wedge." Normally, we expect a contraction in the level of any activity whose tax is raised, so this term makes a *negative* marginal revenue contribution. The third term:

$$tQ \frac{dp}{dt}$$

is the effect that arises from the fact that market prices generally change when tax rates change. Laffer *et al.* suggest that some economists have been led to underestimate the potency of the Laffer effect by ignoring general equilibrium reactions. Exactly the reverse seems to be true for many taxes. Consider, for example, a tax on a factor income where p is the price the firm pays and $p(1-t)$ is the price the factor supplier receives. Standard tax incidence theory suggests that normal market reactions would make p *rise* and $p(1-t)$ fall when t increases, suggesting that this third term is *positive*, not negative. Similarly, if there are possibilities for factor substitution, the demand curves for competing factors of production would be expected to shift out; if these factors are taxed, this will also bring in more revenue.[6]

The shape of the Laffer curve depends on the balancing of these three forces. It is clear that if t* is to occur at an empirically meaningful level, the "wedge" effect will have to be quite large. To illustrate the conditions that are necessary, let us work out a concrete example of a flat rate tax on labor income. Let W be the wage the firm pays and $W(1-t)$ be the wage the worker receives. Let $S(W(1-t))$ be the supply function and $D(W)$ be the demand function, and assume $S(0) = 0$ so that a Laffer curve exists. Tax receipts are:

$$G(t) = tWS(W(1-t)), \tag{2}$$

from which it follows by some simple algebra that marginal tax yield is:

$$\frac{dG}{dt} = W \cdot S(\cdot)\left[1 - \frac{t}{1-t}\eta_s + \frac{t}{W}\frac{dW}{dt}(1 + \eta_s)\right], \tag{3}$$

[6]For excise taxes, the argument cuts the other way. If p is the selling firm's price and $p(1+t)$ is the consumer's price, then p probably falls while $p(1+t)$ rises.

where η_s is the elasticity of supply:

$$\eta_s = \frac{W(1-t)\,S'\,(W(1-t))}{S} > 0.$$

The positive Treasury effect, the negative wedge effect, and the positive price effect mentioned above can be seen clearly here. Working out the elasticity of W with respect to t, and substituting it into (3) gives:[7]

$$(4) \qquad \frac{dG}{dt} = WS(\cdot)[\,1 + \frac{t}{1-t}\,\frac{\eta_s(1+\eta_D)}{\eta_s - \eta_D}\,]$$

where η_D is the elasticity of demand:

$$\eta_D = \frac{WD'(W)}{D} < 0.$$

Notice that (4) cannot possibly be negative in the range where demand is inelastic. The Laffer point, t*, is found by setting (4) equal to zero:

$$(5) \qquad t^* = \frac{\eta_S - \eta_D}{-\eta_D(1+\eta_S)}\,.$$

Table 1 shows the values of t* for selected values of the two elasticities. It is clear that, unless the elasticities are quite high, we can be over the Laffer hill only when marginal tax rates are extremely high. For example, even if each elasticity is as high as 2, receipts continue to rise until the tax rate reaches two-thirds. In other words, it is very unlikely (though not totally impossible) that the peak in the Laffer curve comes at a tax rate that anyone might seriously entertain.

By exactly the same procedure, it is possible to work out the formula for the peak of the Laffer hill for the case of an excise tax at rate t on a commodity with producer price p and consumer price $p(1+t)$. The answer is:

$$(6) \qquad t^* = \frac{\eta_S - \eta_D}{-\eta_S(1+\eta_D)}\,,$$

and Table 2 provides numerical values for selected elasticities. It is clear once again that t* is a huge number unless the elasticities are incredibly high. For example, with elasticities of 2 for both supply

[7]This is, of course, not a general equilibrium analysis, since I consider only one market in isolation. I think most economists would be very surprised if a multi-market setting changed things very much. In any case, the next section takes up a general equilibrium example.

and demand, tax revenues are maximized at a tax rate of 200%. Elasticities as high as 5 are necessary to get t* as low as 50%.

I conclude, therefore, that the revenue-maximizing tax rate is very likely to be so high as to be considered ridiculous for any broad-based tax. Only very narrowly based taxes, where elasticities in the neighborhood of 5 start to become at least believable, are likely to encounter the down side of the Laffer hill. For the important taxes in our economy, the Laffer curve holds no more interest than Rolle's Theorem.

THE CANTO, JOINES, AND LAFFER (CJL) MODEL

Now the examples just considered were mine, not Laffer's. So let me turn next to the empirical relevance of the Laffer curve in the model proposed by the authors. The model has perfectly conventional demands for two factors (called labor and capital, though both are variable) derived from a Cobb-Douglas production function. The factor supply equations are somewhat unconventional, so let me explain them a bit and interpret the parameters.

Households hold fixed supplies of capital and labor, which they

TABLE 1
Values of t* from Equation (5)

		Value of η_s					
		0	.25	.50	1.0	2.0	5.0
Value of $-\eta_D$	below 1.0	1.00	←		more than 1.00		→
	1.0	1.00	1.00	1.00	1.00	1.00	1.00
	2.0	1.00	.90	.83	.75	.67	.58
	5.0	1.00	.84	.73	.60	.47	.33

TABLE 2
Values of t* from Equation (6)

		Value of η_S					
		0	.25	.50	1.0	2.0	5.0
Value of $-\eta_D$	1 or below	←			infinity		→
	2.0	∞	9.0	5.0	3.0	2.0	1.4
	5.0	∞	5.25	2.75	1.5	.88	.50

can either supply to the market—at net-of-tax returns R* and W* respectively—or reserve for home production. Laffer *et al.* view the factor supply decision in a kind of "utility tree" framework. First, the household considers the choice of devoting its resources to the market versus home sectors; this choice depends on the average level of market returns relative to the average level of home returns (the latter is, I suppose, always unity). Second, the household decides on its relative factor supplies to the market by looking at relative market prices. This analysis suggests supply functions (assuming constant elasticity functional forms):

$$(7) \qquad L^s = [(R^*)^{\alpha}(W^*)^{1-\alpha}]^{\varepsilon} \left(\frac{W^*}{R^*}\right)^{\beta} \qquad \varepsilon > 0, \beta > 0$$

$$(8) \qquad K^s = [(R^*)^{\alpha}(W^*)^{1-\alpha}]^{\varepsilon} \left(\frac{R^*}{W^*}\right)^{\lambda} \qquad \lambda > 0$$

where $[(R^*)^{\alpha}(W^*)^{1-\alpha}]$ is the (geometric) weighted average of market returns, weighted by the production function weights. The use of the same "ε" parameter in (7) and (8) reflects the assumption of CJL that the *ratio* of L to K depends *only* on the ratio W*/R*. A tiny bit of manipulation puts (7) and (8) into the form of equations (7) and (8) in the CJL paper:

$$(7') \qquad K^s = \left(\frac{R^*}{W^*}\right)^{\lambda-\varepsilon(1-\alpha)}(R^*)^{\varepsilon}$$

$$(8') \qquad L^s = \left(\frac{W^*}{R^*}\right)^{\beta-\varepsilon\alpha}(W^*)^{\varepsilon}$$

so that the parameters σ_K and σ_L that appear in the CJL paper are seen to have the following interpretations:

$$\sigma_K = \lambda - \varepsilon(1-\alpha)$$

$$\sigma_L = \beta - \varepsilon\alpha.$$

The authors assume these parameters to be *negative*, which means they are assuming a fairly sizable value for ε—which is the one unconventional parameter in this model. The interpretation of ε is the *general* price elasticity of supply of factors to the market sector (from the home sector). That is, if *both* W* and R* were to increase by 1%, then the supplies of *both* capital and labor to the market would increase by ε%. This is not a parameter for which much empirical evidence is available.

The authors take pains to make clear that income effects are ignored in their analysis because marginal tax receipts (positive or negative) are redistributed to the populace in a nondistorting way. In theory, this is correct. In practice, three caveats must be entered.

First, it seems inconsistent to assume that revenue can be raised only by distortionary taxes, but can be given away in a nondistortionary way. Surely, any real way to give back the revenue (through transfer payments or government gifts of goods and services) will be just as distortionary as taxes. And isn't *reducing* lump sum transfers the same as *levying* lump sum taxes?

Second, for the argument to hold, it is necessary that the recipients of the (lump sum?) transfers be the same as the payers of the additional taxes. If, for example, we consider cutting capital taxation and making up for the lost revenue by reducing transfers for the poor, there is no reason to think that income effects are of second order. In fact, I would be inclined to think that income effects would be of first order and substitution effects of second order.

Third, it should be understood that the thought experiments considered in the paper are *balanced-budget* alterations in the tax structure, so we cannot really speak of revenue effects and Laffer curves at all. The model assumes that lump sum transfers are available, and what appear to be "Laffer curves" in Figures 2 and 3 represent instead the behavior of aggregate lump sum transfers as tax rates are increased. If we really care about Laffer curves we *cannot* ignore income effects.

Nothing more need be said about the structure of the model. CJL correctly work out the solutions for prices and quantities and then compute the revenue-maximizing tax rates on capital and labor (their equations (27) and (28)). These can be simplified to:

$$t_L^* = \frac{\lambda + (1-\alpha)}{(1-\alpha)(1+\varepsilon)(1 + \lambda + \beta)} \tag{9}$$

$$t_K^* = \frac{\beta + \alpha}{\alpha(1+\varepsilon)(1 + \lambda + \beta)} \tag{10}$$

Let me now pose the $64 question. Is it possible that the tax rates implied by these formulas could be anywhere near current tax rates, which I take to be approximately $t_L = .3$ and $t_K = .4$?

There are four parameters in these formulas. The one we know fairly well is capital's share, α, which I take to be .25. β is approximately the (compensated) wage elasticity of labor supply in the aggregate. There is much empirical evidence on labor supply. My reading of the evidence suggests that the lowest and highest values that can be seriously entertained are 0 and 0.6 respectively.

TABLE 3

Values of t_L^* and t_K^* from Equations (9) and (10)

	$\varepsilon=0$	
high elasticities	$t_L^* = .77$	$t_K^* =$ NE
low elasticities	$t_L^* = .91$	$t_K^* =$ NE
	$\varepsilon=1$	
high elasticities	$t_L^* = .38$	$t_K^* = .85$
low elasticities	$t_L^* = .45$	$t_K^* = .64$
	$\varepsilon=2$	
high elasticities	$t_L^* = .26$	$t_K^* = .57$
low elasticities	$t_L^* = .30$	$t_K^* = .42$

NE = Nonexistent (i.e., no tax rate under 100% solves equation (10)).

λ is a trickier parameter; it is the elasticity of capital supply to the market (versus to the home sector) with respect to the rate of return. It is hard to know what to make of this parameter in a static model. Will I really keep my capital home if the return in the market is low? Doing what? In a dynamic model, I guess households supply capital to the market by saving, and the steady-state interest elasticity of capital is the same as the interest elasticity of saving. I think the absolute limits on reasonable estimates of the interest elasticity of saving are probably $-.05 < \lambda < +.40$, with zero a strong candidate. This leaves the unconventional parameter ε. Since I have no idea of how to "guesstimate" ε, I will simply try three very different values: 0, 1.0, and 2.0.

Table 3 evaluates equations (9) and (10) for a number of different sets of parameter values. The case denoted "high elasticities" is $\beta = .6$, $\lambda = .4$; the case denoted "low elasticities" is $\beta = .1$, $\lambda = 0$. The results are unambiguous. If $\varepsilon=0$, revenues keep on rising right up to the point where the tax rate on capital income reaches 100%,[8] and the Laffer point for the tax rate on labor

[8]It might be argued that, because of inflationary distortions in the tax system, effective rates of taxation of capital under current inflation rates are over 100% because taxes are being levied on negative real income. If this is the case, however, the Laffer curve no longer follows from Rolle's Theorem, and may not turn down at all.

income far exceeds what we actually observe. If $\varepsilon = 1$, Laffer points do exist for both capital and labor. But the revenue-maximizing tax rates still exceed the rates that characterize the U.S. economy (though perhaps not by much in the case of labor). Only when ε gets as high as 2 does the peak of the Laffer curve come at tax rates that approximate those actually levied in the U.S.—26-30% for labor income and 42-57% for capital income.

Finally, suppose that the elasticities of supply of capital and labor are really much greater than I have allowed for here. Suppose, for example, that both λ and β are unity. Equation (9) then implies that t_L^* will be as low as .30 if ε exceeds 1.6; equation (10) implies that t_K^* is 0.4 when $\varepsilon = 3.2$.

I conclude that, given the CJL model, the only way the contemporary U.S. economy could find itself on the down side of the Laffer hill is if the parameter ε is quite sizable. Unfortunately, this is not a parameter we know much about. Pending evidence to the contrary, I am inclined to think it quite small. But nothing much hinges on this belief; all that matters is that ε not be *huge*. As Table 3 shows, to be anywhere near the top of the Laffer hill with current tax rates, ε will have to be about 2. This means that a 10% increase in *both* wage rates *and* the rate of return on capital must induce a 20% increase in the quantity of each factor supplied to the market sector. I find this scenario quite fantastic.

Summing Up

To establish the existence of a Laffer curve in theory, we do not need to know anything about either economics or the tax system. Rolle's Theorem will do. But it is a long way from proving the existence of a Laffer curve to arguing that existing taxes are on its downhill side. While the down side of the Laffer hill may perhaps be relevant to very narrowly-based taxes, back-of-the-envelope calculations such as those presented here make it seem highly unlikely that broad-based taxes could fall in this range. The specific model presented in the paper by Canto, Joines, and Laffer does nothing to dispel this belief unless the tax system (at the margin) chases huge amounts of capital and labor out of the market system and into the home production sector (or the underground economy).

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Discussion of the Evans Paper

STEVEN BRAUN

Aggregate supply is an old idea. Although discussed by Keynes and the early Keynsians, most recent econometric models can justly be criticized for not adequately developing the supply side. It is therefore exciting to review a supply-side model created by one of the most prominent model-builders. The Evans model was commissioned by the Senate Finance Committee as an attempt to incorporate supply-side effects which were not in existing econometric models. My remarks are based on a version of the model furnished to me courtesy of Dr. Evans (Evans, 1980).

Theory suggests a number of channels through which, in the long run, a reduction in various tax rates might substantially increase aggregate supply. This would make possible a higher level of real output without inflationary consequences. Four of these channels have been built into the Evans model. They are:

1. Because workers bargain for after-tax wages, a reduction in personal tax rates decreases wage demands;
2. Because income taxes reduce the incentive to work, a reduction in the personal tax rate increases *both* the participation rate and hours worked;
3. Because business taxes reduce the incentives to invest, reductions in these taxes will increase the stock of business capital; and
4. Because interest rewards savings behavior, a rise in the after-tax rate of interest will increase savings.

Although theory suggests the possible existence of these channels, it has little to say about their strength. Earlier model builders have found substantial empirical support only for the third channel—business taxes. Evidence for the others have been mixed at best and most other models do not contain them.

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Dr. Evans differs from others in claiming to have been able to measure these channels and he finds their strength to be considerable. I find this evidence unconvincing.

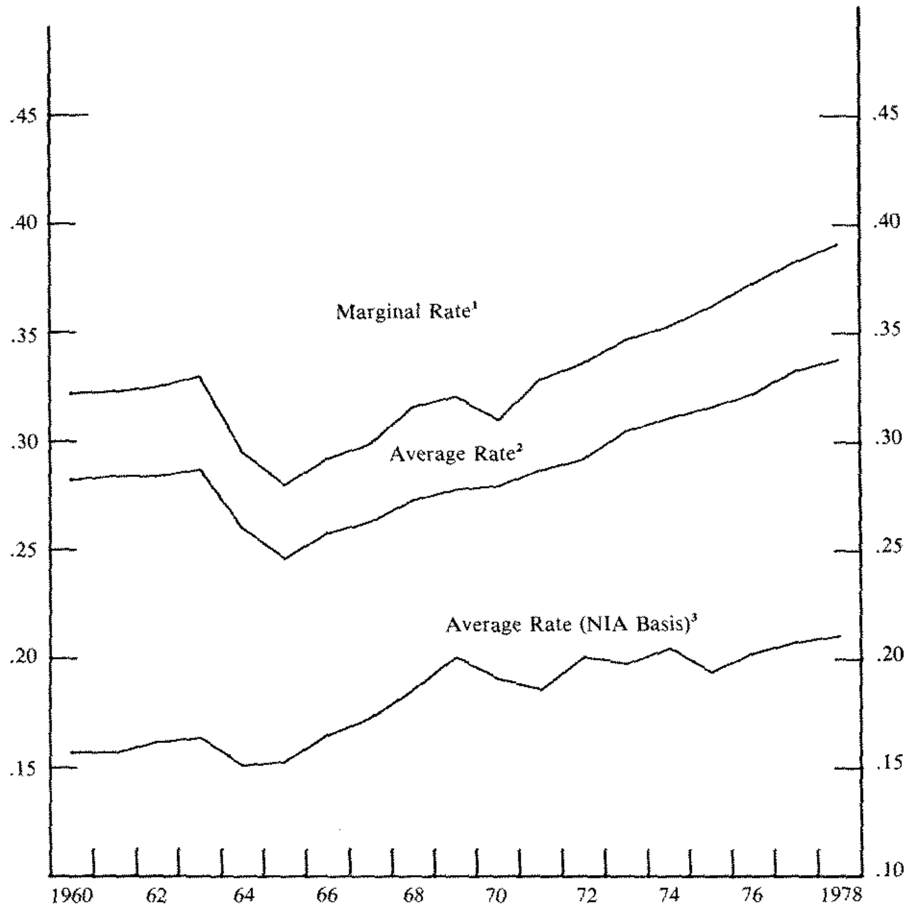
Let us begin by introducing one of the devils of the supply-side pantheon. Figure 1 shows the average and marginal tax rates computed by Dr. Evans from the IRS tables. Except for the 1964 tax cut these variables show a strong upward trend—a fact which is important in understanding this model. For comparison purposes I have computed an average tax rate based on data from the national income accounts. Since this series allows for the standard and personal deductions, which are excludable from income used above, the tax rate level is lower, and its trend is slightly less steep.

Now let us turn to some key equations which incorporate the various supply-side channels. Let me begin with the wage equation (which is the first equation in the Appendix). This wage equation is for the most part a rather standard looking inflation augmented Phillips curve. The rate of wage change depends on (ignoring the various dummy variables) the inverse of the unemployment rate, the rate of change in the CPI, the rate of change of output, and the level of the average personal tax rate. Presumably, the idea is that workers bargain for after-tax wages. But if this were true, the *growth* of taxes rather than the level of taxes should be included. The effects of this misspecification produce odd simulation results. A one time reduction in tax rates will affect the rate of wage growth not only in the following years, but for eternity. Using the coefficients of this equation, I have calculated that a reduction in the tax bill of, say, 3 percent will lower wages also by 3 percent after 6 years. But after 12 years, wages decline by 6 percent—twice the reduction in taxes! This equation is going to make the Kemp-Roth tax cut look very good! Notice that the effect of prices on wages is very low (0.6) implying that workers suffer from money illusion so that even in the long run, a permanent higher level of inflation could lower unemployment. It appears that the tax rate is picking up some of the trend in inflation.

Labor force participation rate equations are perhaps the most visible and the oldest of the supply-side features. Because of conflicting income and substitution effects, the sign of the wage variable could go either way. However, an upward sloping supply curve is plausible. Evans' participation equations (an example of which appears in the Appendix) does not seem to produce credible evidence for this proposition. Since one of the independent variables is the real after-tax wage bill, an increase in employment

FIGURE 1

Average and Marginal Personal Tax Rates



[1]Computed by Evans from IRS, *Statistics on Income*. This series includes state and local taxes and social security taxes.

[2]Computed by Evans from IRS, *Statistics on Income*. This series includes state and local taxes and social security taxes.

[3]Average tax rate computed on an NIA basis:

$$\frac{\text{(tax and nontax payments)} + \text{(personal contributions for social insurance)}}{\text{(personal income)} + \text{(personal contributions for social insurance)}}$$

has the same elasticity as an increase in real after-tax wages. We all know what the trends are in employment and participation. Thus the coefficient of the wage rate in this equation is guaranteed to show the correct sign. Notice also that the level of unemployment does not enter this equation, only its first difference. Will the participation rate snap back to trend when the unemployment rate stops growing?

The effect of tax rates on labor supply in this model is only partially captured in the labor force participation equations. Claiming that increased taxes reduce hours worked, Evans models a tax effect in the total manhours equation (shown in the Appendix). Here taxes are shown to reduce hours worked. This is a curious equation. If the level of productivity were included, rather than its growth rate, this equation would be close to an identity. However, productivity enters only through its growth rate. Because the omitted variable, the level of productivity, also has an upward trend just as the tax rate does, it is likely that the negative sign on the tax rate occurs because it is picking up the trend of the omitted variable.

Even this negative sign is curious. For a given level of output, a decrease in the tax rate will decrease manhours worked. Since output is also in the equation, and therefore held constant, this means that productivity has fallen. Thus, productivity falls when the tax rate falls. I seriously doubt that this is the effect that Dr. Evans wanted to show. I understand that the model presented to the Senate Finance Committee does not simulate. Surely, this equation must generate some problems.

Consider how this equation interacts with the participation equations. When the tax rate rises, manhours fall, causing the wage bill to fall. This in turn causes the participation rate to fall. So while it is claimed that the participation equations only captures part of the effect of higher taxes, we see that in simulations, this will not be true.

The productivity equation is discussed at length in Evans' paper in this volume. However, this equation is really superfluous since productivity is implicitly computed in the total manhours equation. Besides the growth of productivity appearing in the manhours equation and the capacity equation, I do not see how else the productivity variable is utilized. If it were utilized, it would be inconsistent with the manhours equation. (By the way, why does the *level* of secondary workers and the *level* of government regulation affect the *growth* of productivity?)

This model claims the ability to evaluate the effectiveness on investment of several forms of corporate income taxation. Reducing the corporate tax rate, for example, is found to be more effective per Treasury dollar than increasing the investment tax credit. I find these results to be based on a peculiar structure of the investment sector (see Appendix). The demands for new orders is separately influenced by four elements of the cost of capital: an index of industrial prices, the corporate tax rate, the depreciation allowance, and the investment tax credit. Then a single cost of capital variable affects how new orders are translated into investment. This raises problems of double counting the effects of these taxes. Since consumer expenditures are also in both equations, there seems to be double counting here too. These extra terms in the investment equation raise the possibility that investments may occur without antecedent new orders. I know of no theoretical explanation for this peculiar structure, nor has one been offered.

The effect of the interest rate on savings has long been a puzzle. As Keynes recognized, "Some of the subjective motives towards saving will be more easily satisfied if the interest rate rises, others will be weakened."[1] Since Dr. Evans claims a substantial effect, let us examine his equation (the fourth equation in the Appendix). Consumption is a function of lagged consumption, current and lagged income, and the after-tax real rate. However, wealth is omitted, and this omission is serious in interpreting the effects of changes in interest rates. Since the savings rate falls when wealth rises relative to income, and since wealth rises when the interest rate falls, the interest rate in this equation may be merely picking up the wealth effect. So after examining this equation, one still does not know whether the income or substitution effect dominates.

With these remarks in mind, it is time to ask how this model can help analyze aggregate supply. Reducing the personal income tax to reduce wage demands is dependent on an equation in which tax levels influence wage growth. Reducing personal taxes to increase labor force participation is dependent on an equation that cannot distinguish an increase in wages from an increase in total manhours. Reducing personal taxes to add to labor input is dependent on an equation that omits the level of productivity. Reducing the corporate tax rate to spur investment seems to be dependent on an investment sector that counts this parameter twice.

[1] John M. Keynes, *The General Theory of Employment, Interest, and Money*, Harcourt, Brace & World Inc., 1964, p. 93.

Reducing taxes on saving to encourage saving seems dependent on an equation that confuses the wealth effect with the interest rate effect.

Each of these prescriptions seem to be directly connected with an error in the model. What then have we learned about the world?

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APPENDIX

EVANS SUPPLY-SIDE MODEL[1] (selected equations)

Wage Equation (page 8.11)

$$\text{WRM4} = \underset{(-3.1)}{-.9} + \underset{(2.3)}{.004}\ \text{STRIKES} + \underset{(3.3)}{.008}\ \text{DWPP} + \underset{(7.1)}{.6}\ \text{CPI415}$$

$$+ \underset{(3.5)}{.3}\ \text{AVGSUM18} + \underset{(5.2)}{.1}\ \text{XIPM4} + \underset{(3.0)}{.8}\ \text{UNI18}$$

$R^2 = .83$

WRM4 = percentage change[2] of the average hourly wage in manufacturing
STRIKES = Dummy variable, auto and steel strikes
DWPP = Dummy variable, wage-price freeze
CPI415 = percentage change[2] in the CPI, (distributed lag)
AVGSUM14 = sum of average personal tax rates, (distributed lag)
XIPM4 = percentage change[2], index of industrial production

$$\text{UNI18} = 1/(\sum_{i=1}^{8} \text{UN8}), \text{ where UN8} = \text{unemployment rate if} < 8$$
$$= 8 \text{ if unemployment rate} \geqslant 8$$

Labor Force Participation Rate (Females, 25-54), (page 7.53)

$$\text{LFPF2554} = \underset{(14.2)}{.335} + \underset{(3.7)}{.036}\ \text{WMARG14} - \underset{(-4.8)}{.02}\ \text{UN13} + \underset{(3.0)}{.82}\ \text{CPI41}$$

$$+ \underset{(6.0)}{1.3}\ \text{CPI45} \qquad R^2 = .85$$

LFPF2554 = Labor force participation rate, females 25-54
WMARG14 = (real wage and salary disbursements)(1-marginal tax rate), (distributed lag)
UN13 = $UN_{-1} - UN_{-3}$
CPI41 = percentage change[2] in the CPI, lagged (−1)
CPI45 = percentage change[2] in the CPI, lagged (−5)

[1]Based on Evans, 1980. The page numbers from this document are as indicated.
[2]These are not simple percentage changes. Rather, they are defined as,

$$X\% = \frac{X - (1/4)\sum_{1}^{4} X_{-i}}{(1/4)\sum_{1}^{4} X_{-i}}$$

Manhours (manufacturing), (page 7.69)

$$\begin{aligned} \text{EHMFG40} = {} & \underset{(26.)}{33313} + \underset{(14.8)}{101}\ \text{XIPMS} + \underset{(6.1)}{64}\ \text{XIPM14} \\ & - \underset{(-23.4)}{41965}\ \text{AVGSUM18} - \underset{(-7.9)}{1458}\ \text{PRODQ18} \\ & - \underset{(-2.1)}{9.5}\ \text{KPPROD18} \end{aligned}$$

$R^2 = .97$

EHMFG40 = manufacturing manhours
XIPMS = index of industrail production, manufacturing
XIPM14 = distributed lag of XIPMS
AVGSUM18 = sum of average personal tax rates, (distributed lag)
PRODQ18 = annual percentage change in private nonfarm business productivity (distributed lag)
KPROD18 = (manufacturing capital stock) − (pollution control capital stock), (distributed lag)

Consumption, (page 3.19)

$$C = \text{constant} + .336\ C_{-1} + .296\ Y + .299\ Y_{-1} - 2.04\ r$$

(estimated by principal components, long-run MPC = .89), $R^2 = .997$

C = total consumption expenditures per capita, 1972$
Y = disposable income per capita, 1972$
r = after tax real rate of return

Investment Sector
New Orders Equation, (page 4.68)

$$\begin{aligned} \text{NOR} = {} & \underset{(.7)}{3.4} + \underset{(5.0)}{.4}\ \text{PWINOR} + \underset{(22.8)}{.1}\ \text{CDNOR} + \underset{(8.0)}{3.6}\ \text{IHSL1} \\ & + \underset{(9.0)}{45.}\ \text{DCPNOR} + \underset{(5.8)}{.08}\ \text{XIPDSENO} - \underset{(-6.3)}{35.6}\ \text{EFFTAX} \\ & + \underset{(2.5)}{6.4}\ \text{ZENOR} + \underset{(1.4)}{6.3}\ \text{DITC2} \end{aligned}$$

$R^2 = .994$

NOR = New orders, all manufacturing
PWINOR = WPI, industrial commodities, (distributed lag)

CDNOR = consumption expenditures, durables and non-durables, (distributed lag)
IHSL1 = total housing starts, (distributed lag)
DCPNOR = index of capacity utilization (special functional form).
XIPDSENO = industrial production index, defense and space equipment
EFFTAX = corporate tax rate
ZENOR = tax savings from depreciation allowance
DITC2 = investment tax credit, (distributed lag)

Investment Equation, (page 4.80)

$$\underset{(4.6)}{\text{IPE} = -12.5} + \underset{(17.1)}{1.3\ \text{NORL6}} - \underset{(-6.1)}{1.8\ \text{CREDL5}} + \underset{(8.4)}{.09\ \text{CDNL}} - \underset{(5.9)}{\Sigma\, a_i\ \text{RCCPL3}_{-i}}$$

$R^2 = .992$

IPE = business fixed investment, producers durables
NORL6 = new orders, all manufacturing, (distributed lag)
CREDL5 = index of credit rationing, (distributed lag)
CDNL = consumption expenditures, durable and non-durables, (distributed lag)
RCCPL3 = cost of capital, (distributed lag)

Discussion of the Evans Paper

ALBERT ANDO

While the political discussion in the United States has suddenly focused on the so-called "supply-side effects," this is not a new discovery in the literature of economics. I don't believe any one has denied the theoretical possibility that labor supply may depend on the real wage rate, and that personal savings may depend on the real after-tax rate of interest. The question has always been about the empirical order of magnitudes of these responses. In the case of savings, there are two further questions: whether or not an increase in savings will necessarily lead to correspondingly larger investment in capital goods, and how much the additional investment will contribute to potential and actual output.

Evans appears to claim in his summary (Evans, 1981) that he has resolved all these empirical questions, and his new model is now capable of predicting major effects of macro and micro policies aimed at supplies of productive factors. A detailed appraisal of his claims is difficult because they are embedded into a large model, and the model in question is not laid out for easy understanding.

I therefore propose to look at one critical group of equations in Evans' model as a representative of the model. Since Evans himself says that the equation explaining productivity plays the central role in his model, let us look at this equation as the starter. It is given in his summary paper (Evans, 1981) and (Evans, 1980, pp. 7.88–7.89).

First of all, we have to presume that Evans, when he defines PRD as private nonfarm business productivity, means by this variable output per manhour in this sector. The dependent variable in this equation is the rate of change of PRD. We may dispute the choice of variables that Evans introduces to the right-hand side of this equation. In order to concentrate our attention on less controversial issues, however, let us accept his choice as appropriate. There remains the question of the form of this equation.

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The most curious thing about this equation is the lack of correspondence of dimensions among variables, and consequent implausible steady state characteristics associated with it. As I indicated before, the dependent variable of this equation is the *rate of change of* productivity per manhour. Yet some of the independent variables, notably the ratio of the number of secondary workers to total employment, and direct federal government expenditures on regulations *in current dollars*, are level variables.

To understand clearly the nature of absurd results that follow from this setup, let us consider the situation in which all independent variables, including the two variables mentioned above, remain constant for a while, generating a constant rate of growth of productivity. Now suppose that the proportion of secondary workers in total employment increases by some fixed amount, say 1%, and remains at the new level thereafter. Then, the *rate of growth* of productivity (not the level of productivity) declines by a fixed amount. (If I believe in the definitions and numerical values reported in Evans' paper, it does so by .84% per year. However, this is too large an effect for me to accept for the first year, the only period in which this equation makes any sense, and I suspect that there may be some misprint and/or errors of units in the definitions.) Consequently, a once-and-for-all increase in the proportion of secondary workers to total employment will, according to the Evans equation, lead to a continual decline in the level of productivity relative to the reference path. Taking Evans' equation literally, if the ratio of the secondary workers to total employment rises 1%, say from 40% to 41%, and remains at the new level thereafter, the level of productivity will fall by .84% the first year, 8.7% during the first 10 years, and 18.3% during the first 20 years, and will continue to decline forever.

The level of federal government expenditure on regulation is even more absurd. The variable entered is total expenditure *in current dollars*. Thus, if the total expenditure in current dollars rises slowly for whatever reason, perhaps because of inflation, perhaps because the scale of the economy increases, the rate of increase of productivity must fall even if the federal government expenditure on regulation is becoming smaller and smaller relative to total GNP in current dollars. (As an illustration, suppose that GNP in current dollars is growing at 7% per year, while the government expenditure on regulation in current dollars grows at 4% per year and the inflation rate is 5% per year. The rate of growth of productivity will still continue to decline, according to Evans' equation.) Since no other variable on the right hand side of this equation is an extensive variable that grows with the growth of the economy as a whole, the presence of this variable, the level of direct federal government expenditures on regulation in current dollars, must eventually make the rate of increase of the productivity negative, even though this expenditure as a proportion of GNP in current dollars becomes smaller and smaller.

Even some of the more reasonable-looking variables have their troubles. The ratio of business fixed investment to gross national product sounds like a reasonable candidate for influencing the rate of growth of productivity. But anyone who has worked with models of growth will soon realize that this is not really a sensible variable. The variable of this sort that can be fairly readily accommodated in this context is the rate of growth of capital stock per employee net of depreciation, not the gross investment—gross output ratio.

His statement that the relevant ratio is investment in constant dollars to the gross output in constant dollars, and not the ratio of current dollar values is also a serious suspect. The only theory bearing on this point in a multi-goods model that I am aware of is my own (Ando, 1964); the conclusion in that theory was that the only aggregate ratio that could be interpreted meaningfully was the ratio of the value of capital goods to the value of output, not the ratio between implicitly deflated figures in national income accounts. But that proposition was in the context of a specific, well-defined model, and here we are dealing with an assertion by Evans, which is apparently not based on any coherent view of the world.

On a basis of these observations, I conclude that Evans' equation explaining the rate of growth of productivity, the equation which, in Evans' own words, reflects the main thrust of his model (Evans, 1981), is not worthy of our further attention.

Even though Evans imputes great importance to the equation for the productivity discussed above, the output of this equation feeds into only two places in Evans' model, and it is probably worth extending our review of Evans' model to cover these two additional groups of equations.

The first group of equations in which output of the productivity equation plays a role is the equation expressing total manhours as a function, among other things, of total output and productivity. One typical such equation in Evans' model is given as the third equation in Braun's discussion (Braun, 1981), also (Evans, 1980, p. 7.69). Since productivity, PRD, is defined as output per manhour, if all definitions are assured of consistency everywhere, then the manhours equation must be an identity, namely

$$\text{EHMFG40} = \text{XIPMS} \cdot \frac{1}{\text{PRD}}$$

where

EHMFG40: manhours in manufacturing
XIPMS: index of industrial production, manufacturing
PRD: productivity per manhour, private, nonfarm, business sector

The identity does not hold because EHMFG40 and XIPMS refer to manhours and output in manufacturing industries while PRD refers to productivity per manhour in private nonfarm business sector, XIPMS is an index of production rather than total volume of production, and for a host of other definitional discrepancies. But I do not see anywhere in Evans' writing or in his handling of these equations any indication that there are any important conceptual reasons why the above identity should not hold. Yet, the manhours equation Evans actually estimates and reports is basically of the form

$$\text{EHMFG40} = \text{constant} + \alpha_1\text{XIPMS} + \sigma_2 \frac{\Delta\text{PRD}}{\text{PRD}} + \ldots\ldots$$

where dots represent additional terms in the equation which are not related to output or productivity. In other words, Evans has substituted for the level of productivity, PRD, in the identity the rate of change of productivity, linearized the equation, and then introduced a host of other variables. I see absolutely no justification for this substitution or for linearization. That it has disastrous consequences should not come as a surprise to us.

For instance, given a level of output and a rate of growth of productivity (not the level of productivity), other things equal, the manhours needed to produce this output remains the same. To put it another way, if output remained the same from year 0 to year 10, while productivity (output per manhour) increased at the constant rate of 3% per year, then the manhours required to produce this same output in year zero and in year ten are nevertheless the same. If this statement sounds contradictory, it nevertheless accurately reflects the statement embodied in the equation.

Clearly, such a characteristic of the equation cannot be reconciled with data, and something else must enter this equation to help reduce the manhour requirement per unit of output over time. The only variable introduced by Evans into this equation with the type of time trend for performing this function is, of all things, the sum of average personal tax rate. (This rate, computed by Evans, has a strong positive trend over time. Whether or not this is a reasonable concept is another matter, since one could also compute the average rate which does not have as much trend). It is therefore not at all surprising that the average personal tax rate acquires a strong negative coefficient.

Evans seems to suggest that the definitional identity among manhours, output and the productivity does not apply here because manhours and output measures that enter the manhours equation reflect short-run, cyclical movements of these variables while PRD reflects the longer-run, secular trend of the productivity. This excuse does not wash because PRD is simply calculated as the ratio of output to manhours in each year, and to reflect this fact, the equation explaining the rate of change of PRD has explanatory variables that are strictly related to short-run, cyclical variation in productivity, such as the rate of change of GNP and the index of capacity utilization.

I must conclude, therefore, that Evans' formulation of the manhours equation makes no sense, that its fit against data is purely accidental, and that the large negative coefficient for the sum of average personal income tax rates estimated in this equation is at best due to a combination of vagaries of the pattern of time series data and of serious misspecifications of the equation form.

I would like to repeat here a curious feature of this manhours equation observed by Steve Braun (Braun, 1981). Since output and the personal income tax rate enter separately as independent variables in this equation given the level of output, an increase in the average personal income tax rate will reduce manhours. That is, the higher the average personal income tax rate, the higher the productivity per manhour. I am sure those who are interested in supply responses to a change in the tax structure are interested in getting an explanation for this phenomena.

The only other place where the variable PRD plays a role is in the equation defining the maximum production. It is a definition rather than an estimated equation, and takes the form (Evans, 1980, p. 11.11)

$$XIPC = (EM^*)^{2/3}(K)^{1/3}e^{PRODQ}$$

where

XIPC: index of maximum production in the manufacturing sector 1967 = 100.0
EM*: "full employment" supply of labor in manhours
K: "stock" of capital goods, somehow measured

We shall not discuss the serious problem of how EM* and K are measured by Evans, since the focus of our discussion here is how the measure of productivity is utilized in the model. Evans says that PRODQ is the annual change in private nonfarm business productivity. Evans could not mean what he says, since if we take him literally, it makes no sense, and I don't believe that he could have generated the data reported by him preceding the specification of this definition (Evans, 1980, p. 11.10). I therefore assume that PRODQ is something that does make a minimum of sense, say, the accumulated value of the rate of change of productivity starting from some initial period, with the initial value of it coordinated with the constant term in the definition so as to fit the data.

Even then, this equation makes no sense. If PRODQ is some concept such as the one I suggested above, and in any case it is based on the measure of productivity per manhour, then anyone who has ever worked with growth models based on homogeneous production functions, particularly the Cobb-Douglas function, will know that the productivity measure cannot be introduced into the production function unmodified. This is because productivity per manhour already reflects the contribution of an increase in the capital-labor ratio, as Evans' equation explaining the rate of change of PRD tries to describe. Therefore its introduction together with the capital stock into the production function without the proper restriction is a double counting. One possible, though rather naive and unrealistic way to handle this problem is to replace the term e^{PRODQ} by $e^{\frac{2}{3}PRODQ}$ in the above equation defining XIPC (assuming, always, that my reinterpretation of Evans' PRODQ is basically correct). At least, this will make the structure logically consistent.

Even if PRODQ is introduced correctly into a Cobb-Douglas production function, it is most doubtful that such a formulation will be adequate for estimating the maximum productive capacity of the U.S. economy. On a year-by-year basis, at least some of capital goods are not malleable. Hence, it is a doubtful procedure to utilize any production function for the whole economy (or a large segment of it) incorporating the concept of the aggregate capital stock in order to describe the production possibilities in the sense that Evans uses the concept of capacity or maximum output. Moreover, the depreciation or abandonment of capital goods may very well depend on movements of relative prices. But this is really taking us too far afield away from the subject at hand, namely, the most obvious defects of Evans' model.

In this note, I have so far limited myself to discussing the explanation of productivity in Evans' model and two sets of his equations in which the productivity so explained is a critical input. I have, however, looked at the large, 850 page document (Evans, 1980), which is an explanation of his model, and I must report that everywhere I turned, every equation that I have examined, I have objections rather similar in nature to the ones I have been discussing. Very few of his equations make "good sense" as this convenient term is normally understood by most of us economists, and most of them imply what I would consider rather absurd behavior of the dependent variable when one of its explanatory variables is changed from one level to another while all other explanatory variables are held constant. That is, most of his equations have what may be called "unacceptable steady state properties."

In his oral discussion, Evans took the position that he did not care what properties individual equations possessed, so long as the whole system generated dynamic behavior in simulation that appeared reasonable. Although Evans is not alone in taking this position[1], I for one do not consider this position a tenable one in building econometric models. Some misspecifications in short-run, dynamic behavior of some subsidiary equation might be tolerated, after a careful examination to make sure that such a misspecification did not affect the overall behavior of the system, either for good or for bad. The requirement that the whole system behave in an understandable, reasonable manner under a variety of shocks is a useful criteria in judging the quality and acceptability of any econometric model, but is a criteria in addition to, and not in place of, the traditional one that each equation in the system be sensible.

My review of Evans' two papers (Evans, 1980 and 1981), then, convinces me that the whole model does not make much sense, and I cannot have any confidence in his model nor in any analysis based on his model. I have seen many errors and bad judgments in many econometric studies, including my own. Seldom have I seen,

[1] I recollect that Jay Forrester tended to take a position somewhat similar to this in his writings in *Industrial Dynamics*, but I am unable to find a specific reference at the present time.

however, a large-scale work such as this one of Evans, undertaken by a reputable and experienced econometrician, where the pattern of such major defects have dominated so large a part of the entire work.

This is really too bad, because the case for rationalizing the tax and transfer payment structure of the United States seems to me to be quite strong. The shift from the personal income tax to the expenditure tax originally proposed by Kaldor has its appeal, provided that is is combined with adequate taxation of estates. I believe such a shift will make it much easier to handle the vexing problem of capital gains, to cope with inflation and indexing of the tax base, and may possibly stimulate savings. A great deal of work is beginning to be done in this area. I believe the rationalization of depreciation allowances should be pursued, and the immediate and complete write-off of capital good purchases as cost should be considered as one possible alternative, more in the case of producers' equipment than in the case of structures. Going beyond that, some form of integration of corporate profit tax, personal income tax, and the social security tax would be worth analyzing. An even more difficult problem is the coordination of taxation by the federal, state, and local governments. On the transfer side, any movement to make payments less dependent on income of the recipient is likely to be helpful. The aim is, as it always has been, to design the tax and transfer payment system which raises the needed revenue, approach the desired redistribution of income as closely as possible while minimizing the distortion of relative prices.

There are many careful studies of these possibilities, although they are all quite incomplete, and further research on them as well as open public discussion of these issues should prove helpful in formulating our economic policies in the coming decades. A work such as Evans' new model, undertaken at public expense, and well publicized, claiming so much and yet so misleading, is likely to divert the attention of both economists and the public away from basic issues and focus it on questionable gimmicks, raising false expectations in the process. I fear that it will, in the end, retard rather than advance the cause of fundamental reform of our tax and transfer payment structure. I hope that I am wrong in this premonition.

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