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The Macroeconomic Supply Effects of Tax Rate Changes

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I. Introduction and Summary

Economists have always been concerned with the possible disincentive effects of taxes. Recently, many studies, both theoretical and empirical, have been undertaken on the welfare cost of various taxes. Much of this research has concluded that these costs may have been either overlooked or underestimated. 1/ In addition to this mainly academic research, a popular (i.e., nonacademic) "supply-side" school of economic policy, has developed, and its exponents have written in the U.S. financial press and the editorial pages of certain U.S. newspapers. 2/ The academicians are concerned mainly with microeconomic efficiency and the effects of taxes on economic welfare, while the supply-side economists deal more with the effects of taxes on aggregate supply. These two concerns are not the same.

The journalistic supply-side economists claim to have some new insight into the relevance of tax policy for short-run to intermediate-run macroeconomic policy, which is supposedly neglected or underemphasized under the conventional approach. Specifically, they have argued that a general tax reduction can have a very significant effect on aggregate supply. As the extreme claims of the journalistic supply-side school are quite implausible, they have received a lot of critical attention. 3/

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1/ See, for example, Hausman (1981) and Boskin (1978) for empirical studies of the effect of taxation of labor and savings, respectively.

2/ In particular, the Wall Street Journal. Books or collections of readings on supply-side economics include those of Wanniski (1979), Bartlett (1982), and Laffer (1978).

3/ See, for example, Kay and Hemmings (1980), Tobin (1980), Blinder (1981), Rousseas (1981-82), and Weintraub (1981-82).

The aim of this paper is to analyze the aggregate supply effects of taxes with the aid of some simple macroeconomic models. It also uses these models to evaluate the claims of the journalistic supply-side school, but it does not present a detailed outline or critique of this group's views. 1/

The two principal conclusions of the paper are that changes in tax regimes could conceivably have a significant effect on macroeconomic behavior beyond their effects on aggregate demand and liquidity, but that it is highly unlikely that these effects are important in practice in the short to medium term. Using a very simple macroeconomic model with parameters chosen to approximate those of the U.S. economy, it is found that the increase in aggregate supply induced by a tax reduction would be much less than the increase it causes in aggregate demand, even if labor supply and savings elasticities are much higher than normally assumed. Moreover, for a tax cut to be self-financing, the responsiveness of the supply of labor to its after-tax rate of return would have to be enormous. Yet the much more modest claim that a reduction in tax rates might have some effect on aggregate supply is a valid one. Exclusive focus on the aggregate demand impact of a reduction in taxes could result in an overestimation of its inflationary impact. Tax cuts are found to increase the rate of growth of aggregate supply in a simple neoclassical growth model whose parameters approximate characteristics of the U.S. economy and in which savings and labor supply are sensitive to tax rates. However, a really significant response requires drastic tax reductions and very high elasticities of savings and labor supply. Of course, the results of experimentation with a simple model are only illustrative. The models cannot supply answers to questions about the implications for economic welfare of tax reforms, but they may shed a little light on the relative magnitude of supply-side effects.

II. Brief Summary of the Journalistic Supply-Side View

The popular advocates of supply-side economics claim that conventional macroeconomics has ignored the effects of changes in tax rates on labor supply, savings and investment, and the supply of aggregate output. Changes in tax rates affect relative prices, and hence the supply decisions of producers. An increase in the rate of income tax has the effect, among others, of reducing the cost of leisure; that is, the income forgone by not working is reduced. It also reduces the cost of consuming now rather than later, because the after-tax rate of return to savings is lowered. Thus, an increase in income tax affects the incentives to work and to save.

1/ For such criticism the reader is referred to the references listed in footnote 3, p. 1, as well as to Fullerton (1981) and Laffer (1979). Supply-side arguments are found in Laffer (1979) and in Keleher (1979).

It can lead to changes in the amount of labor supply and capital accumulation and hence to changes in aggregate supply. 1/ In the supply-side economists' view, increases in taxes eventually lead to a reduction in the supply of the affected factors of production or to their diversion to the "underground" economy. At some point an increase in tax rates will have the paradoxical effect of reducing tax revenues. An increase in the rate of income tax will, if the rate is sufficiently high to begin with, reduce both the supply of labor and the share of it allocated to the legal (taxpaying) economy so greatly that the tax base will fall by more than the average tax rate will rise. In this situation, a reduction in the tax rate will lead to an increase in tax revenue.

The popular supply-side economists argue that a reduction in income taxes in the United States would lead to a significant increase in the supply of labor and in the volume of savings and investment. These increases in "factor supplies" (or rightward shifts in their supply functions) will lead to an increase in the supply of aggregate output. Effective demand would also increase, and there would be increases in employment and output. The tax reduction is expansionary, but it need not be inflationary. Laffer (1978, p. 3) argues that

> Only . . . [when] . . . the per cent increase in the money supply due to the tax rate decrease exceeds the per cent of output increase due to the tax rate reduction [i.e., in the case when the tax cut causes an increase in the budgetary deficit, which is financed by monetization] could inflation result. In general, a proper reduction in tax rates will mean less inflation.

An implication of this argument is that even if a tax reduction had no effect at all on aggregate supply, it would not be inflationary if the resulting deficit were not monetized. Another implication is that changes in tax rates do not have "demand-side" effects, but only supply-side effects.

It is undeniable that a tax regime affects relative prices and economic welfare. Such effects are the subject matter of texts on public finance and welfare economics. While textbooks on macroeconomics have given little attention to the effects of taxation on the work, savings, or investment decisions, more advanced and more technical studies have given them a great deal of attention. Tanzi (1981, p. 2) states that

> On the one hand, macroeconomic textbooks have recognized only the demand-pull effects of tax changes. On the other hand, the analysis of tax changes in public finance textbooks has

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1/ An exposition of this line of argument is presented in Keleher (1979), pp. 5-20.

been concerned with other issues such as tax shifting, effects on factors' supplies, etc. There has thus been no integration between the microeconomic and the macroeconomic analyses of tax changes.

Presentations of the journalistic supply-side view often contain an exposition of the welfare effects of taxation. They note that taxes drive a wedge between the actual return to an input into production and the return enjoyed by its owners. For example, the marginal revenue product of labor is greater than the net-of-tax wage, and the gross return to investment is greater than the net-of-tax return to the saving that makes the investment possible.

In assessing the welfare or efficiency costs of a tax regime, economists compare it with a hypothetical regime of lump-sum taxes. These do not drive a wedge between the real marginal products and real rates of return and those perceived by the taxpayer. Lump-sum taxes are used as a benchmark because they do not create a distortion in the prices facing economic agents. Any real-life tax regime necessarily involves some efficiency cost or deadweight loss in comparison with a regime of lump-sum taxation.

Some recent studies have argued that the deadweight loss of particular taxes may be larger than it was previously believed. For example, Hausman in his study of the U.S. income tax and its effect on labor supply contends that the present progressive income tax is significantly less efficient than a proportional tax (with a high basic personal exemption) of equal yield would be. However, Hausman (1981) finds that the number of hours worked by the dominant group in the labor force (i.e., married men) would not be greatly altered by a reduction in rates of income tax. This implies that for these workers the income effect of a tax reduction offsets the substitution effect. Hausman's study differs from previous studies of taxation and labor supply in its finding that the substitution effect is important for this group. It is on this effect that the efficiency cost of the progressive tax system depends.

If a particular tax regime has a high efficiency cost, this does not imply that a reduction in rates will cause a large increase in the volume of the taxed economic activity. It is therefore incorrect to argue, as some supply-side advocates do, that because a tax is distortionary a reduction in its rates would have a significant effect on output. 1/

A reduction in income taxes that has a strong substitution effect and a weak income effect will lead to a significant increase in employment, if labor markets function in a neoclassical manner. Whether tax cuts have such an effect is entirely an empirical question. They might well have significant effects on the supply of labor, and the volume of

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1/ See, for example, Keleher (1979), pp. 11-17.

saving and investment, and it is interesting to consider how these might be incorporated in simple macroeconomic models.

III. Tax Variables and Aggregate Supply in Simple Macroeconomic Models

The effect of a tax reduction on short-run aggregate supply and demand is examined in this section with the aid of three simple models. The first is essentially the elementary Keynesian model, where aggregate supply, instead of being fixed, is a function of a fixed capital stock and a supply of labor that varies directly with the after-tax real wage. Prices are fixed in this model, so that financial effects cannot be examined. This first model is about as simple a one as could be used to analyze the supply-side effects of a tax cut. The second model incorporates prices and interest rates. The third model is used to examine the long-run effects of tax changes.

1. Simple Keynesian model with endogenous aggregate supply

The model is specified as follows:

$$Y_D = E + C \tag{1}$$

$$Y_S = AK^a L^{1-a} \tag{2}$$

$$C = C[(1-a)Y_D(1-t_w),\ aY_D(1-t_r),\ r(1-t_r)] \tag{3}$$

$$L_S = F[w(1-t_w)]^b \tag{4}$$

$$L_D = [(1-a)AK^a]^{1/a}\ w^{-1/a} \tag{5}$$

$$L_S = L_D = L \tag{6}$$

$$t_r = ct_w \tag{7}$$

Key to symbols

Y_D - aggregate demand

Y_S - aggregate supply

E - autonomous expenditure

C - aggregate consumption

K - capital stock

L_S - labor supply

L_D - labor demand

L - actual employment

Y - actual aggregate output

t_w - tax on labor income

t_r - tax on capital income

w - real wage rate (in units of output)

r - real rate of return to capital (assumed equal to before-tax return to saving)

A, F - constant terms

Because it is desired to investigate the conditions under which the increase in aggregate demand caused by a tax reduction would be offset by an increase in aggregate supply, an equilibrium condition for the product market has not been included. In the specification of the model, it has been assumed that the labor market always clears (the real wage playing the equilibrating role). Equations (4), (5), and (6) determine labor market equilibrium. Labor supply (equation (4)) is a function of the after-tax real wage. The demand for labor (equation (5)) is a function of the fixed capital stock and the after-tax real wage.

Employment and, hence, aggregate supply are a function of t_w, the tax on labor income, as may be seen by solving equation (5) for w, substituting this expression for w in equation (4), making use of the labor market equilibrium condition, and solving for L as a function of t_w. The standard production relationship of equation (2) makes aggregate supply a simple function of employment, as the capital stock is assumed to be fixed. The model incorporates two proportional taxes. For simplicity, the tax on capital income (i.e., profits) is assumed to be a multiple of the tax on labor income. The production relationship of equation (2) implies that the shares of labor (LS) and capital (KS) in national income are fixed and are equal to $(1 - \alpha)$ and α, respectively. The consumption function (equation (3)) makes consumption a function of labor income, profits, and the after-tax rate of interest. Given the assumptions of this model, the only strictly supply-side effect of a tax reduction is its effect on the supply of labor. However, the model allows for the possibility that changes in the tax rate on capital income may affect the savings propensity.

It is assumed that aggregate demand (Y_D) and aggregate supply (Y_S) are initially equal. To determine the effect of a change in tax rates, the responsiveness of both Y_D and Y_S to such a change must be calculated.

By appropriate substitutions, aggregate supply can be expressed as a function of $(1-t_w)$, as follows:

$$\text{Log } Y_S = D + [(1-a)\ b/(ba + 1)]\ \text{Log } (1-t_w) \qquad (8)$$

with D being a constant term.

This in turn implies the following expression for the elasticity of aggregate supply with respect to t_w:

$$dY_S/Y_S/dt_w/t_w = [(1-a)\ b/ba+1]\ (-t_w)/(1-t_w) \qquad (9)$$

The elasticity of aggregate demand with respect to t_w can be expressed as follows (superscripts denoting partial derivatives):

$$dY_D/Y_D/dt_w/t_w = \frac{[C^1LS + C^2cKS + C^3rc/Y_D]\ (-t_w)}{1 - C^1LS(1-t_w) - C^2KS(1-ct_w)} \qquad (10)$$

C^1 and C^2 are, respectively, the marginal propensities to consume from labor and capital income and are both positive in sign. C^3 is the partial derivative of consumption with respect to the after-tax rate of return on capital, whose sign is uncertain.

Given initial values for Y_S, L, K, a, t_w, and t_r, and assigning values to C^1, C^2, and C^3, the two equations (9) and (10) may be solved for that value of b--the elasticity of labor supply with respect to the after-tax real wage--for which the supply and demand response to a change in the rate of tax on labor income (with an equiproportionate change in the tax on capital income) will be the same. It should be noted that the supply response is determined uniquely by b, given a and t_w. The values listed below were assigned to the model's parameters:

Parameter or Initial Value	Value
Y	100
K	264
L	100
a	0.2
t_w	0.25
t_r	0.4
c	1.6

The parameter values for this model and the simple growth model presented below have been chosen to depict a highly stylized version of the U.S. economy. 1/ Table 1 displays the labor supply elasticity required for various combinations of values for C^1 and C^2, and the interest elasticity of savings implied by various values of C^3 with an assumed initial savings rate of 7.92 per cent (i.e., initial savings (S) of 7.92 units of output). 2/

Table 1. Labor Supply Elasticity Required for Maintenance of Aggregate Supply-Demand Equilibrium Following a Tax Rate Change

Elasticity of Savings with Respect to After-Tax Rate of Return	0	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.5	2.0
Marginal propensities to consume (C_1, C_2) 1/										
0.8, 0.5	2.4	2.3	2.2	2.1	2.1	1.9	1.7	1.6	1.2	0.9
0.6, 0.5	1.3	1.3	1.2	1.1	1.1	1.0	0.9	0.8	0.6	0.4

1/ With respect to after-tax income.

It is interesting to compare the figures in Table 1 with empirical estimates of the two elasticities. The conceptual and empirical problems involved in estimating the interest elasticity of savings are considerable, as are the problems posed by an attempt to estimate the elasticity of labor supply with respect to the real wage. 3/ Rosen (1980) summarizes

1/ They imply an after-tax rate of return to capital (i.e., $(1-t_r)r$)) of 0.045.

2/ The relationship between C^3 and the elasticity of savings (ess) with respect to the after-tax rate of interest is given by:

$$ess = -C^3 r(1-t_r)/S$$

It should be noted that the labor supply elasticity b and the savings elasticity are uncompensated elasticities--i.e., they include both the substitution effect of a change in the after-tax wage rate or interest rate and the income effect. There is no compensating adjustment of real income to hold it constant.

3/ McLure (1980) discusses the problems involved in and the significance of the econometric estimation of savings elasticities. Hausman (1981) discusses the problems of estimating labor supply elasticities.

some earlier research on labor supply elasticity in two "stylized facts": (1) for prime-age males, the substitution effect of changes in the net wage on hours worked is small and often statistically insignificant, and the hours of work are unresponsive to changes in net wages; (2) the hours of work and the decisions of married women as to labor force participation are quite sensitive to changes in the net wage, with some elasticity estimates exceeding 1.0. Fullerton (1981) calculated a measure of aggregate labor supply elasticity of 0.15 based on the estimates of elasticities for male and female workers in various econometric studies. The study by Hausman (1981) estimated uncompensated supply elasticities for secondary female earners of close to 1.

A recent and often-cited study by Boskin (1978) estimated the elasticity of savings with respect to the expected after-tax interest rate at between 0.2 and 0.4. While this is not the highest estimate ever reported, it is higher than most previous studies. 1/

As Table 1 shows, the required labor supply elasticity varies inversely with the interest elasticity of savings and with the marginal propensity to consume. If saving is relatively unresponsive to the change in the after-tax rate of return to capital, the required elasticity is well above most estimates of the aggregate uncompensated labor supply elasticity reported for the United States. For estimates of labor supply elasticity within the limits of most reported empirical research, the required elasticity of savings must be similarly high.

Some versions of journalistic supply-side economics make the argument that a reduction in taxes would be self-financing--that, to use the phrase of one wit, the economy is ". . . over the Laffer hill." 2/ It turns out that, with the parameters of the simple model, a self-financing tax cut would require a labor supply elasticity of 15. 3/

However, it should be noted that any positive response of either savings or labor supply to an increase in the real after-tax rate of return and in the real wage rate, respectively, means that the conventional multiplier analysis overstates the extent to which a tax cut creates an

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1/ Some surveys of the empirical evidence report elasticities as high as 2.5. These, however, refer to the elasticity of the quantity of second-period consumption in a two-period model where period one's saving equals the present discounted value of second-period consumption. The implied savings elasticity is much lower.

2/ See Blinder (1981). The reference is to the Laffer curve, or that part of it where a decline in tax rates leads to an increase in revenues.

3/ Maintenance of aggregate supply-demand equilibrium in the simple Keynesian model does not require that tax revenue remain unchanged. Tax revenue can decline if savings increase by an exactly offsetting amount.

inflationary gap or reduces a deflationary one. Table 2 presents illustrative calculations of the relative magnitude of the supply and demand effects in the simple Keynesian model resulting from a reduction in t_w under a range of assumed values for the elasticities of savings and labor supply. The ratio displayed in the main body of the table represents the ratio of the elasticities with respect to t_w of aggregate supply and aggregate demand, given, respectively, by equations (9) and (10) and expressed in percentage form. The set of low marginal propensities to consume from Table 1 is used. The relative size of the supply effect is not insignificant in all cases, even in cases of modest values for labor supply and savings elasticities.

2. Supply-side effects in a simple macroeconomic model with financial variables

While the preceding model does highlight two basic ways in which taxes can affect aggregate demand-supply balance in the short run beyond the traditional demand effects, it includes neither a price, money stock, nor financial interest rate. To illustrate how a supply-side effect could be incorporated in a simple macroeconomic model including these variables, this section presents a modified version of a model in Turnovsky (1977).

The model is specified as follows:

$$Y - C[Y(1-t)] - I(r) - G = 0 \qquad (11)$$

$$L(Y, r) - M/P = 0 \qquad (12)$$

$$a_0 + a_1 (Y-Y_P) + b\, p_e + d[E(t)-t_{-1}/1-t_{-1}] - p = 0 \qquad (13)$$

$$Y_P - Z[e(1-t)] = 0 \qquad (14)$$

$$P - (1+p)P_{-1} = 0 \qquad (15)$$

Key to symbols

- Y - realized real output
- $C(\ )$ - consumption function
- $I(\ )$ - investment function
- r - interest rate
- t - tax rate
- G - government expenditure
- Y_P - potential output

Table 2. Comparison of Demand and Supply Effects of a Tax Reduction

		Labor Supply Elasticity							
		0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.0
Supply Effect		0.0	-0.026	-0.051	-0.075	-0.099	-0.143	-0.184	-0.222
Savings Elasticity	Demand Effect	Supply Effect as Percentage of Demand Effect							
0.0	-0.275	0.0	9.5	18.5	27.3	36.0	52.0	66.9	80.7
0.1	-0.266	0.0	9.8	19.2	28.2	37.2	53.8	69.2	83.5
0.2	-0.255	0.0	10.1	19.8	29.1	38.4	55.4	71.3	86.0
0.3	-0.245	0.0	10.4	20.5	30.1	39.8	57.4	73.9	89.2
0.4	-0.234	0.0	10.9	21.3	31.4	41.4	59.8	77.0	92.9
0.6	-0.213	0.0	11.8	23.1	33.9	44.8	64.7	83.3	100.5
0.8	-0.193	0.0	12.8	25.1	36.9	48.8	70.4	90.6	109.4
1.0	-0.172	0.0	14.1	27.6	40.5	53.5	77.3	99.5	120.0
1.5	-0.121	0.0	18.7	36.7	54.0	71.2	102.9	132.2	159.7
2.0	-0.069	0.0	27.7	54.3	79.8	105.3	152.2	195.7	236.2

Note: The demand effect is the elasticity of aggregate demand of the simple Keynesian model with respect to t_w. The supply effect is the elasticity of aggregate supply with respect to t_w. The demand effect has been calculated by employing the set of low marginal propensities to consume.

P - price level

M - nominal money supply

p_e - expected inflation rate

L( ) - demand for money function

Z( ) - potential output function

p - actual inflation rate

E(t) - expected tax rate

M, G, and p_e are exogenous; t is a policy variable. A budgetary deficit is assumed to be financed by the issue of bonds. 1/

The first equation represents the familiar IS curve. Here, consumption is made a simple function of after-tax real income. The second equation is the LM curve, the demand for money relationship. The third equation is the price equation, which incorporates a wage equation of the Phillips curve type and the assumption of a constant markup of prices over wages. The term containing the tax variable is included to allow for the effect of changes in the tax rate on wage bargaining. This is rather complicated and is further explained below.

The basic Phillips curve relationship supplemented by an inflation-expectations variable can be expressed as

$$w = a_0 + b_0 (U) + b(p_e) \qquad (16)$$

The symbol w represents the rate of change of nominal wages, U the unemployment rate, and p_e the expected rate of inflation. If the share of wages in output is assumed to be a constant, and prices are set at a constant markup of labor costs, the rate of change of prices will equal the rate of change of nominal wages, as follows:

$$p = w \qquad (17)$$

Finally, if unemployment--the difference between labor supply and labor demand--can be approximated by a linear function of the difference between potential and actual output, $(Y_p - Y)$, then equation (16) can be expressed as

$$p = a_0 + a_1 (Y - Y_p) + a_2(p_e) \qquad (16a)$$

1/ However, a change in the stock of bonds outstanding is assumed to have no effect on any of the behavioral equations.

The tax term in equation (13) represents the effect of any expected increase in the tax rate, t, on the rate of increase in nominal wages: if workers expect inflation at rate p_e, and an increase of Δt in the tax rate, then, to maintain unchanged their expected real after-tax wage, they must demand a nominal wage increase equal to $p_e + \Delta t/1+t_{-1}$. 1/ The parameter d varies from 0 to 1 to allow for variation in the strength of this impact. It is assumed that the expected tax rate, $E(t) = \Delta t+t_{-1}$, is a function of the actual rate.

Equation (14) is included to incorporate the effect of a tax change on potential output (aggregate supply). The supply of labor is assumed to be a function of the after-tax real wage, W(1-t)/P, where W stands for the nominal wage rate. Assuming that W/P = e, where e is a constant, this may be expressed as e(1-t). Since potential output is a function of labor supply, the former may be expressed as a function of e(1-t). Equation (15) is necessary to relate p, the rate of inflation, to P, the current-period price level.

A tax reduction always increases real output. If it did not, then it may be deduced from equations (13) and (15) that p, the rate of inflation, and P, the price level, would decline. This would require a decrease in r, the rate of interest, to maintain money market equilibrium (equation (12)). However, this decline would be inconsistent with a lower level of real output, as equation (11) shows.

The impact of a reduction of the tax rate, t , on the rate of inflation in the model is determined by the sign of the total partial derivative of p with respect to t in the reduced form relationship.

The total partial derivative, $\partial p/\partial t$, is given by the following expression:

$$\partial p/\partial t = \frac{|C|}{|J|} \qquad (18)$$

|J| is the Jacobian of the system of equations (13) to (17)--the determinant of the matrix of partial derivatives with respect to the endogenous variables--and is given by the following expression:

$$|J| = \begin{vmatrix} 1-C'(1-t) & -I' & 0 & 0 & 0 \\ L^1 & L^2 & M/P^2 & 0 & 0 \\ a^1 & 0 & 0 & -1 & -a_1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & -P_{-1} & 0 \end{vmatrix} \qquad (19)$$

1/ See Turnovsky (1977), pp. 107-108 and pp. 114-123, for amplification.

This expression reduces to

$$(-I')\ (L^1) + [1-C'(1-t)]\ L^2\ (-1) + (-I')\ (M/P^2)\ a_1 P_{-1}$$

Each of these three terms is positive ($I', L^2 < 0$; $L^1, C', a_1 > 0$). Hence, the sign of $|C|$ determines the sign of δ_p/δ_t.

$|C|$ is equal to $|J|$ above, but with the column vector

$$\begin{bmatrix} -C'.Y \\ 0 \\ -d.E'(t)/1-t_{-1} \\ -Z'.e \\ 0 \end{bmatrix}$$

substituted for the fourth column of J.

The numerator, $|C|$, can be expressed as three terms:

$$|C| = [(1-C'(1-t))\ (-L^2) + (-I')(L^1)]\ dE'(t)/1-t_{-1}$$
$$+ [(1-C'(1-t))(-L^2)(a_1) + (-I')(L^1)a_1]Z'e$$
$$+ C'YL^2a_1 \qquad (20)$$

The first two terms of this expression are positive, and the third term is negative. The first term captures the effect of an expected change in taxes on the wage bargain and, hence, on inflation; if the tax rate is reduced, and d is greater than 0, then the tax reduction exerts a depressing effect on inflation through this term, as nominal wages can rise less rapidly than otherwise. The second term captures the effect of a change in the tax rate on potential output (i.e., in this model, its effect on the supply of labor). The magnitude of this term varies directly with Z'.e; i.e., the depressing effect on the rate of inflation caused by a tax reduction is greater the more responsive is potential output to the change in the tax rate. The third term represents the demand-increasing effect of the tax reduction, where a tax reduction exerts a positive impact on the rate of inflation.

Conceivably, the effects of the first and second terms could offset the conventional Keynesian effect, so that a tax reduction could result in a decline in the rate of inflation. On the influence of taxes on wage bargaining (first term), Tanzi (1981) notes that considerable evidence from wage negotiations for several industrial countries suggests that wage earners have, in fact, at times bargained on the basis of net-of-tax wages.

Without assigning values to the parameters of the model, the overall effect cannot be determined. However, if the effect of an expected tax rate change on wage demands is suppressed, by assuming that the parameter d equals zero, something may be said about the possibility of a tax reduction causing a decrease in the rate of inflation, p, and the price level, P. Consider the following two cases: (1) where the tax reduction causes no change in the interest rate, and (2) where the tax reduction actually results in a decline. In the first case, equation (11) may be solved for the effect of a tax reduction on real output, which would be:

$$\Delta Y = \frac{-dtY}{1-C'(1-t)} \qquad (21)$$

This expression is a simplified version of the demand effect (although not expressed in elasticity form) of the earlier model, with dt standing for the actual change in the tax rate. But as equation (13) shows, for p to be reduced by a tax reduction, the change in the tax rate must increase Y_p by more than Y (d, it may be recalled, is assumed to equal zero). With no increase in interest rates to offset the increase in aggregate demand, the increase of Y is that given by the simple multiplier analysis of the earlier model and the same conclusions apply.

A decline in the interest rate (the second case) reinforces these conclusions, since a lower interest rate would mean that equation (21) would understate the impact on Y of a tax change. These arguments suggest that if a tax reduction were to reduce p, it would also have to be associated with an increase in r, the rate of interest. This could occur if the LM curve were very steep (i.e., if the interest-elasticity of the demand for money were low). The increase in the interest rate would offset most of the increase in demand and the increase in potential output, Y_p, induced by the tax reduction could be greater than the increase in Y. (The decline in p would have the effect of an increase in the supply of money in real terms, which would have the effect of increasing Y and partly offsetting the increase in the rate of interest.)

3. The effect of tax rate changes in a simple neoclassical growth model

Thus far it has been assumed that the capital stock is fixed, in effect implying that investment does not add to the current stock of capital. Here it is considered how changes in tax rates might affect the evolution of real output in a version of the basic neoclassical growth model.

Summers (1981) has shown that in simple neoclassical growth models with either disembodied or embodied technical progress and exogenous labor supply large increases in the rate of investment have only a minor effect on the rate of growth of output. His analysis has been criticized by Ture (1981) for ignoring the effect of increases in capital stock on the real wage and the level of employment.

The model presented here makes labor supply a function both of time and of the after-tax real wage. Saving is made a function of the level of output and the after-tax rate of return to capital. Saving in one period is assumed to add to the stock of capital in the following period. There are two proportional taxes, one on labor and one on capital income, respectively, as in the Keynesian model. It is assumed that there are no aggregate demand effects from a change in tax rates.

The model is specified as follows:

$$Y(t) = AK(t)^{a}\ L(t)^{1-a} \tag{22}$$

$$L(t) = (w(t)(1-t_w))^{els} LA(1+g)^{t} \tag{23}$$

$$K(t) = K(t-1) + SY(t-1)(r(t-1)(1-t_r))^{ess} \tag{24}$$

$$w(t) = (1-a)AK(t)^{a}L(t)^{-a} \tag{25}$$

$$r(t) = aAK(t)^{a-1}L(t)^{1-a} \tag{26}$$

Key to symbols

$Y(t)$ - output at time t

$K(t)$ - capital stock at time t

$L(t)$ - labor supply at time t

$w(t)$ - before-tax wage rate at time t

$r(t)$ - before-tax rate of return to capital at time t

els - elasticity of labor supply with respect to after-tax wage

ess - elasticity of savings with respect to after-tax rate of return

g - rate of increase in "efficiency units" of labor supply

t_w - tax on labor income

t_r - tax on capital income.

A - constant term

The wage rate (w) and the rate of return to capital (r), which are expressed in units of final output, are equal to the marginal products of labor and capital, respectively, as is the case in neoclassical models.

The parameter g represents the rate of growth of efficiency units of labor and is assumed to be 3 per cent, which is the steady-state rate of growth. The initial values for Y, L, and K are 100, 100, and 264, respectively. Tax rates are initially 0.4 for t_r, the tax on capital income, and 0.25 for t_w, the tax on labor income. The parameters are again meant to approximate those of the U.S. economy. The savings rate necessary for steady-state growth at this capital output ratio is 7.92 per cent. Capital's share, a, is 0.20. The scale parameters LA and S are made functions of els and ess respectively, so that a change in the value of the elasticities when the economy is on its steady-state growth path with a capital-output ratio of 2.64 does not alter savings or labor supply. This permits a comparison of the effect of changing the tax rates under different assumptions regarding the elasticity of savings and labor.

The results of two simulations of this simple model are presented in Tables 3 and 4. In each simulation the two tax rates were reduced with effect in year 1. The values of t_w and t_r are 0.25 and 0.4 in the initial period (year 0). In the first simulation (Table 3) they are reduced to 0.20 and 0.32, respectively (i.e., a 20 per cent reduction), and in the second simulation (Table 4) they are both reduced to 0.20. The simulations were run by using labor and savings supply elasticities ranging from 0 to 1. The tables show the average annual compound rates of growth of output over ten year intervals.

The two tax reductions simulated with the model are quite drastic. In the first, both taxes are cut by 20 per cent, and in the second the tax on capital income is cut by 50 per cent and the tax on labor income is cut by 20 per cent. In this model (in effect a barter economy) the tax reductions are real; there is no inflation-induced bracket creep that must be offset. Despite this, the resulting increases in the rate of growth of real output are not particularly great for elasticity combinations at the low end of the range, even in the first ten years following the reductions. The effect on the rate of growth dwindles quickly in later years. For elasticity combinations at the higher end of the range, the average rate of growth for years 0 to 10 is increased by as much as 0.77 of a percentage point, from 3.0 to 3.77 per cent (see Table 4). The rate of growth subsequently declines sharply. It should be noted that since there is only one steady-state growth rate, a sharp decline must occur if the growth model converges to a steady-state path. But the model does not generate a truly spectacular spurt of growth even in the initial years following the tax reductions under any of the elasticity assumptions employed.

IV. Conclusions and Qualifications

The paper has analyzed supply-side effects with the aid of three simple models. On the basis of this analysis, it can be concluded that a supply-side effect is possible. How great is the effect is an empirical question.

Table 3. Average Annual Growth Rate of Output for Indicated Periods, with Tax Rates Changed to $t_w = 0.2$, $t_r = 0.32$ in Year 1 for Various Combinations of Elasticities

(In per cent)

Savings Elasticity	Period	Labor Supply Elasticity					
		0	0.2	0.4	0.6	0.8	1.0
	0-10	3.00	3.11	3.21	3.31	3.40	3.48
0	10-20	3.00	3.01	3.01	3.02	3.03	3.03
	20-30	3.00	3.00	3.01	3.01	3.02	3.03
	0-10	3.01	3.12	3.23	3.33	3.42	3.51
0.2	10-20	3.01	3.02	3.03	3.04	3.05	3.06
	20-30	3.01	3.01	3.02	3.03	3.04	3.04
	0-10	3.02	3.14	3.25	3.35	3.45	3.54
0.4	10-20	3.02	3.03	3.04	3.05	3.06	3.08
	20-30	3.01	3.02	3.03	3.04	3.05	3.06
	0-10	3.04	3.15	3.26	3.37	3.47	3.57
0.6	0-20	3.03	3.04	3.05	3.07	3.08	3.10
	20-30	3.02	3.03	3.04	3.05	3.06	3.07
	0-10	3.05	3.17	3.28	3.39	3.49	3.59
0.8	10-20	3.03	3.05	3.06	3.08	3.10	3.11
	20-30	3.02	3.03	3.04	3.05	3.06	3.08
	0-10	3.06	3.18	3.30	3.41	3.52	3.62
1.0	10-20	3.04	3.05	3.07	3.09	3.11	3.13
	20-30	3.02	3.03	3.04	3.06	3.07	3.08

Table 4. Average Annual Growth Rate of Output for Indicated Periods, with Tax Rates Changed to $t_w = 0.2$, $t_r = 0.2$ in Year 1 for Various Combinations of Elasticities

(In per cent)

Savings Elasticity	Period	Labor Supply Elasticity					
		0	0.2	0.4	0.6	0.8	1.0
	0-10	3.00	3.11	3.21	3.31	3.40	3.48
0	10-20	3.00	3.01	3.01	3.02	3.03	3.03
	20-30	3.00	3.00	3.01	3.01	3.02	3.03
	0-10	3.03	3.14	3.25	3.35	3.45	3.54
0.2	10-20	3.02	3.03	3.04	3.06	3.07	3.08
	20-30	3.02	3.03	3.03	3.04	3.05	3.06
	0-10	3.06	3.18	3.29	3.40	3.50	3.60
0.4	10-20	3.05	3.06	3.07	3.09	3.11	3.13
	20-30	3.03	3.04	3.05	3.07	3.08	3.09
	0-10	3.09	3.21	3.33	3.44	3.55	3.66
0.6	10-20	3.06	3.08	3.10	3.12	3.14	3.16
	20-30	3.04	3.05	3.07	3.08	3.10	3.11
	0-10	3.11	3.25	3.37	3.49	3.61	3.72
0.8	10-20	3.08	3.10	3.12	3.15	3.17	3.20
	20-30	3.05	3.06	3.08	3.10	3.11	3.13
	0-10	3.14	3.28	3.41	3.54	3.66	3.77
1.0	10-20	3.09	3.12	3.14	3.17	3.20	3.23
	20-30	3.05	3.07	3.09	3.10	3.12	3.14

The simulation experiments with the first model suggest that, while supply-side effects might not be insignificant, they were generally much smaller than the demand-side effects. Even in the simple neoclassical growth model where the demand-side effects of tax reduction were assumed away, the effects were in most cases relatively small in relation to the size of the assumed tax reduction.

It is important to emphasize the limitations of the models employed in the paper. In the first model, both taxes were proportional, meaning that a reduction in the marginal rate of tax implies an equal reduction in the average rate of tax. By adding a lump-sum tax to the model--for example, in the form of a basic exemption for labor and interest income--the marginal rates of tax could be lowered without stimulating an increase in aggregate demand, because the effect of the reduction in the marginal rate would be offset by the effect of an increase in the lump-sum tax. To take a real life example, the introduction of a flat-rate income tax in the United States could conceivably have this type of effect. If the new rate of the tax were much lower than the present top tax rate, and if the basic personal exemption and dependent exemptions were greatly reduced or eliminated, the substitution effect might dominate the income effect, without a resulting increase in disposable income. In terms of the first model, the supply effect would be greater than the demand effect.

In the basic growth model, the rate of technical progress (or the rate of growth of the labor supply in efficiency units) is given and it cannot be permanently increased by an increase in the rate of saving (the share of investment in national income). A model in which the rate of technical progress was endogenous and dependent on the share of investment in national income might yield quite different results.

The difficulties posed by the empirical estimation of the parameters used in the models were discussed in the paper. One basic difficulty is the measurement of labor supply. This is normally proxied by the number of hours worked, but this measure may be a poor indicator of total work effort, which might be thought of as the product of intensity of work effort and the number of hours worked. Individuals may or may not have much control over the amount of time they must spend at the workplace, but they can certainly vary the intensity at which they work. A tax regime may also distort occupational choice.

Aside from its effects on the level of savings and investment, a tax regime can influence the composition of investment. It may also influence the decision to invest in human capital, although such effects would be very hard to measure. 1/ Through these channels a tax regime could have a significant effect on productivity growth, but no simple macroeconomic model could capture the extent of such an effect.

1/ These are discussed in Rosen (1980) and in Boskin and Shoven (1980).

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