Welfare Costs per Dollar of Additional Tax Revenue in the United States

By CHARLES STUART*

Assessing the optimal level of government spending is as difficult as it is important. On a theoretical level, the issue can be stated simply as one of comparing the marginal benefits and costs of public expenditures. It is the measurement of the benefits and costs that presents problems. In this paper, I present fairly striking calculations of the costs of marginal governmental expenditures.

An insight by Edgar Browning serves as the starting point for the analysis. Browning (1976) observed that the social cost of financing a marginal dollar of public expenditure is the sum of that dollar, which is diverted from private use, plus the change in the total welfare cost of taxation caused by increasing tax revenue by the dollar. This latter component will be termed "marginal excess burden" in what follows. It can be regarded as a per dollar surcharge that must be borne whenever the public sector alters the allocation or distribution of resources through fiscal measures. Not surprisingly, the notion of marginal excess burden plays a central role in theories of optimal taxation. For instance, Peter Diamond and Daniel McFadden (1974, p. 12) point out that optimal taxation requires equality of marginal excess burdens across revenue sources. Similarly, Dan Usher (1982) reworks the analysis of Anthony Atkinson and Nicholas Stern (1974) to argue that Browning's marginal cost of public funds (one plus marginal excess burden) enters into the first-order conditions for the optimal provision of publicly supplied goods.

Using a partial-equilibrium approach based on Arnold Harberger's (1964) excess burden formula, Browning calculated that the value of the marginal excess burden from labor income in the United States was on the order of 9¢ to 16¢ on the dollar in 1974. This would mean that a dollar of public funds was efficiently spent only if it generated social benefits of at least \$1.09 to \$1.16. However, there are a number of reasons for questioning Browning's partial-equilibrium treatment. First, the Harberger formula is exact only in the neighborhood of an undistorted equilibrium for an economy with a linear production frontier (Harberger, 1971, p. 792). Here, the undistorted equilibrium requirement accords poorly with today's significant marginal tax rates on labor income while the linearity condition seems implausible in light of the literature on the magnitude of the elasticity of substitution in the aggregate production function. Second, and possibly more importantly, the Harberger formula is conceptually inadequate for measuring marginal excess burden. It is certainly true that this formula correctly measures the cost of failing to use lump sum taxation. However, lump sum taxation is not the alternative foregone in raising an additional dollar of tax revenue. To calculate the welfare cost of raising an additional dollar of revenue, one wishes to compare changes in utility and revenue as the economy moves from an equilibrium before a tax increase to one after the increase. The Harberger formula does not do this. Instead, it compares an undistorted equilibrium to a hypothetical, fully compensated allocation (Diamond and McFadden). The problem is that the change in the level of tax revenue as the economy moves between fully compensated points does not generally equal the change in revenue that the actual (uncompensated) economy experiences, so estimates of marginal

*Department of Economics, University of California, Santa Barbara, CA 93106, and University of Lund, Sweden. This paper was formerly titled "Marginal Excess Burden in the U.S." I am indebted to Ingemar Hansson for numerous valuable comments on different versions of this work. Thanks are also due to Edgar Browning, Don Fullerton, and John Riley. The research support of the Bank of Sweden Tercentenary Foundation is gratefully acknowledged.

excess burden based on the Harberger formula are biased.[1] A related problem is that since the equilibrium level of tax revenue generally depends on the way in which the government spends the revenue, the value of marginal excess burden cannot itself be independent of the type of marginal spending (compare Atkinson and Stern, equation (3); my 1982 paper). In the Harberger-Browning approach, however, the dependence of marginal excess burden on the use of marginal public revenue via the government budget constraint fails to show up. A third difficulty with Browning's calculation is that while he computes welfare loss triangles arising when taxation reduces the amount of labor supplied, he assumes that taxation does not reduce the tax base (compare his equations (4) and (5)).

All of these difficulties can be overcome by estimating marginal excess burden in a simple, general-equilibrium framework. Further, such an approach can provide valuable information on how marginal excess burden varies with the type of government spending or with other policy or structural parameters. In this paper, I adapt the model developed in my earlier paper (1981) to calculate the marginal excess burden from taxes on labor income in the United States. For simplicity, I follow Browning's assumptions—especially on labor supply elasticities—as closely as possible. To highlight the potential magnitude of marginal excess burden, however, estimates based on higher but not implausible labor supply elasticities are also reported.

In Section I, the structure of the model used for the calculations is presented. Parameterization corresponding to U.S. economic experience is treated in Section II. Section III contains the results as well as sensitivity tests.

I. The Model

Briefly, the model contains a single, utility-maximizing, aggregate household that allocates a fixed amount of labor time between a taxed and an untaxed sector. Each sector is represented by a production function, and each has a fixed and immobile capital stock. Revenue from the taxation of labor in the taxed sector is partially redistributed to the household as a lump sum and partially expended on government consumption. The government budget balances. An increase in the marginal tax rate causes labor to flow from the taxed to the untaxed sector and thus influences the equilibrium consumptions of taxed and untaxed sector outputs. Consequent welfare changes are evaluated by calculating the compensation required to equate the utility levels of the pre-tax-increase and the post-tax-increase consumption vectors.

Let L denote the household's total labor time, L_1 be the amount of time devoted to taxed uses (i.e., to the taxed sector), and L_2 be the amount allocated to untaxed uses (sector). Assume that

$$L_1 + L_2 = L. \tag{1}$$

A rough picture of the dichotomization between L_1 and L_2 is that the former corresponds to normal market employment while the latter encompasses time devoted to home production and leisure, as well as to "on-the-job leisure" and to activities leading to tax evasion and fringe benefits.

The outputs produced by taxed and untaxed uses of labor, denoted Y_1 and Y_2, respectively, are represented by Cobb-Douglas production functions:

$$Y_1 = AL_1^a, \tag{2a}$$

$$Y_2 = BL_2^b, \tag{2b}$$

where A, a, B, and b are parameters.[2] Capital stocks in each sector are constant and are hence subsumed in A and B.[3] The

[1]Under certain conditions (for example, homotheticitiy and separability of publicly supplied goods in utility) the bias is upward (see my 1982 paper).

[2]Early cross-section work on the elasticity of substitution in the aggregate production function for the United States (Jora Minasian, 1961; Robert Solow, 1964; Frederick Bell, 1964) supports a Cobb-Douglas specification, at least for the taxed sector. Stronger support is in work by Zvi Griliches (1967).

[3]This assumption should cause downward-biased estimates of the welfare cost of tax increases—for dis-

parameters a and b represent labor's shares. Taxed-sector output is taken as the numeraire.

The household maximizes a Stone-Geary generalized CES utility function:

$$(3)\quad U=\left[\alpha\overline{Y}_1^{-\rho}+(1-\alpha)\left(\overline{Y}_2-\delta\right)^{-\rho}\right]^{-1/\rho},$$

where $\overline{Y}_1$ and $\overline{Y}_2$ are the amounts of taxed- and untaxed-sector consumption, respectively, and where α, ρ, and δ are parameters. The maximization is performed by allocating labor time to the two sectors in accord with (1) so as to influence the marginal consumptions of taxed- and untaxed-sector output.

Since no tax wedge exists in the untaxed sector, the amounts of sector-two output produced and consumed are equal:

$$(4)\qquad Y_2=\overline{Y}_2,$$

and hence the increase in the consumption of untaxed-sector output given a one unit increase in L_2 is simply

$$\partial\overline{Y}_2/\partial L_2=\partial Y_2/\partial L_2=bBL_2^{b-1}.$$

To represent the household's perceived increase in $\overline{Y}_1$ obtained by a small increase in L_1, assume that any redistribution of tax revenue to the household is regarded as a lump sum and that any capital income, $(1-a)Y_1$, is similarly viewed as a lump sum. Letting w be the gross wage and t' be the (constant) marginal tax rate, the household thus sees the net wage as the marginal determinant of $\overline{Y}_1$, that is,

$$\partial\overline{Y}_1/\partial L_1=w(1-t').$$

The first-order condition for utility maximization is then

$$(5)\quad (1-t')w=\left\{(1-\alpha)/\alpha\left[\left(\overline{Y}_2-\delta\right)/\overline{Y}_1\right]^{-\rho-1}\right\}bBL_2^{b-1},$$

or that the number of units of $\overline{Y}_1$ obtained on a non-lump-sum basis per marginal unit of L_1 equals the number of units of $\overline{Y}_2$ obtained per marginal unit of L_2 times the marginal rate of substitution (in braces).

The government budget is assumed to balance with tax revenue from labor income being expended on redistribution (R) and government consumption (G):

$$(6)\qquad R+G=twL_1,$$

where t is the average tax rate on labor income. To allow the model to treat situations where marginal tax revenue is expended only on R, or only on G (or on a mixture of the two), it is convenient to write G as a linear function of total revenue from labor income:[4]

$$(7)\qquad G=g_0+g_1(twL_1).$$

When $g_1=0$, the model then directs all marginal tax revenue to spending on R, while when $g_1=1$, all marginal revenue is assumed to be spent on G. Note that the initial level of G can be set to any feasible value by an appropriate choice of g_0.

With the public sector specified in this way, there is a linear relationship between taxed-sector output and consumption. Writing $\overline{Y}_1$ as the sum of net wages, capital income, and redistributions, this relationship is

$$(8)\quad \overline{Y}_1=(1-t)wL_1+(1-a)Y_1+R$$
$$=(1-g_1ta)Y_1-g_0,$$

cussion, see my 1981 article. As well, disaggregating to more than two sectors should increase welfare costs (see John Shoven, 1976).

[4]Government consumption does not explicitly enter the utility function (3). An interpretation is that the model treats government consumption as providing utility in a way which is mathematically separable from $\overline{Y}_1$ and $\overline{Y}_2$ (and which is notationally suppressed in (3)). Thus g_1 can be regarded as the share of marginal tax revenue that is publicly spent on goods that are separable from $\overline{Y}_1$ and $\overline{Y}_2$, and which therefore do not influence the allocation of labor to L_1 or L_2 (compare condition (5)). Note that "public good-like" benefits from redistributions (over and above the direct utility value of the Y_1 obtained by recipients) can also be introduced without disturbing the present structure and results by merely appending a separable function of R to equation (3).

where the final equality uses (2a), (6), and (7), as well as the assumption that the wage in the taxed sector is set competitively:

$$(9) \qquad w = aAL_1^{a-1}.$$

In order to close the model, it is necessary to specify how the average tax rate in the economy changes when the government raises the marginal rate. For simplicity, it is assumed that the ratio of the marginal to the average tax rate is a constant, τ:[5]

$$(10) \qquad t = t'/\tau.$$

For any initial value of the marginal tax rate, numerical solution of (1), (2a), (2b), and (4)–(10) yields equilibrium values of t, L_1, L_2, Y_1, Y_2, $\bar{Y}_1$, $\bar{Y}_2$, w, and the two uses of tax revenue, G and R. It now remains to calculate welfare effects. First, suppose a tax increase causes the household's equilibrium consumption to change from $(\bar{Y}_1, \bar{Y}_2)$ to $(\bar{Y}_1', \bar{Y}_2')$. Denote the numeraire value of the resulting reduction in household utility by ΔC. Then ΔC can be measured as the amount of taxed-sector output (the numeraire) that would just be needed to restore the household to its original utility level; that is, by the root of $U(\bar{Y}_1, \bar{Y}_2) = U(\bar{Y}_1' + \Delta C, \bar{Y}_2')$.[6] When all marginal tax revenue is expended on government consumption ($g_1 = 1$), this root includes changes in both the direct burden (i.e., in tax revenue) and in the excess burden of taxation, so the change in excess burden is $\Delta C - \Delta(twL_1)$. Since marginal excess burden is defined here as the change in excess burden *per additional dollar of tax revenue*, the correct expression for marginal excess burden is therefore $\Delta C/\Delta(twL_1) - 1$ when $g_1 = 1$. On the other hand, when all tax revenue is returned to taxpayers on the margin ($g_1 = 0$), the direct burden is balanced by a change in redistributions and is thus in effect netted out of ΔC. Marginal excess burden is then conveniently taken as simply $\Delta C/\Delta(twL_1)$. In general, netting redistributions out of ΔC to find excess burden entails calculating marginal excess burden as[7]

$$(11) \qquad MEB = \Delta C/\Delta(twL_1) - g_1.$$

II. Parameterization

This section describes how values for A, a, B, b, L, α, δ, ρ, g_0, g_1, and τ were chosen so as to be consistent with economic experience in the United States. Whenever possible, parameterization was undertaken using data from 1976, which was a year of "normal" business activity, being neither a business cycle peak nor a trough.

Some of the parameters can be chosen with more certainty than others. These will be discussed first.

A. *Tax Rates*

The marginal tax rate in 1976 is taken as the weighted average of marginal rates for different brackets, with weights equal to shares of income in each bracket.[8] Income,

[5] It should be emphasized that this relationship reflects the way in which the government changes the tax schedule over time to raise or lower total tax revenue and *not* just the shape of the tax schedule at any point in time. For instance, one may think of the government beginning with a linear tax schedule, raising the slope of the schedule (t') incrementally, and then adjusting the intercept. Equation (10) merely specifies that the intercept is to be adjusted so that the average tax rate in the new equilibrium exceeds the initial average tax rate by exactly $1/\tau$ times the increment in t'. The assumed relationship is adequate to closely approximate the tax-change assumptions made by Browning in two of his three cases (i.e., proportional and "degressive" taxes).

[6] This is John Hicks' (1946) "compensating surplus." A justification for using it is in my 1982 paper. Alternative welfare measures that might instead be used are the equivalent surplus, the compensating variation, and the equivalent variation. In the implementation of the model described here, substitution of these alternative measures was found to affect the results only at the third significant digit.

[7] This formulation neglects administration and other compliance costs of running the tax system. Browning (p. 293) cites a figure of 2–2.5 percent of tax revenues for these costs.

[8] Browning calculates changes in excess burdens for taxpayers in different income classes and sums to get the aggregate change in excess burden. His approach is equivalent for proportional or degressive tax systems to finding the marginal excess burden for an aggregate household whose tax rate is a weighted average of the marginal rates for each income class, with weights equal to class income shares.

TABLE 1—GOVERNMENT SPENDING, 1976[a]

Counted as Government Consumption		Counted as Redistributions	
Federal		**Federal**	
National Defense	89.4	Agriculture	2.5
International Affairs	5.6	Commerce and Housing Credit	3.8
Natural Resources and Development	8.1	Education, Training, Employment and, Social Services	18.7
Community and Regional Development	4.8	Health	33.4
Administration of Justice	3.3	Income Security	127.4
General Government	3.0	Veterans' Benefits	18.4
(1/2) General Space, Science, and Technology	2.2	(1/2) General Space, Science, and Technology	2.2
(1/2) Energy	1.6	(1/2) Energy	1.6
(1/4) Transportation	3.4	(3/4) Transportation	10.1
State and Local		**State and Local**	
Highways	23.9	Education	97.2
(4/5) Other	82.4	Public Welfare	32.6
		(1/5) Other	20.6
Total	$G = 227.7$		$R = 368.5$

[a]Amounts are in billions of 1976 dollars.

payroll, and indirect taxes as well as the tax effect of income-indexed transfers are included since all of these can be avoided if labor is shifted from taxed to untaxed uses. Data on federal marginal rates by brackets are published by the Internal Revenue Service (1979). On the basis of work by Browning and William Johnson (1979, pp. 63–65), the progressivities of federal, and state and local income taxes are assumed to be equal. Data on the tax effect of transfer payments are also from Browning and Johnson. Calculated values for 1976 are $t' = .427$ and $t = .273$. Dividing the former by the latter yields the estimate $\tau = 1.564$. This is close to the value implicit in Browning's "degressive tax" case (1.629). (Using Browning's figure instead of 1.564 would increase marginal excess burden slightly.)

B. *Government Consumption*

The model sketched above dichotomizes government expenditures into government consumption, which is assumed to have no influence on the marginal rate of substitution between the outputs of the two sectors, and redistributions to the household, which are treated as perfect substitutes for private consumption of taxed-sector output. The procedure for estimating g_0 and g_1 was to interpret federal, and state and local budget outlays (*Economic Report of the President*, 1981, Tables B-70, B-76) as either G or R for 1976 and 1971. The assumptions are detailed in Table 1; these implied 1976 values of $G = 227.7$ and $R = 368.5$.[9] Similar figures for 1971, expressed in 1976 dollars (using the *CPI*) were $G = 235.1$ and $R = 290.5$. The recent historical pattern thus appears to be that government consumption has been relatively constant while redistributions have increased. Parameter values of $g_1 = 0$ and $g_0 = 227.7$ ($= G$ in 1976) reflect this. Most simulations are run with these values. However, several simulations are also run on the assumption that all marginal tax revenue is spent on G instead of R. To capture this

[9]This procedure is not as exact as one might like. For instance, roughly 20 percent of state and local revenues are provided by the federal government, so some expenditures may be double counted. This makes the assumed 1976 value of G too high and imparts a slight conservative bias to the results. A possible countervailing effect is that some of the assumed components of R may in reality be less than perfect substitutes for private income.

given $G=227.7$ involves assuming that $g_1=1$ and $g_0=-63.1$.

C. *Labor*

Not all of the 24 hours in a day are subject to an allocational choice between L_1 and L_2. It is assumed that 10 hours per day can be freely allocated (sensitivity analysis indicates that this assumption is innocuous, see Section III). On a yearly basis, this is 3,660 hours, which is taken as the value of L. In 1976, there were 157.32 billion hours of work in the taxed portion of the U.S. economy.[10] During the same year, the noninstitutional population 16 years of age and older was 156.05 million (*Economic Report of the President*, p. 264). Thus the average hours of work per employable person in 1976 was 1008.14. The 1976 allocation of labor is therefore taken to be $L_1=1008.14$ and $L_2=2651.86$.

D. *Taxed-Sector Production*

Net national product for 1976 was 1527.4 billion dollars (*Survey of Current Business*, 1977, p. 8). This is taken to be the value of Y_1. (Thus $\overline{Y}_1=1527.4-227.7=1299.7$ in 1976.) Compensation of employees was 1036.3 and proprietors' incomes were 88.0 (*SCB*, p. 9) If it is assumed that labor's share of Y_1 equaled labor's share of proprietors' incomes then total labor income is $1036.3+(88.0)\,a$. This, with $a=$ total labor income/1527.4 yields $a=.720$. Plugging the assumed values of Y_1, L_1, and a into (2a) gives $A=10.506$.

E. *Untaxed-Sector Production*

Little empirical analysis has been directed at determining the shape of the untaxed-sector production function. On the basis of the observed stability of the Cobb-Douglas function (see Paul Douglas, 1976), however, the naive assumption that $b=a=.720$ is not unreasonable (sensitivity analysis suggests that the choice of b is unimportant, see Section III). The value of B merely determines the units in which Y_2 is measured and has no influence on the results. A useful choice is to pick B so that the marginal rate of substitution in consumption equaled one as of 1976. Inserting (9) into (5) to eliminate w, imposing $MRS=1$, and setting t', a, A, L_1, L_2, and b to their assumed (1976) values then implies $B=7.892$.

F. *Utility*

Data on labor supply elasticities are used to fix α, δ, and ρ. In particular, Browning's survey of the (early) labor supply literature led him to assume that the compensated supply elasticity for labor was .2. From the studies referenced by Browning, a reasonable estimate of the uncompensated elasticity might be zero (i.e., elasticities for males were negative while female elasticities were generally positive and somewhat greater in magnitude). I therefore derive the compensated and uncompensated labor supply elasticities implied when the household's first-order condition (5) is differentiated first with respect to the gross wage and then with respect to lump sum income, and impose the constraints that these elasticities equal .2 and zero, respectively. A third constraint (from above) is that $MRS=1$ given the 1976 values of all variables. Solution of these three relationships yields $\alpha=.9429$, $\delta=1968.36$, and $\rho=1.0625$. Deriving parameters in this way "calibrates" the model so that its equilibrium solution exactly replicates the 1976 magnitudes of the endogenous variables when the marginal tax rate t' is set to its 1976 level.

III. Results

Given the set of parameters generated by the procedure described in Section II, simulations were run by letting the marginal tax rate increase in one-percentage-point increments. The results are labeled "benchmark case" in Table 2. Note that the assumptions

[10]From *Survey of Current Business* (1977, p. S15), 151.39 billion hours were worked by waged and salaried employees in nonagricultural establishments in 1976. At the same time, 84,188 (000's) persons were employed in nonagricultural industries and 3,297 (000's) were employed in agriculture (*SCB*, p. S13). The text figure of $157.32=(151.39)(1+3297/84188)$.

TABLE 2—RESULTS

Explanation	Marginal Excess Burden at $t'=.427$	Marginal Excess Burden at $t'=.46$	t^*
0. Benchmark Case	.207	.244	85
1. Spending on Government Consumption	.072	.090	88
2. $b=.95$	.207	.245	85
3. $L=5490$ hours/year	.207	.245	85
4. No Payroll Tax	.234[a]	.278[b]	84
5. $\eta=.318$	.574	.719	71
6. $\eta=.318$, Spending on Government Consumption	.427	.533	72
7. $\eta=.636$	.999	1.33	63

Note: Marginal excess burdens reported here contain no adjustments for administrative costs of collecting taxes. Unless otherwise stated, marginal public spending is on redistributions; η is the aggregate uncompensated wage elasticity of labor supply; t^* is shown in percent.

[a] $t'=.377$.

[b] $t'=.41$.

in this case correspond closely to those made by Browning in his analysis of degressive taxes. At a 41.3 percent marginal tax rate, Browning estimated marginal excess burden to be 13.4¢. The figure for the benchmark here is 20.7¢ of welfare loss per additional dollar of tax revenue at the 42.7 percent marginal tax rate that prevailed in 1976. This is roughly 1.5 times Browning's estimate. Note that if taxes have increased from 1976 to the present, marginal excess burden under this set of assumptions would be still higher today. It is difficult to know just what has happened to the aggregate marginal tax rate in the years since 1976. A rough estimate derived from data in the 1981 *Economic Report of the President* is as follows. Taking the sum of federal receipts from the individual income tax, Social Security tax, excise taxes, and customs duties (Table B-70), together with state and local revenues from sales and individual income taxes (Table B-76), and dividing by net national product (Table B-17) yields 0.210 for 1976 and 0.230 for 1979. This suggests that the average tax rate on L_1 may have risen by about two percentage points from 1976 to 1979. Given the value of τ assumed in Section II, the marginal tax rate on L_1 may thus be approximately 46 percent today. This would imply a marginal excess burden of 24.4¢.[11]

Also revealed in Table 2 is the marginal tax rate at which simulated tax revenue peaks. This rate is denoted t^* and equals 85 percent in the benchmark. Note that a similar result has been obtained by Don Fullerton (1982); in a more detailed model of the U.S. economy, he calculated that total tax revenue would reach a maximum at $t^*=.75$. By the way it is defined, marginal excess burden becomes infinite at t^* and is not a particularly useful concept beyond t^*.

Seven alternative sets of parameterizing assumptions were also simulated to examine the sensitivity of the results. The effects of these alternative assumptions are also displayed in Table 2. The basic method for finding parameter values is unchanged. By the numbers:

1) *Spending on government consumption*. In the benchmark, all marginal tax revenue was redistributed on a lump sum basis. This assumption approximates the historical trend more closely than would the alternative specification that spending was on government consumption. When one sets $g_1=1$ (and $g_0=-63.1$) so that all marginal tax revenue is funneled into government consumption, the calculated 1976 value of marginal excess burden drops to 7.2¢. The

[11]A caveat is that the net impact on t' of developments since 1979—including bracket creep, payroll tax increases, and the 1981 tax cut—is uncertain. In any case, comparing marginal excess burden at $t'=.427$ and at $t'=.46$ provides a feel for the sensitivity of the results to the level of t'.

size of this reduction—from double to roughly one-half of Browning's estimated value—provides strong confirmation that the ultimate use of public funds matters. There is an interesting and important explanation for the decline. Redistribution of tax revenue to taxpayers induces an income effect that increases the tendency for labor to leave the taxed sector when tax rates rise. This makes tax revenue increase less rapidly than would be the case if public spending were directed toward government consumption. The net effect is to reduce the denominator in equation (11); that is, to make the change in excess burden per dollar of additional revenue greater. A striking implication is that the relevant marginal excess burden for national defense is likely to be lower than the marginal excess burden for a redistributional social program. In very much the same way, the relevant marginal excess burden for wasteful government programs (i.e., programs that use resources but produce nothing of value) is lower than the marginal excess burden for redistributional social programs.

2) *Sensitivity analysis*, b. In parameterizing the untaxed-sector production function, the *ad hoc* assumption that $b = a = .720$ was employed. Here, the assumption that $b = .95$ is used instead. The effect of this replacement on the results is nil.

3) *Sensitivity analysis*, L. The benchmark parameterization assumed that 10 hours per day, or 3,660 hours in 1976, could be freely allocated to L_1 and L_2. The sensitivity of the results to this assumption is assessed by specifying instead that 15 hours per day can be freely allocated to L_1 and L_2. Thus $L = 5490$ (hours/year). Again, there is no effect on the results. The explanation is that the assumed wage and income elasticities of labor supply are the critical determinants of marginal excess burden. Thus with these elasticities held constant, changes in L (or b) induce compensating adjustments in the parameters of the utility function and no change in marginal excess burden occurs.

4) *Sensitivity analysis, payroll tax not treated as a tax*. One might argue that part of the Social Security payroll tax reflects a forced payment for individual retirement benefits that would be purchased voluntarily even in the absence of the Social Security system. Such a view implies that part of the payroll tax is not distortionary and hence should not, for purposes of welfare analysis, be included in t' and t. To assess this, all payroll taxes are netted from t' and t in the present scenario and the model is reparameterized at the reduced 1976 tax rates. Netting out payroll taxes lowers the 1976 marginal tax rate from .427 to .377. The average rate declines more sharply, falling from .273 to .174. As a consequence, the implied value of τ increases; that is, eliminating the (regressive) payroll tax causes the (remaining) tax structure to become more progressive. Simulation then yields a 1976 marginal excess burden (at $t' = .377$) of .234, which amounts to a small rise from the benchmark case. This rise is largely due to the implied increase in τ; without it, marginal excess burden would fall since assumed tax rates are lower.

5) *Higher assumed labor supply elasticity*. The labor supply elasticities assumed above are low by the standards of the recent literature. For instance, Fullerton examines male and female elasticities as cited in a survey by Mark Killingsworth (1983), weights these by relative income shares, and concludes that the aggregate uncompensated labor supply elasticity is +.15. Even this aggregate value may be too low as it is based largely on a relatively older and less sophisticated body of studies. In particular, recent work on male labor supply tends to produce positive elasticity estimates as often as negative ones, although absolute magnitudes are generally small.[12] Two important examples are studies by Thomas MaCurdy (1981), who considers labor supply in a life cycle setting and obtains elasticites in the range .05 to .13, and by B. K. Atrosic (1982), who considers variations in preferences in a model with flexible functional forms and finds male elasticities of .19 to .39. My reading is therefore that a

[12] Studies by Julie DaVanzo, Dennis De Tray, and David Greenberg (1976) and by George Borjas (1980) have examined several questionable practices common in earlier work (i.e., regarding wage and asset values as exogenous, severely restricting samples, and defining the independent wage variable as income divided by the dependent variable, hours worked). Simple corrections for these practices generally caused elasticities to change in sign from negative to positive.

TABLE 3—RECENT ESTIMATES OF THE WAGE ELASTICITY OF FEMALE LABOR SUPPLY

Study	Elasticity	Notes
Rosen (1976)	2.30	Corrects for nonlinearities in budget due to taxes; uses Tobit to deal with observations with zero supplied labor.
Heckman (1976)	4.31	Corrects for sample-selection bias.
Cogan (1980)	2.45	Corrects for selection bias; allows fixed costs of working. Estimate is from Heckman et al. (1981), which refers to this study as Cogan (1980).
Schultz (1980)	1.26	Uses Tobit. Reported figure is average elasticity (over age cohorts) for whites; average for blacks is 0.88.
Heckman (1980)	4.83	Corrects for selection bias; allows fixed costs of working; treats labor market experience as endogenous.
Hanoch (1980)	1.44	Corrects for selection bias; allows fixed costs of working; allows simultaneous determination of annual hours and weeks worked; treats 52 weeks/year of work as corner solution.
Hausman (1981)	0.91	Corrects for nonlinear budget caused by taxes and income-indexed transfers. Reported elasticity is evaluated at means for women who work.

zero uncompensated wage elasticity for males is not an unreasonable assumption.

For females, a survey by James Heckman et al. (1981) partitions the literature into "first-generation" and "second-generation" studies. Browning cities the simpler first-generation studies exclusively; according to Heckman et al., these studies report elasticities between $-.1$ and $+1.6$. The later, second generation work, on the other hand, attempts to correct for the presence of discontinuities in the labor supply function (due to fixed costs of working), nonlinear budget constraints (due to taxes), sample selection biases, and/or endogeneity of wage and asset variables. A digest of the more recent studies, with elasticity estimates, is in Table 3. The average elasticity in the table is 2.5. On this basis, I would think that an assumed female wage elasticity of 1.0 is not implausibly high; indeed, an elasticity of 2.0 is not completely out of the ballpark given the distribution of estimates of recent studies. Since the relative shares of labor income for males and females were .682 and .318, respectively, in 1976 (*Current Population Reports*, 1978, Table 49), these elasticity assumptions for females imply aggregate elasticities of .318 and .636, respectively, when combined with a zero elasticity for males. While the latter figure may be on the high side, the former is, again, not unreasonable given the recent evidence.

Accordingly, simulation 5 modifies the benchmark by assuming that the uncompensated wage elasticity is .318. As in the benchmark, the compensated elasticity is taken as the uncompensated elasticity plus .2. This causes marginal excess burden to rise to 57.4¢ on the dollar at the 1976 tax rate and to roughly 72¢ on the dollar at a 46 percent marginal tax rate on labor income.

6) *Higher elasticity with spending on government consumption*. In simulation 5, marginal public spending was redistributional; here, marginal spending is instead assumed to be on government consumption. As was the case in comparing simulations 1 and 2, government consumption entails a lower marginal excess burden (.427 at 1976 tax rates). Indeed, the absolute difference in marginal excess burden is roughly the same between the two pairs of simulations. That is, a shift from redistribution to government consumption lowers marginal excess burden by about 14¢.

7) *A still higher elasticity*. As a final sensitivity test, the implications of assuming the high labor supply elasticity of .636 are examined. The compensated elasticity is

taken to be .836. This causes calculated marginal excess burden to rise to one dollar or more per dollar of tax revenue for redistributional spending.

REFERENCES

Atkinson, Anthony, and Stern, Nicholas, "Pigou, Taxation and Public Goods," *Review of Economic Studies*, January 1974, *41*, 119–28.

Atrosic, B. K., "The Demand for Leisure and Nonpecuniary Job Characteristics," *American Economic Review*, June 1982, *72*, 428–40.

Bell, Frederick, "The Role of Capital-Labor Substitution in the Economic Adjustment of an Industry Across Regions," *Southern Economic Journal*, October 1964, *31*, 123–31.

Borjas, George, "The Relationship between Wages and Weekly Hours of Work: The Role of Division Bias," *Journal of Human Resources*, Summer 1980, *15*, 409–23.

Browning, Edgar, "The Marginal Cost of Public Funds," *Journal of Political Economy*, April 1976, *84*, 283–98.

______ **and Johnson, William,** *The Distribution of the Tax Burden*, Washington: American Enterprise Institute, 1979.

Cogan, John, "Labor Supply with Costs of Labor Market Entry," in James Smith, ed., *Female Labor Supply*, Princeton: Princeton University Press, 1980.

DaVanzo, Julie, De Tray, Dennis and Greenberg, David, "The Sensitivity of Male Labor Supply Estimates to Choice of Assumptions," *Review of Economics and Statistics*, August 1976, *55*, 313–25.

Diamond, Peter and McFadden, Daniel, "Some Uses of the Expenditure Function in Public Finance," *Journal of Public Economics*, February 1974, *3*, 3–21.

Douglas, Paul, "The Cobb-Douglas Production Function Once Again: Its History, Its Testing, and Some New Empirical Values," *Journal of Political Economy*, October 1976, *84*, 903–15.

Fullerton, Don, "On the Possibility of an Inverse Relationship Between Tax Rates and Government Revenues," *Journal of Public Economics*, October 1982, *19*, 3–22.

Griliches, Zvi, "Production Functions in Manufacturing: Some Preliminary Results," in M. Brown, ed., *The Theory and Empirical Analysis of Production*, Studies in Income and Wealth, Vol. 31, New York: Columbia University Press, 1967, 275–322.

Hanoch, Giora, "A Multivariate Model of Labor Supply: Methodology and Estimation," in James Smith, ed., *Female Labor Supply*, Princeton: Princeton University Press, 1980.

Harberger, Arnold, "Taxation, Resource Allocation, and Welfare," in *The Role of Direct and Indirect Taxes in the Federal Reserve System*, Princeton: Princeton University Press, 1964.

______, "Three Basic Postulates for Applied Welfare Economics," *Journal of Economic Literature*, September 1971, *9*, 785–97.

Hausman, Jerry, "Labor Supply," in H. Aaron and J. Pechman, eds., *How Taxes Affect Economic Behavior*, Washington: The Brookings Institution, 1981.

Heckman, James, "The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables and a Simple Estimator for Such Models," *Annals of Economic and Social Measurement*, December 1976, *5*, 475–92.

______, "Sample Selection Bias as a Specification Error with an Application to the Estimation of Labor Supply Functions," in James Smith, ed., *Female Labor Supply*, Princeton: Princeton University Press, 1980.

______, **Killingsworth, Mark and MaCurdy, Thomas,** "Empirical Evidence on Static Labour Supply Models: A Survey of Recent Developments," in Z. Hornstein, et al., eds., *The Economics of the Labour Market*, London: HMSO, 1981.

Hicks, John R., "The Generalized Theory of Consumer's Surplus," *Review of Economic Studies*, No. 2, 1946, *13*, 68–74.

______, *A Revision of Demand Theory*, Oxford: Clarendon, 1956.

Killingsworth, Mark, *Labor Supply*, New York: Cambridge University Press, 1983.

MaCurdy, Thomas, "An Empirical Model of Labor Supply in a Life-Cycle Setting," *Journal of Political Economy*, December 1981, *89*, 1059–85.

Minasian, Jora, "Elasticities of Substitution and Constant-Output Demand Curves for Labor," *Journal of Political Economy*, June 1961, *69*, 261–70.

Rosen, Harvey, "Taxes in a Labor Supply Model with Joint Wage-Hours Determination," *Econometrica*, May 1976, *44*, 485–507.

Schultz, T. Paul, "Estimating Labor Supply Functions for Married Women," in James Smith, ed., *Female Labor Supply*, Princeton: Princeton University Press, 1980.

Shoven, John, "The Incidence and Efficiency of Taxes on Income from Capital," *Journal of Political Economy*, December 1976, *84*, 1261–83.

Smith, James, *Female Labor Supply: Theory and Estimation*, Princeton: Princeton University Press, 1980.

Solow, Robert, "Capital, Labor and Income in Manufacturing," in *The Behavior of Income Shares: Selected Theoretical and Empirical Issues*, NBER Studies in Income and Wealth, Vol. 27, Princeton: Princeton University Press, 1964, 101–28.

Stuart, Charles, "Swedish Tax Rates, Labor Supply, and Tax Revenues," *Journal of Political Economy*, October 1981, *89*, 1020–38.

______, "Measures of the Welfare Costs of Taxation," mimeo., 1982.

Usher, Dan, "The Private Cost of Public Funds: Variations on Themes by Browning, Atkinson and Stern," mimeo., 1982.

U.S. Council of Economic Advisers, *Economic Report of the President*, Washington, 1981.

Internal Revenue Service, *Statistics of Income —1976, Individual Income Tax Returns*, Washington: 1979.

U.S. Department of Commerce, *Survey of Current Business*, Washington, December 1977.

______, *Current Population Reports: Consumer Income*, Washington, 1978.