Work Disincentive Effects of Taxes: A Reexamination of Some Evidence

By THOMAS MACURDY*

In the recent public debates over tax reform, much of the controversy revolves around the presumed size of the work-disincentive effects of income taxes. Whereas tax policy of the 1970's primarily accepted the view that these work-disincentive effects are small, the tax programs of the 1980's moved steadily closer to flat-rate proposals, taking as their basic premise that labor supply is significantly affected by taxes and that a highly progressive schedule leads to substantial welfare losses.

Tax proposals in the early 1990's focus on schemes directed at raising the rates on earnings in the upper tax brackets, sometimes proposed in exchange for lower rates on capital income. Such proposals partially revert back to the 1970's view that labor supply is relatively insensitive in the top brackets. There are two avenues through which increases in upper-bracket tax rates influence hours of work: the first is the direct effect on primary workers whose earnings place them in high-income brackets; and the second involves the consequences on secondary workers who are spouses of these high-wage workers. This paper focuses on predicting the likely magnitude of the first effect, using the empirical literature on taxes and labor supply as the basis for formulating predictions. Since men are mainly the primary workers, predicting their behavior is the critical factor.

The empirical literature on men's labor supply offers conflicting evidence concerning the disincentive effects of income taxes on men's hours of work. Advocates of the belief that disincentive effects are small merely need consult John Pencavel (1986), which offers a comprehensive survey of both early and recent contributions on estimating the sensitivity of men's hours of work to changes in wages and income. Proponents of the view that raising marginal rates in upper tax brackets leads to considerable adjustments in men's labor supply can find evidence supporting this position in the survey of Jerry Hausman (1985). The divergence in the predictions implied by these two surveys reflects the different studies reviewed in them. Whereas Pencavel (1986) integrates results from empirical studies primarily done in the 1970's which implement mostly standard econometric approaches (e.g., least-squares and instrumental-variable procedures) to estimate labor-supply responses to changes in wages and income, Hausman (1985) mainly considers studies of the 1980's which incorporate piecewise-linear budget constraints to estimate responses using statistical models that accommodate continuous–discrete variables.

The purpose of this paper is to reconcile the divergent predictions suggested by these two surveys. The discussion highlights a single rationale, arguing that estimation procedures based on the piecewise-linear approach automatically impose satisfaction of the Slutsky condition on the estimates of behavioral parameters over a wide range of wage and income values. This forces higher estimates of substitution effects or lower estimates of income effects than are obtained from other procedures. This reason alone goes a long way toward reconciling the different predicted tax effects, and it raises serious questions about the reliability of evidence cited by much of the literature to support recent tax reforms aimed at lowering marginal tax rates.

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I. A Simple Model of Labor Supply

To quantify the alternative predictions in the literature for hours-of-work responses to shifts in upper-bracket tax rates, consider a familiar static model of labor supply in which an individual determines hours of work and consumption by maximizing utility subject to the budget constraint: $C = Wh + Y - T(Wh, Y)$, where C = consumption; W = wage per hour; h = hours of work; Y = nonlabor income, and T = taxes determined by the function $T(\cdot,\cdot)$. To capture the essential features of current tax law, suppose the tax schedule $T(\cdot,\cdot)$ consists of three income brackets, as illustrated in Figure 1 which depicts a familiar consumption–leisure diagram. The progressively higher marginal tax rates in successive brackets, combined with the existence of nonlabor income, yield a budget set that is piecewise-linear with kinks occurring at the boundaries of tax brackets. The kinks in Figure 1 are the hours-of-work points H_j, representing the maximum number of hours that an individual can work before his earnings advance him from tax bracket j to bracket $j+1$ (i.e., from segment j to $j+1$). The slope of each segment is given by the marginal wage rate for that segment: $\omega_j = (1-t_j)W$, where t_j signifies the marginal tax rate for segment j. Finally, virtual income at zero hours of work (the intercept of the budget line) is $y_1 = Y - T(0,Y)$. Given this value, one computes virtual incomes associated with successive budget segments by repeated application of the formula:

$$y_j = y_{j-1} + (\omega_{j-1} - \omega_j) H_{j-1}$$
$$= y_{j-1} + (t_j - t_{j-1}) W H_{j-1}.$$

Given a constant wage rate ω and nonlabor income y, maximization of the utility function subject to the budget constraint defines a conventional labor supply function: $h = f(\omega, y)$. A popular formulation assumes that f takes the linear form:

$$(1)\quad h = f(\omega_j, y_j) = \mu + \alpha\omega_j + \beta y_j + \nu$$
$$\equiv \hat{h}_j + \nu \qquad j = 1,2,3$$

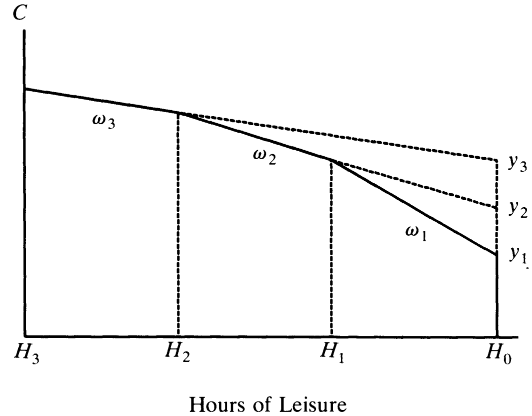

FIGURE 1. REPRESENTATIVE BUDGET CONSTRAINT

where the error component ν represents unobserved heterogeneity. The j subscripts in (1) designate the wage rate and the value of virtual income associated with occupancy of the jth tax bracket. The coefficients α and β are structural parameters, with α representing the uncompensated substitution effect and β determining the income effect.

A simple formula provides the predicted response to a change in the upper-bracket tax rate. In particular, suppose the marginal rate for the third segment in Figure 1 increases from t_3 to $t_3 + \Delta t_3$ ($\Delta t_3 > 0$). The budget constraint to the right of kink-point H_2 remains unaffected, but the budget line to the left flattens with the slope ω_3 falling and with the virtual income y_3 rising. Using the above definitions for these quantities, the implied change in the slope and virtual income are given by: $\Delta\omega_3 = -\Delta t_3 W$; and $\Delta y_3 = \Delta t_3 W H_2$. Accordingly, the resulting adjustment in predicted hours for those in the uppermost bracket (assuming individuals do not change hours sufficiently to leave the highest tax bracket) is given by

$$(2)\quad \Delta\hat{h} = \alpha\Delta\omega_3 + \beta\Delta y_3$$
$$= -\Delta t_3 W(\alpha - \beta H_2) \equiv -\Delta t_3 W S_2.$$

The quantity $S_2 \equiv (\alpha - \beta H_2)$ is the compensated substitution effect or the Slutsky term evaluated at the kink-point H_2.

II. Predictions of Work Disincentive Effects

Summarizing results from a large group of studies, Pencavel (1986) concludes that uncompensated substitution effects are negative for men, indicating backward-bending labor-supply functions. The estimates for income effects suggest relatively small responses, with some estimates actually taking slightly positive values. Rather than providing values for α and β directly, Pencavel expresses his recommended point estimates in terms of elasticities evaluated at sample means. In particular, he summarizes the literature as implying an uncompensated substitution elasticity equal to about $\alpha\bar{\omega}/\bar{h} = -0.1$, where $\bar{\omega}$ is the average after-tax wage rate and $\bar{h}$ is average annual hours of work; and the implied "total income" elasticity equals about $\bar{\omega}\beta = -0.2$.[1] To convert these estimates into substitution and income derivatives relevant for predicting men's responses in 1990, solve for the values of α and β implied by these elasticity estimates using information on the averages of ω and h in 1990.[2] This yields the estimates $\alpha = -28.0$ and $\beta = -0.025$.

Advocates of the view that raising marginal tax rates and the progressivity of tax schedules induce important decreases in men's labor supply invariably cite empirical studies incorporating piecewise-linear budget constraints as their evidence supporting this view. Surveying estimates primarily based on this methodology, Hausman (1985) reports a pattern of estimates for U.S. males indicating slightly positive uncompensated substitution effects, with near vertical labor-supply functions. The estimated income effects are always negative, implying nontrivial responses in men's hours of work to shifts in income. Fortunately, Hausman expresses his recommended point estimates for α and β directly, although they are specified in terms of 1975 dollars. Translating his preferred estimates into 1990 quantities using a wage index for the conversion yields the following implied estimates:[3] $\alpha = 0.09$; and $\beta = -0.055$.

It is now possible to compare the predictions of these two surveys regarding an increase in the marginal tax rate in the highest income bracket. In particular, consider a 5-percent boost in the highest rate, raising it from 33 percent (its current value) to 38 percent; and consider an individual who earns \$22.00 per hour in 1990. Suppose this person receives income from other sources so that he enters the highest income tax bracket (i.e., segment 3 in Fig. 1) whenever he works more than 2,000 hours per year and, further, he is predicted to do so. According to Pencavel's suggested estimates, the implied value for the Slutsky term relevant for predicting the labor-supply response to the proposed tax change is $S_2 = -28-(-0.025)2{,}000 = 22$; according to Hausman's, it is $S_2 = 0.09 - (-0.055)2{,}000 = 110$. For the case considered here, $\Delta t_3 = 0.05$ and $W = \$22$ in formula (2). Consequently, the results reviewed in Pencavel's survey predict a 24-hour decrease in annual hours of work by the high-wage workers in response to the tax change, and the findings reported in Hausman predict a 121 hour decline.[4]

[1] These estimates are taken from Pencavel (1986 pp. 69–70, 82).

[2] According to table B-44 in the *Economic Report of the President, 1991*, (Council of Economic Advisers, 1991), average hourly earnings in "total private employment" equal \$10.03 in 1990. The marginal tax rate in 1990 for full-time earnings at this wage rate is 15 percent or 28 percent depending on the level of other household income. Choosing a midpoint rate of 20 percent implies a value for $\bar{\omega} = (1-0.02)\ \$10.03 \approx$ \$8.00. Average annual hours are set at $\bar{h} = 2{,}200$, which is about the value reported in most empirical studies of men's labor supply.

[3] The preferred estimates reported in Hausman (1985) come from table 2 of Hausman (1981). For the convex case, the estimate of α is 0.2 and the estimate of the median of β equals -0.12, both quantities expressed in 1975 dollars. According to table B-44 in the *Economic Report of the President, 1991* average hourly earnings in "total private employment" increased about 220 percent from 1975 to 1990. The values reported in the text equal the 1975 estimates divided by 2.2 to account for inflation.

[4] These predictions increase monotonically in the wage rate. The choice of \$22 as the high-wage measure is simply a direct conversion of the high-wage level

Thus, a substantial difference arises in the predictions, amounting to about two weeks of full-time work, with the predictions of the piecewise-linear approach considerably larger than those produced by other estimation methods. Of course, one might argue that the linear specification assumed for f in the above calculations is inappropriate for assessing the labor-supply responses of high-wage workers because these persons are not "average" individuals whose behavior determine the properties of f. While this argument no doubt has merit, practically all the empirical specifications considered in Pencavel (1986) and Hausman (1985) are linear in wage and income variables, which still leaves open the question of why the piecewise-linear applications produce larger predictions. A simple explanation for this phenomenon becomes apparent when one examines the piecewise-linear method.

III. Piecewise-Linear Empirical Specifications

The piecewise-linear approach for estimating work-disincentive effects offers both advantages and disadvantages over other methods. Surely, one of its most attractive features concerns its recognition of the institutional characteristics of tax systems that induce budget sets with linear segments and kinks, admitting regressive attributes of the tax code. While the piecewise-linear method can conceptually incorporate very general formulations, existing applications commonly maintain dubious assumptions concerning several factors. The subsequent analysis, however, does not attempt to assess the importance of these shortcomings, because to do so would require an analogous evaluation of fully comparable limitations afflicting alternative estimation approaches. Instead, the following discussion focuses on a unique limitation of piecewise-linear applications involving the implicit imposition of particular inequality restrictions on behavioral parameters.

A. *Description of the Approach*

To characterize the empirical formulation implemented in piecewise-linear analyses of labor supply, assume that Figure 1 describes the budget sets of a sample of individuals, and consider a representative sample member. Given a convex constraint, this representative individual's optimization yields the solution:

$$(3)\quad h = \begin{cases} H_0 & \text{if } f_1 \leq H_0 \text{ (lower limit)} \\ f(\omega_1, y_1) & \text{if } H_0 < f_1 < H_1 \text{ (segment 1)} \\ H_1 & \text{if } f_1 \geq H_1 \text{ and } f_2 \leq H_1 \text{ (kink 1)} \\ f(\omega_2, y_2) & \text{if } H_1 < f_2 < H_2 \text{ (segment 2)} \\ H_2 & \text{if } f_2 \geq H_2 \text{ and } f_3 \leq H_2 \text{ (kink 2)} \\ f(\omega_3, y_3) & \text{if } H_2 < f_3 < H_3 \text{ (segment 3)} \\ H_2 & \text{if } f_3 \geq H_3 \text{ (upper limit)} \end{cases}$$

where $f_i = f(\omega_i, y_i)$. In these relations, suppose the linear relation (1) constitutes the empirical specification for the labor-supply function, a standard choice in studies applying the piecewise-linear methodology. Assume the error component ν in (1) possesses a continuous distribution.

All studies implementing this approach require the existence of measurement error

used by Hausman (1981) in his predictions of tax effects on labor supply; a high-wage individual is defined here as a man who earns \$10 per hour measured in 1975 dollars. Applying the 2.2 inflation factor described in footnote 3 translates this 1975 wage to \$22 in 1990. If one instead considered a higher wage such as \$30 with a marginal tax rate of 33 percent, then Hausman's suggested income effect is so large that it implies that consumption is an inferior good. In particular, an individual receiving a \$100 windfall in after-tax income would lower his labor supply by 5.5 hours (for $\beta = -0.055$). Given that the after-tax wage rate is \$20, this response results in a \$110 decline in after-tax earnings. Thus, the \$100 increase in after-tax income induces a \$10 decline in consumption. Furthermore, the estimate of β used in these calculations corresponds to the median reported in table 2 of Hausman (1981). If one were instead to choose the mean of β reported in this table, which implies an estimate of β equal to -0.073 in 1990, consumption would be an inferior good for the worker earning a gross wage of \$22.

in hours of work to avoid the implication that hours bunch at kinks, which the data reject. Letting h^* denote measured hours of work and ε designate measurement error, suppose the following relationship links measured hours and optimal hours: $h^* = h + \varepsilon$, where ε is continuously distributed.

The implied log-likelihood function for this model is given by $\Sigma_i \log P(h_i^*)$, where i designates an observation, and

$$(4)\quad P(h_i^*) = \int_{-\infty}^{\underline{\nu}_{1i}} b_1[h_i^* - H_0, \nu_i]\, d\nu_i \qquad \text{(lower limit)}$$

$$+ \sum_{j=1}^{3} \int_{\underline{\nu}_{ji}}^{\bar{\nu}_{ji}} b_2\left[h_i^* - \hat{h}_{ji}, \nu_i\right] d\nu_i \qquad \text{(segment 1,2,3)}$$

$$+ \sum_{j=1}^{2} \int_{\bar{\nu}_{ji}}^{\underline{\nu}_{j+1,i}} b_1[h_i^* - H_{ji}, \nu_i]\, d\nu_i \qquad \text{(kink 1,2)}$$

$$+ \int_{\bar{\nu}_{3i}}^{\infty} b_1[h_i^* - H_3, \nu_i]\, d\nu_i \qquad \text{(upper limit).}$$

In this expression, the limits of integration are $\underline{\nu}_{ji} \equiv H_{j-1,i} - \hat{h}_{ji}$ and $\bar{\nu}_{ji} \equiv H_{ji} - \hat{h}_{ji}$; the function $b_1(\cdot,\cdot)$ is the bivariate density of (ε, ν); and $b_2(\cdot,\cdot)$ is the joint density of $(\nu + \varepsilon, \nu)$. Maximizing the log-likelihood function produces estimates for the coefficients of the labor-supply function f, which provides the information used to infer both substitution and income responses.

B. *Parametric Restrictions*

For the likelihood function to be defined, the components in (4) must be nonnegative. This in turn requires $\bar{\nu}_{ji} \geq \underline{\nu}_{ji}$ and $\underline{\nu}_{j+1,i} \geq \bar{\nu}_{ji}$. The first inequality is true by construction since $H_{ji} > H_{j-1,i}$. The second inequality, however, involves restrictions on the parameter estimates of the labor-supply function.

To identify the implications of these latter restrictions, rewrite the second inequality as

$$H_{ji} - \hat{h}_{j+1,i} \geq H_{ji} - \hat{h}_{ji}.$$

Using the definition of $\hat{h}$ yields

$$\alpha(\omega_{ji} - \omega_{j+1,i}) \geq \beta(y_{j+1,i} - y_{ji})$$

and further using the formula for y_j produces

$$\alpha(\omega_{ji} - \omega_{j+1,i}) \geq \beta(\omega_{ji} - \omega_{j+1,i}) H_{ji}.$$

Thus, the second inequality requires satisfaction of the constraints

$$(5)\qquad S_{ji} \equiv \alpha - \beta H_{ji} \geq 0$$

which is, of course, the compensated substitution effect or the Slutsky condition for the ith individual evaluated at his jth kink point.

Thus, in order for the likelihood function to be defined in piecewise-linear analyses, the Slutsky conditions must hold for all individuals i at all their kink-points j corresponding to interior points of their budget constraints.[5] Formally, maximum-likelihood estimation computes values for the coefficients α and β requiring that these behavioral parameters satisfy the inequality restrictions (5) for all i and relevant j. As demonstrated in MaCurdy et al. (1990), the number of constraints involved in typical piecewise-linear applications literally runs into the thousands due to the accumulation of several inequality restrictions (j) for each observation (i) included in a sample; additionally, the resulting restrictions involve

[5]As shown in MaCurdy et al. (1990), this result does not depend on the function f being linear; it merely requires f to be monotonic in the error term ν. Also, requiring satisfaction of Slutsky conditions to obtain a properly defined statistical model in piecewise-linear analyses is not unique to the application of maximum-likelihood methods; it is needed in the implementation of other estimation procedures as well. Further, MaCurdy et al. (1990) demonstrates that parametric restrictions also arise in the application of maximum-likelihood methods when tax schedules are modeled as differentiable functions; the implied inequalities are weaker than Slutsky conditions.

evaluation points that range approximately from zero hours to the largest admissible values. Consequently, obeying constraints (5) essentially invokes global satisfaction of the Slutsky condition.

Imposition of these inequality constraints in piecewise-linear estimation does not come about due to some external introduction of structural restrictions based on economic theory; instead, these constraints arise purely from properties needed to formulate a properly defined statistical model. One way to think of the result described here involves a form of inference that is the reverse of what most economists are used to following. Economists are comfortable in accepting the following proposition: if preferences are quasi-concave in the presence of piecewise-linear constraints, then the implied likelihood function describing consumer choices satisfies conventional distributional properties. The result outlined above implies a converse form of this proposition. Namely, if a likelihood function of the sort in piecewise-linear analyses obeys familiar properties, then the implied specification for preferences must exhibit quasi-concavity over a broad range of hours.

This quasi-concavity restriction effectively translates into the requirement that $\alpha \geq 0$ and $\beta \leq 0$ for the specification of labor supply considered above.[6] Before analyzing any data, this requirement alone automatically rules out the possibility that labor supply is backward-bending; and, in doing so, it does not even permit the estimates proposed by Pencavel (1986) as admissible options.

IV. Conclusion

Contrary to suggestions in the literature that the piecewise-linear approach produces different estimates of substitution and income effects due to its recognition of taxes, this paper argues that the divergent estimates found in existing implementations of the piecewise-linear methodology result in large part from an enforcement of Slutsky conditions over a broad range of hours. Implicit imposition of these conditions necessitates a shift in estimates to produce higher values of compensated substitution effects, which in turn raises estimated uncompensated effects or lowers estimated income effects (or both). Recognizing the presence of binding parametric restrictions suggests caution in using the resulting estimates to forecast responses to tax policy. Given the available evidence, following this advice lends support to the view that raising upper-bracket tax rates is likely to induce relatively minor adjustments in men's hours of work.

One should not infer from the criticisms presented here that the piecewise-linear approach provides a deficient framework for analyzing taxes and labor supply. One may wish to impose quasi-concavity, especially if the aim of an analysis is to infer deadweight losses associated with taxation. There are many options available for enriching the piecewise-linear framework to enhance its compatibility with the data. For example, introducing a flexible hours-of-work specification that admits both a backward-bending property and broad satisfaction of the Slutsky condition offers a possible avenue for avoiding the binding nature of the computational restrictions identified in this study. A more ambitious extension combines this option with an expansion that incorporates the joint labor-supply decisions of husbands and wives. This latter model would capture the possibility that a major impact of tax increases in upper brackets operates through the interactions between husbands and wives when their joint income places them in the highest brackets. While some studies address these issues, there is clearly much to be learned from further research in this area.

[6] Indeed, MaCurdy et al. (1990) finds that these inequalities are strictly binding in applications of the piecewise-linear approach data sources analyzed by prominent studies surveyed in Hausman (1985).

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[Footnotes]

[5] **Assessing Empirical Approaches for Analyzing Taxes and Labor Supply**
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