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WAGE TAX DISTORTIONS AND PUBLIC GOOD PROVISION

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ABSTRACT

When comparing marginal costs and benefits of a public project, most economists think in terms of adding together the marginal costs of production plus marginal costs of additional distortionary taxation. This paper clarifies how the "revenue effect" offsets the "distortionary effect." For Cobb-Douglas utility with a marginal increase in a proportional wage tax, they exactly offset each other and the Samuelson rule is unaffected. Also, with a preexisting wage tax, an incremental lump-sum tax has only this "revenue effect:" it increases labor supply, increases tax revenue from the preexisting wage tax, and thus makes the project easier to fund. In our numerical example, the incremental lump-sum tax costs taxpayers only $.77 per dollar raised.

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WAGE TAX DISTORTIONS AND PUBLIC GOOD PROVISION

1. Consider a single aggregate individual facing a constant gross wage and a flat 50% wage tax, with Cobb-Douglas utility over leisure and a single consumption good, such that the uncompensated labor supply elasticity is zero and the compensated labor supply elasticity is positive. Is this wage tax distortionary?

yes_____ no_____

2. In the same model, with the same assumptions, suppose a public project with production costs (MRT) of $1, and benefits ($\sum$MRS) of slightly more than $1, could be funded by a 1% increase in the wage tax. Would this be desirable?

yes_____ no_____

Most economists would probably answer yes to question 1, since the wage tax leaves the consumer worse off than a lump-sum tax with the same revenue. The wage tax "distorts" the choice between labor and leisure, and thus creates excess burden, which depends on the compensated labor supply elasticity. Most economists would probably answer no to question 2, following the logic of Pigou (1947) that this excess burden should be added to production costs when deciding whether to fund a project.

In fact, the (yes, no) combination of answers to these questions appeared on 16 out of 22 usable responses (73 percent) in a survey of public finance economists at major universities.[1] Four out of 22 (18 percent) answered (no, yes), and two (9 percent) answered (yes, yes).

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[1]This short questionnaire was mailed in November, 1988, to the 63 invited participants of a conference on taxation at the National Bureau of Economic Research. The survey is not scientific, but it does reflect the current understanding of many of those who teach graduate public economics. Of 26 responses, 22 included yes or no answers to both questions. To elicit responses based on the current understanding of these issues, respondents were asked to "take 60 seconds right now to answer the following two questions and return this sheet in the enclosed envelope. Please do not ask for precise definitions, work out the whole model, or give long answers. Just use 'standard' definitions and indicate the 'standard' answer that you think the model would provide." We thank Larry Summers for suggested wording of the questions and instructions.

To the first question, we would respond like most of those in the survey: yes, the wage tax is "distortionary".[2] However, we will show that the best answer to the second question also is "yes". Contrary to the answer in most of the questionnaire responses, the project would raise utility. Thus, we support the 9 percent who answered (yes, yes).

In fact, the (yes, yes) answers are suggested by some papers in the theoretical literature on the provision of public goods in the presence of distortionary taxation.[3] However, our survey results indicate that this literature is not well-understood as it applies to the wage tax example. This paper clarifies the reasons that the project financed with the "distorting" wage tax is still worthwhile.

Section I spells out a complete but simple version of the model suggested in the questions. For a single consumer with Cobb-Douglas utility, no non-labor income, linear production, and a separable public good, it is shown that utility must increase if the wage tax is replaced by a lump-sum tax (yes, the wage tax is "distortionary"). When the marginal rate of transformation (MRT) between the public good and the private good is one, and the marginal rate of substitution (MRS) between the public good and the private good is slightly greater than one, it is shown that utility must increase if the wage tax is raised to fund the

[2]To a certain extent, the answer to the first question turns on the definition of "distortionary". Some of the respondents who said "no" to this question may agree with us on the economic analysis while merely using different terminology. We discuss some ambiguities below.

[3]With lump-sum taxation, the Samuelson (1954) rule says that a public project is worthwhile if the sum of the marginal rates of substitution ($\sum$MRS) exceeds the marginal rate of transformation (MRT). Early discussions with distortionary taxes include Stiglitz and Dasgupta (1971), Atkinson and Stern (1974), Wildasin (1979, 1984), and Stuart (1982). Other relevant results appear in Ballard (1987), Hansson and Stuart (1988), Mayshar (1988a,b), Slutsky (undated), and Triest (1988).

public good (yes, the project is worthwhile). In addition to qualitative results, we provide a numerical example.

Section II uses a more general utility function to show analytically that, if uncompensated labor supply is backward-bending, the "distorting" wage tax could raise utility if it were used to fund a project with production costs of one dollar and benefits of less than a dollar (see references in fn.3). We follow Atkinson and Stern (1974), who define a "distortionary effect" (associated with the consumer's substitution effect) and a "revenue effect" (associated with the consumer's income effect). The distortionary effect makes it less likely that the project will be approved. The revenue effect also works against the project in the case of a tax on a normal consumption good. However, if leisure is a normal good, a wage tax increase has an income effect that increases the amount of labor subject to the pre-existing wage tax. It thereby makes the project easier to fund.

Finally, to provide numbers more consistent with recent empirical results, Section III uses the labor supply function estimated by Hausman (1981). A concluding section discusses the interpretation of results.

I. A Simple Model, as Implied by the Questions

Consider a single representative consumer with an endowment of time, T, to allocate between labor, L, and leisure, ℓ. In the market sector, labor is translated directly into a single output, some of which is used by government to provide a public good, G, and the rest of which is purchased as consumption, C. The production possibilities frontier is linear, and the MRT is one. The private consumption good is numeraire. The gross wage is w, the flat tax rate is t, and the price of leisure is $P = w(1-t)$. Full income, $I = PT$, is used to buy ℓ and C, while tax revenue, twL, is used to buy G.

The public good is separable in utility and fixed to the consumer. She chooses C and ℓ to maximize:

$$U = C^{(1-\alpha)}\ell^{\alpha} + \beta G \quad , \tag{1}$$

which leads to the demand functions:

$$\begin{aligned} C &= (1-\alpha)I \quad \text{and} \\ \ell &= \alpha I/P \quad . \end{aligned} \tag{2}$$

Since $I = PT$, without any non-labor income, it is easy to see that $\ell = \alpha T$. Thus leisure does not change, and the uncompensated labor supply elasticity, η_u, is zero.

Substitution of (2) into (1) provides the indirect utility function

$$V = I/\bar{P} + \beta G \tag{3}$$

and the expenditure function

$$E(P,V) = (V-\beta G)\cdot\bar{P} \quad , \text{ where} \tag{4}$$

$$\bar{P} = \frac{P^{\alpha}}{(1-\alpha)^{(1-\alpha)}\alpha^{\alpha}} \quad . \tag{5}$$

To derive the compensated labor supply elasticity, η_c, we use $(V-\beta G)\cdot\bar{P}$ in place of I in the demand for leisure and differentiate with respect to the net wage P, holding V constant. Thus $\eta_c = (1-\alpha)\ell/L$, which is necessarily positive.

A. Wage Tax Distortions. Atkinson and Stern (1974) define the distortionary effect as "the excess burden (at the margin of tax revenue) associated with commodity as opposed to lump-sum taxation" (p. 123). We can calculate this effect in the simple model outlined above. We fix G and say that any variation in the wage tax, t, is matched by a lump-sum redistribution, R, such that $I = PT + R$. An increase (decrease) in t makes R positive (negative), so $dR/dt = d(twL)/dt$. In this case, dL/dt is not equal to zero, even though $\eta_u = 0$. Since leisure is a normal good, the income effect of R implies that dL/dt must be negative.

We differentiate $V = I/\bar{P} + \beta G$ to find the sign of dV/dt. We note that $dI/dt = -w\ell + tw(dL/dt)$, and $d\bar{P}/dt = -\alpha\bar{P}/(1-t)$. A few further steps provide $dV/dt = (tw/\bar{P})(dL/dt)$. Thus dV/dt is unambiguously negative. Any increase in the wage tax matched by a lump-sum rebate would decrease utility; the wage tax is "distorting."

B. Public Good Provision. Now we delete the lump-sum redistribution, R. We let changes in tax revenue caused by changes in t be reflected in additional public goods, G. The premise of the second question is that the MRT is 1.0, and the MRS is slightly higher. We differentiate the direct utility function to get $\partial U/\partial G = \beta$ and $\partial U/\partial C = 1/\bar{P}$, where the latter uses the expenditure function in (4) and the demand in (2). The ratio of these is the $MRS = \beta\bar{P}$, which must exceed one. Therefore β exceeds $1/\bar{P}$.

Differentiation of the indirect utility function in this case provides $dV/dt = wL(\beta - 1/\bar{P})$. In other words, since β exceeds $1/\bar{P}$, the tax-and-spending package will increase utility. The answer to question 2 is yes: given the conditions of the question, an increase in this "distorting" tax used to finance more of the public good will lead to an unambiguous increase of utility. The distortionary effect of Atkinson and Stern (1974) is exactly offset by the revenue effect.[4]

C. Wage Tax Distortions in a Numerical Example. Just to provide some rough numerical magnitudes, suppose that the consumer faces $t = .5$ and $w = 1$, while working 2000 hours per year out of a possible $T =$ 4000 hours. The above equations then imply $\alpha = .5$, $P = .5$, $I = 2000$, and $\bar{P} = 1.4142$. For the MRS to equal 1.01, the value of β must be .7142. We also know that η_u is zero, and $L = \ell = 2000$, so $\eta_c = (1-\alpha)\ell/L = .5$.

We answered question 1 by saying that the tax is distorting, relative to a lump-sum tax. "Excess burden" is the name often given to measures of that distortion. Typically, calculations of excess burden ignore G in utility, so that the expenditure function is just $E(P,V) = \bar{P}\cdot V$. The measure of Kay (1980) is the equivalent variation associated with imposing the tax, minus the actual revenue, and it is expressed in prices of the no-tax equilibrium. In this example, Kay's excess burden

[4]The text presumes that the MRT and MRS reflect costs and benefits in terms of the private consumption good. This good also is numeraire. Neither the choice of reference good nor the choice of numeraire affects the final decision about whether to fund the project. The choice of reference good does affect the stated criterion, however, as shown in Slutsky (undated). In this case, the MRT in terms of labor is 1.0, and the MRS in terms of labor would have to exceed 2.0 (which it does, given these parameters and prices). The choice of reference good is a potential ambiguity of question 2, but we doubt whether this affected the responses.

is 171.6, or 17.2 percent of the tax revenue.[5]

D. Public Good Provision in the Numerical Example. Although "excess burden" (which is related to question 1) depends on the compensated labor supply elasticity, the decision of whether to fund the public project (question 2) depends on the actual change in labor supply. Since labor does not change in this example, the project is worthwhile if MRS > MRT. The parameters in this example were set such that the project is barely worthwhile, but utility ($= I/\bar{P} + \beta G$) still increases from 2128.4 to 2128.5.

II. More General Utility and Tax Function

The previous section considers the narrow case of Cobb-Douglas utility, as suggested by the questions. It is important to make clear that our main result, surprising as it may be to 73 percent of the survey respondents, is not attributable to any peculiarity of that particular functional form. Consider the more general utility:[6]

$$U = U[f(C,\ell),G] \quad , \tag{6}$$

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[5]The measure of Diamond and McFadden (1974) uses the compensating variation to express excess burden in cum-tax prices, and it subtracts the revenue that would occur if the consumer were compensated for the imposition of the tax (back to the no-tax utility). This measure is 242.6, or 24.3% of actual revenue. Finally, the frequently-used linear approximation for excess burden is $.5\eta_c(wL)t^2/(1-t)$, as derived for example in Browning (1987). This measure is 250, or 25% of revenue.

[6]The algebra in this section is similar to that in Stiglitz and Dasgupta (1971) and Atkinson and Stern (1974) as well as Wildasin (1979, 1984), Stuart (1982), Mayshar (1988a,b), and others. We analyze the wage tax specifically, like Mayshar, whereas the other papers consider an arbitrary set of commodity taxes. This specific application is interesting because the revenue effect works in the opposite direction from the distortionary effect. (See Atkinson and Stern, p. 123.)

with the same linear production technology as before, where the MRT is 1.0. Our goal is to determine the circumstances under which $dU/dt > 0$. In other words, we seek to know when a balanced-budget increase in taxes and government expenditure will increase utility. In this algebra, t may refer to a marginal tax rate, an inframarginal (lump-sum) tax rate, or any parameter of a more complicated tax system. From (6):

$$\underset{}{\frac{dU}{dt}} = \left[\underset{(+)(-)}{\frac{\partial U}{\partial C}\cdot\frac{dC}{dt}} + \underset{(+)(?)}{\frac{\partial U}{\partial \ell}\cdot\frac{d\ell}{dt}}\right] + \underset{(+)}{\frac{\partial U}{\partial G}}\cdot\Delta, \quad \text{where} \quad \Delta = \left[\underset{(-)(-)}{\frac{\partial G}{\partial C}\cdot\frac{dC}{dt}} + \underset{(-)(?)}{\frac{\partial G}{\partial \ell}\cdot\frac{d\ell}{dt}}\right] , \tag{7}$$

where the known signs of terms are indicated in parentheses. Changes in t involve commensurate changes in G. The derivatives of C and ℓ with respect to t are full equilibrium responses, including both price and income effects. The derivative of G with respect to C is the MRT in production. Equation (7) uses the (weak) separability of the public good in utility, because otherwise $\partial U/\partial C$ would have to be multiplied by a term involving $\partial C/\partial G$ in utility (and similarly for ℓ).

In Δ, the sign of $d\ell/dt$ is unknown. We showed that this term is zero in the Cobb-Douglas case with a flat wage tax. Here, it can be positive or negative, and we assume only that it is smaller than dC/dt in absolute value. Then, with $\partial G/\partial C = \partial G/\partial \ell = -1$, Δ must be positive.

Clearly, dU/dt will only be positive if

$$\frac{\partial U}{\partial G}\cdot\Delta \quad > \quad - \left[\frac{\partial U}{\partial C}\cdot\frac{dC}{dt} + \frac{\partial U}{\partial \ell}\cdot\frac{d\ell}{dt}\right] \quad . \tag{8}$$

In order to express this inequality in its clearest form, we divide by $(\partial U/\partial C)\Delta$ to get

$$\frac{\partial U/\partial G}{\partial U/\partial C} > (-\partial C/\partial G) \cdot \left[\frac{\frac{dC}{dt} + \frac{\partial U/\partial \ell}{\partial U/\partial C}\cdot\frac{d\ell}{dt}}{\frac{dC}{dt} + \frac{\partial G/\partial \ell}{\partial G/\partial C}\cdot\frac{d\ell}{dt}}\right] \qquad (9)$$

or

$$\text{MRS} > \text{MRT} \cdot \text{MCF} ,$$

where we define the right side ratio as the public sector's marginal cost of funds (MCF). We can now discuss three special cases.

First, when $d\ell/dt$ is zero, this marginal cost of funds is clearly 1.0. Then the project funded by the distorting wage tax will raise utility whenever the MRS > MRT. Cobb-Douglas utility with a flat wage tax is a special case, but this algebra shows that the result holds for any separable utility function.

Second, when $d\ell/dt$ is positive, labor supply falls with the tax. In the numerator of the MCF ratio, the term $(\partial U/\partial \ell)/(\partial U/\partial C)$ is the net wage, which is less than one. In the denominator, the term $(\partial G/\partial \ell)/(\partial G/\partial C)$ is equal to one by the linearity of production. Therefore the MCF exceeds one, and the benefits of the public project must cover more than its production costs.

The third, and most interesting, case occurs when $d\ell/dt$ is negative. By similar arguments, the MCF is less than one in this case. The project is made easier to fund by the fact that the additional tax increases the actual labor supply that is subject to the pre-existing tax. We can distinguish two important cases in which $d\ell/dt$ will be negative. The first is the case of backward-bending labor supply, in which the income effect of a wage tax increase dominates the substitution effect. Utility could increase even if the "distortionary" wage tax were used to fund a one-dollar project with benefits of <u>less</u>

than a dollar. The second case is that of a lump-sum tax (or, equivalently, an increase in an inframarginal tax rate in a progressive tax system). If leisure is normal, and t is a lump-sum tax, then $d\ell/dt$ must be negative. Thus, as long as the net wage in the numerator of the ratio in (9) is less than the gross wage, a lump-sum tax must have a MCF of less than one dollar! We confirm this result with some numerical calculations in the next section.

III. A More Elaborate Example

The Cobb-Douglas example is useful for illustrating the concepts discussed above, but it does not necessarily convey the most plausible numerical magnitudes. In this section, we use the labor supply estimates of Hausman (1981) to simulate the effects of tax rate increases. We calculate the changes in government tax revenue and in the utility of the consumer. This allows us to calculate the MCF.

Hausman uses 1975 data to estimate a linear labor supply function:

$$L = aP + bY + c \ , \tag{10}$$

where L is annual hours of work, P is the net wage rate (in dollars per hour), Y is virtual income (in dollars per year), and c is a constant term. This labor supply function is associated with the following indirect utility function:

$$V = e^{\beta P}\left(Y + \frac{\alpha}{\beta} P - \frac{\alpha}{\beta^2} + \frac{c}{\beta}\right) . \tag{11}$$

We use this and the associated expenditure function to evaluate the equivalent variation and MCF.[7] Following Burtless (1981), we use as our central case Hausman's estimates for husbands in the "nonconvex" case, using the median value for the coefficient on virtual income. Thus, our central case has $a = 11.3$, $b = -0.113$, $c = 2593$ hours, and $Y = \$1266$. The gross wage, from Hausman, is \$6.18 per hour. In most cases, we start with a progressive tax system where the average tax rate is 27 percent and the marginal rate is 43 percent.[8]

Our results are shown in Table 1. Hausman's estimate of the uncompensated labor supply elasticity is very slightly positive. Thus, for an increase in a proportional tax, we have a MCF of about \$1.01. If labor supply is backward-bending, with an uncompensated labor supply elasticity of -0.1, the MCF for this tax change is \$0.94. For an elasticity of 0.1, the MCF is \$1.07.

If we simulate a progressive tax system, an increase in the marginal rate will increase virtual income, and this will lead to decreases in actual labor supply, even if the uncompensated elasticity is zero.[9] Thus, when we use Hausman's labor supply parameters with these tax rates, increasing the average and marginal rates by the same

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[7]In the previous section, costs and benefits are expressed in terms of the traditional MRS and MRT of Samuelson (1954). Thus the MCF is expressed in terms of the same reference commodity. Most cost-benefit analyses are conducted in dollar amounts, however, and our framework is easily amended to use income equivalents. In this case, the MCF is the income-equivalent loss in consumer welfare from the tax increase (the EV) per dollar of additional revenue collected.

[8]These tax rates correspond very closely to the central cases of Stuart (1984) and Browning (1987). Similar results also appear in Wildasin (1984) and Triest (1988).

[9]This is why Stuart finds a MCF of \$1.07, even with an uncompensated labor supply elasticity of zero: he models a progressive tax system, and the change in virtual income leads to a change in actual labor supply. The condition for MCF = 1 is not that the uncompensated labor supply elasticity is zero, but that actual labor supply is unchanged.

percentage leads to a MCF of $1.23.[10]

A third experiment involves using a progressive tax rate system, but increasing only the top marginal rate. This experiment would be expected to lead to a substantially higher MCF. It increases the distortion of the labor-leisure choice, but only collects additional revenue per hour of labor for the few hours that are taxed at the top marginal rate. If the highest kink in the tax function is close to actual income, we get a perverse revenue effect--the decrease in labor supply brought about by the increase in virtual income leads to a fall in tax revenue. Thus, for practical purposes, the MCF is infinite. If the kink is sufficiently well below actual labor supply, the perverse revenue effects no longer occur, but the MCF is still large.

The fourth type of experiment performed here involves increasing tax revenue through a lump-sum tax. From discussion in the previous section, we expect a MCF of less than one dollar. Using Hausman's estimates of the income effect, we find that the MCF is $0.77. The lump-sum tax raises revenue without exacerbating distortion. Thus, even though the MCF is $1.00 for a proportional wage tax when labor supply is inelastic, and less than $1.00 for a backward-bending labor supply function, it is still true that the lump-sum tax is best.

In the first and third rows of Table 1, we provide some sensitivity analysis. We keep the same value for the income coefficient, but choose values for the wage coefficient that lead to uncompensated labor supply

[10]Hausman's estimated income elasticities are much larger than those used by Stuart. Thus, the change in actual labor supply is much larger when we use Hausman's coefficients than it would be if we were to use Stuart's parameters. This is why the MCF is so much larger in this case ($1.23) than in Stuart's paper ($1.07).

elasticities of -0.1 and 0.1. Not surprisingly, the MCF increases as the labor supply elasticity increases, for the proportional tax and for the progressive tax in which both the average and marginal rates are increased by the same percentage. Since a lump-sum tax does not involve any change in the net wage, the results for the lump-sum tax are unaffected by changes in the wage coefficient. The lump-sum results depend only on the existing tax rates and on the income effect.

Finally, it should be kept in mind that this entire exercise is very much in the tradition of second-best analysis. The results of these marginal calculations depend crucially on the fact that we begin from an initial position that is already distorted by taxes. (See the discussion in the previous section.) To verify this numerically, we also ran simulations using the Hausman parameters, but starting from an initial position with no taxes. In this case, for small increases in taxes, the MCF is $1.00 for all of the experiments described above.

IV. Conclusion

Properly interpreted, a previous literature (cited in fn.3) has shown that a wage tax can be associated with a marginal cost of public funds of 1.0, or even less. This can be true despite the fact that the wage tax is clearly distortionary, in that it leaves the consumer worse off than does an equal-revenue lump-sum tax. Our survey indicates that this result may not yet be widely understood among public finance economists. This paper provides some simple algebra and numerical examples intended to clarify and interpret this result.

A few other points are worth noting. First, with other distortions in addition to the wage tax, we would not generally expect the MCF to be exactly 1.0, even in the case of no labor supply response. In general equilibrium, the change in the wage tax would result in changes in all other prices and quantities, so that the tax revenue collected from other sources would also change. See Ballard (1987).

Second, if G were not separable in utility, it is easy to see how interactions could affect the results. If the public project encouraged labor (e.g., mass transit, or protection of businesses), then the higher revenue from the pre-existing wage tax would make the project easier to fund. If the project discouraged labor (e.g., a public beach), then the reduced revenue means that benefits must more than exceed production cost. See discussion in Atkinson and Stern (1974), and results in Ahmed and Croushore (1988).

Finally, we can explain the answers to question 1 of the four respondents who said the tax is not distorting. The problem is that "marginal excess burden" has been used to describe a variety of rather different calculations.[11] One set of papers defines "marginal excess burden" as MCF - 1.[12] In the case described by question 1, where the increase in the proportional wage tax does not change actual labor supply, the MCF = 1 and this "MEB" is zero. These four respondents may then infer that the tax is not "distorting." However, this is not the common usage of the term. Distortions are defined with respect to a lump-sum tax in all public finance textbooks, and by Atkinson and Stern (1974). The distortionary effect may be large, even when the MCF = 1.

[11]See, e.g., discussions in Auerbach and Rosen (1980), Mayshar (1988b), or Fullerton (1989).

[12]See, for examples, Stuart (1982, 1984), Ballard, Shoven, and Whalley (1985), Ballard (1987), Ahmed and Croushore (1988), Mayshar (1988b), and Hansson and Stuart (1988).

Table 1

The Public Sector's Marginal Cost of Funds (MCF) for Small Tax Changes, with a Pre-existing Wage Tax

	Tax Change				
			Progressive Wage Tax:		
Uncompensated Labor Supply Elasticity	Lump-Sum Tax	Proportional Wage Tax	Marginal and Average Rates Rise by same Proportion	Only Marginal Rate Rises: Highest Kink at 2/3 of Actual Labor	Only Marginal Rate Rises: Highest Kink Close to Actual Labor
-0.10	0.77	0.94	1.06	1.73	*
0.01 (Hausman)	0.77	1.01	1.23	2.13	*
0.10	0.77	1.07	1.41	2.42	*

Notes:

(1) Initial marginal tax rate is 43%, and initial average tax rate is 27%. In the case of a proportional tax, both marginal and average tax rates are initially 43%.

(2) Labor supply behavior is based on the linear model of Hausman (1981). See text for discussion of labor supply parameters. In all cases, we use Hausman's estimate of the virtual income coefficient, so the compensated labor supply elasticity exceeds the uncompensated elasticity by 0.40. The middle row uses Hausman's wage coefficient.

* In these simulations, tax revenue actually decreases.

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