The Economic Effects of Changing The Ohio Sales Tax: Estimates using the BHI State Tax Analysis Modeling Program (Second Edition)

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THE ECONOMIC EFFECTS OF CHANGING THE OHIO SALES TAX

ESTIMATES USING THE BHI STATE TAX ANALYSIS MODELING PROGRAM

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1. INTRODUCTION AND SUMMARY

On March 24, 1997, the Ohio State Supreme Court ruled that funding for poorer school districts must be brought closer to the statewide average. This ruling will entail additional state spending of about $1 billion. Three proposals for raising the new funds have emerged. One proposal would increase the state sales tax from 5% to 6% and cut property taxes. BHI examined the economic effects of this policy in a previous study. A second proposal would freeze or cut spending on other government programs and use money from the state budget surplus. A third proposal would increase the state sales tax from 5% to 5.5% but not cut property taxes. This third proposal is the focus of our analysis here.

The most important question that needs to be answered is this: what effect would any proposed tax changes have on employment, the wage rate, the stock of capital, and tax revenue in Ohio?

The only reliable way to answer this question is by applying a formal model. BHI's State Tax Analysis Modeling Program (STAMP) has been designed for this purpose. This report explains the theory underlying the model (section 2), estimates it for Ohio (section 3), and uses the results to simulate the effect of an increase in the state sales tax by one percentage point (section 4).

Even before explaining how the model works it is worth summarizing the main finding: ***an increase in the state sales tax rate from 5% to 5.5% would result in the loss of at least 49,000 jobs and would leave Ohio's stock of capital at least $4.4 billion smaller***. These and related results are also shown in Table 1. The analysis demonstrates that there is a 90% probability that this outcome will occur.

Table 1
Minimum Economic Effects of Increasing the Ohio State Sales Tax from 5% to 5.5%

Change in Payroll	Change in Jobs	Change in Capital Stock	"Static" Tax Revenue Effect	"Dynamic" Tax Revenue Effect	Net Tax Revenue Effect
-$1.465 billion	-49,484	-$4.41 billion	$571 million	-$55 million	$517 million

Source: Based on calculations in section 4.

The tax increase would lower employment by at least 0.87%. As a result, the annual payroll in Ohio would fall by $1.5 billion. This would raise the state unemployment rate, which stood at 4.4% in November 1997, to as much as 5.2%. It is noteworthy that when Ohio raised the sales tax from 4% to 5% in 1981, the unemployment rate increased from 8.9% in December 1980 (1.6% above the national average of 7.3%) to 13.7% in December 1982 (4.0% above the national average).

The tax reductions would produce a net revenue gain of up to $517 million in 1998. This is the result of two effects:

(1) the "static" revenue gain of $572 million (computed on the assumption that the tax hike has no effect on the Ohio economy) and

(2) the "dynamic" revenue loss of at least $55 million (the revenue lost as a result of the decreased production and personal income brought about by the tax hike).

The second proposal would avoid the loss of jobs and capital by raising the required $1 billion through reductions in government spending and by using money from the state budget surplus.

2. THE FORMAL STRUCTURE OF THE *STAMP* MODEL

The formal structure of the model is set out in this section. Readers who are more interested in the results than in the technical specifications of the model may turn directly to section 3.

The economy is divided into households and producers. Households supply their labor in order to earn income. Producers demand labor and capital in order to produce output. The two sectors interact to determine equilibrium employment, wage rates and the stock of capital in the economy.

The model is designed to be able to capture the effects of important policy variables, especially tax rates of various types, on employment, wage rates and the capital stock. For instance suppose the state tax on labor income were increased. This would reduce the after-tax wage received by households; because work is now less remunerative, some people will work less. Employers will now face a lower supply of labor, and so the (pre-tax) wage rate will rise somewhat. After the effects have been worked out employment, the stock of capital, and after-tax wages will all be lower than before.

We now consider the components of the model in more detail.

A. *Labor Supply by Households*

Households with a fixed labor endowment of $\bar{L}$ choose how to divide $\bar{L}$ between work (L) and leisure ($l = \bar{L} - L$) based on the maximization of a utility function subject to a budget constraint. The household budget is the sum of the value of labor endowments (whether sold or retained as leisure) and unearned income. The household consumes goods and leisure, where the price of leisure is the after-tax wage rate. Assuming a Cobb-Douglas utility function, the household choice problem is then specified as:

$$(2.1) \qquad \max U = AC^{\theta} l^{1-\theta},$$

subject to

$$(2.2) \qquad C(1+t_{sa}) + lw(1-t_{fl})(1-t_{sl}) = w\bar{L}(1-t_{fl})(1-t_{sl}) + G_{tr} + Y_{un},$$

where

C = the consumption of goods and services;

t_{sa} = the sales tax rate;
l = the consumption of leisure;
w = the wage rate;
t_{fl} = the federal tax rate on labor income;
t_{sl} = the state tax rate on labor income;
G_{tr} = government transfer payments; and
Y_{un} = unearned income.

The problem in (2.1) may be rewritten as:

(2.3) $$\text{Max. } \Psi = AC^{\theta} l^{(1-\theta)} - \lambda[(1+t_{sa})C + lw(1-t_{fl})(1-t_{sl}) - w\bar{L}(1-t_{fl})(1-t_{sl}) - G_{tr} - Y_{un}].$$

Differentiating Ψ with respect to C, l and λ yields:

(2.4) $$\frac{\partial \Psi}{\partial C} = \frac{\theta U}{C} - \lambda(1+t_{sa}) = 0,$$

(2.5) $$\frac{\partial \Psi}{\partial l} = \frac{(1-\theta)U}{l} - \lambda w(1-t_{fl})(1-t_{sl}) = 0,$$

(2.6) $$\frac{\partial \Psi}{\partial \lambda} = (1+t_{sa})C + lw(1-t_{fl})(1-t_{sl}) - w\bar{L}(1-t_{fl})(1-t_{sl}) - G_{tr} - Y_{un} = 0.$$

By solving (2.4) and (2.5) simultaneously for l one obtains:

(2.7) $$l = \frac{(1-\theta)(1+t_{sa})C}{\theta w(1-t_{fl})(1-t_{sl})}.$$

Now, substitute (2.7) into (2.6) to get:

(2.8) $$C = \frac{\theta[w\bar{L}(1-t_f)(1-t_s)+G_{tr}]}{(1+t_{sa})}.$$

And substituting C in (2.8) into (2.7) yields the demand for leisure:

(2.9) $$l = (1-\theta)\left[\bar{L} + \frac{G_{tr}}{w(1-t_f)(1-t_s)}\right].$$

Then, the total supply of labor, L^s, is $\bar{L} - l$ and is written as:

$$(2.10)\quad L^s = \theta\bar{L} - \frac{(1-\theta)G_{tr}}{w(1-t_f)(1-t_s)}.$$

A log-linear approximation of the L^s function in (2.10) gives:[1]

$$(2.11)\quad \ln L^s \approx a_0 + a_1\ln(G_{tr}+Y_{un}) + a_2 t_{fl} + a_3 t_{sl} + a_4 \ln w,$$

where a_0 is a constant, $a_1<0$, $a_2<0$, $a_3<0$, and $a_4>0$.

B. Labor Demand by Producers

Producers use two primary production factors – labor (*L)* and capital (*K)*. They are assumed to maximize profit, given a production function and factor costs. The gross factor cost of labor is the pretax wage rate, *w*, plus nonwage costs such as unemployment insurance and workers compensation. We treat nonwage costs (*v*) as an ad valorem tax on the use of labor services, and measure it by the sum of the unemployment insurance tax rate and the workers compensation insurance rate paid, expressed as a percentage of total payroll.

The gross factor cost of capital to producers, *r*, is derived from the equilibrium condition whereby the present value of the future income stream to the owners of capital (i.e., households) is equal to the price of capital.[2] As explained below, *r* increases with the total tax rate on capital t_{ck}.

We treat the sales tax rate, t_{sa}, as an ad valorem tax on the output of producer goods. As shown below, this implies that producer demand for labor and capital varies negatively with the sales tax rate. Thus, for instance, an increase in the sales tax rate causes the demand for labor and capital to fall.

This treatment of the sales tax rate is consistent with that strand of the public finance literature that treats the sales tax as an income tax. In this vein, James M.

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[1] A detailed derivation of (2.11) from (2.10) appears in Section 1a of David Tuer
Application of the BHI State Tax Analysis Modeling Program to the State of Oklah
University, Boston, MA.

Buchanan and Marilyn R. Flowers have observed that "the effects of a general sales tax are approximately equivalent to those of a proportional tax on all factor incomes. Consumers, as such, do not bear the burden of the tax."[3] Richard E. Wagner reaches the same conclusion, noting that "a general tax on retail sales, even with significant exemptions from its base, seems to operate largely as a reduction in the price received by suppliers and, hence, to be equivalent to a proportional tax on income."[4]

The labor market in a state is influenced by national economic trends. To capture this, the model assumes that producers reflect nationwide economic conditions in their production decisions, i.e., other things being equal, they increase production when the national economy is strong. Let the US production index, q, be a national economic indicator. We assume a generalized Cobb-Douglas production function of the following form:

$$Q = \mathrm{H}qL^{\alpha}K^{\beta}. \tag{2.12}$$

where $0<\alpha,\beta<1$ and H is a parameter. The profit-maximizing problem of producers may be written as:

$$\text{Max. } \Pi = \mathrm{H}q(1-t_{sa})L^{\alpha}K^{\beta} - w(1+v)L - rK. \tag{2.13}$$

Differentiating Π with respect to L and K gives:

$$\frac{\partial \Pi}{\partial L} = \alpha \mathrm{H}q(1-t_{sa})L^{\alpha-1}K^{\beta} - w(1+v) = 0. \tag{2.14}$$

$$\frac{\partial \Pi}{\partial K} = \beta \mathrm{H}q(1-t_{sa})L^{\alpha}K^{\beta-1} - r = 0. \tag{2.15}$$

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[2] A detailed derivation of cost of capital appears in Appendix 3.
[3] James M. Buchanan and Marilyn R. Flowers. 1975. The Public Finances: An Intr
Fourth Edition. Richard D. Irwin. Page 400.
[4] Richard E. Wagner. 1983. Public Finance: Revenues and Expenditures in a Democ
Brown and Company Page 269.

Solving (2.14) and (2.15) simultaneously for demand for labor and capital gives:[5]

$$(2.16) \qquad \ln L^d = \lambda_0 + \lambda_q \ln q + \lambda_r \ln r + \lambda_w \ln w + \lambda_v v + \lambda_{sa} t_{sa},$$

where $\lambda_q = (1-\alpha-\beta)^{-1}>0$, $\lambda_r = -(1-\alpha-\beta)^{-1}\beta<0$, $\lambda_w = -(1-\alpha-\beta)^{-1}(1-\beta)<0$, $\lambda_v = -(1-\alpha-\beta)^{-1}(1-\beta)<0$ and $\lambda_{sa}=-(1-\alpha-\beta)^{-1}<0$; and also

$$(2.17) \qquad \ln K^d = \kappa_0 + \kappa_q \ln q + \kappa_r \ln r + \kappa_w \ln w + \kappa_v v + \kappa_{sa} t_{sa},$$

where $\kappa_q = \lambda_q = (1-\alpha-\beta)^{-1}>0$, $\kappa_r = (\lambda_r-1) = -(1-\alpha-\beta)^{-1}(1-\alpha)<0$, $\kappa_w = (1+\lambda_w) = -(1-\alpha-\beta)^{-1}\alpha<0$, $\kappa_v = (1+\lambda_v) = -(1-\alpha-\beta)^{-1}\alpha<0$, and $\kappa_{sa} = \lambda_{sa} = -(1-\alpha-\beta)^{-1}<0$.

C. Equilibrium in the Labor Market

By solving the system of structural equations 2.11, 2.16 and 2.17 simultaneously one arrives at a set of *reduced form equations* which express employment, the wage rate, and the stock of capital as functions of the remaining set of exogenous variables. These reduced form equations can then be estimated econometrically, which is done in section 3 below.

In equilibrium the labor market clears, which implies that labor supply (equation 2.11) equals labor demand (equation 2.16). Setting these equal and solving for ln(w) gives

$$(2.18) \qquad \ln w = \varpi_0 + \varpi_q \ln q + \varpi_r \ln r + \varpi_v v + \varpi_g \ln(G_{tr}+Y_{un}) + \varpi_f t_{fl} + \varpi_s t_{sl} + \varpi_{sa} t_{sa},$$

where $\varpi_q = (a_4-\lambda_w)^{-1}\lambda_q>0$, $\varpi_r = (a_4-\lambda_w)^{-1}\lambda_r < 0$, $\varpi_v = (a_4-\lambda_w)^{-1}\lambda_v < 0$, $\varpi_g = -(a_4-\lambda_w)^{-1}a_4 > 0$, $\varpi_f = -(a_4-\lambda_w)^{-1}a_2 > 0$, $\varpi_s = -(a_4-\lambda_w)^{-1}a_3 > 0$, and $\varpi_{sa} = (a_4-\lambda_w)^{-1}\lambda_{sa} <0$. Substituting (2.18) into (2.16) gives the reduced-form equation for equilibrium labor.

$$(2.19) \qquad \ln L = \eta_0 + \eta_q \ln q + \eta_r \ln r + \eta_v v + \eta_g \ln(G_{tr}+Y_{un}) + \eta_f t_{fl} + \eta_s t_{sl} + \eta_{sa} t_{sa},$$

where $\eta_q = \lambda_w\varpi_q+\lambda_q > 0$, $\eta_r = \lambda_w\varpi_r+\lambda_r < 0$, $\eta_v = \lambda_w\varpi_v+\lambda_v < 0$, $\eta_g = \lambda_w\varpi_g < 0$, $\eta_f = \lambda_w\varpi_f < 0$, $\eta_s = \lambda_w\varpi_s < 0$, and $\eta_{sa} = \lambda_w\varpi_{sa}+\lambda_{sa} < 0$. Finally, substituting (2.18) into (2.17) gives the reduced-form equation for capital:

$$\ln K = \gamma_0 + \gamma_q \ln q + \gamma_r \ln r + \gamma_v v + \gamma_g \ln(G_{tr}+Y_{un}) + \gamma_f t_{fl} + \gamma_s t_{sl} + \gamma_{sa} t_{sa}, \tag{2.20}$$

where $\gamma_q = \kappa_w\varpi_q+\kappa_q > 0$, $\gamma_r = \kappa_w\varpi_r+\kappa_r < 0$, $\gamma_v = \kappa_w\varpi_v+\kappa_v < 0$, $\gamma_g = \kappa_w\varpi_g < 0$, $\gamma_f = \kappa_w\varpi_f < 0$, $\gamma_s = \kappa_w\varpi_s < 0$, and $\gamma_{sa} = \kappa_w\varpi_{sa}+\kappa_{sa} < 0$.

D. Notes on the Variables

It is these three equations, (2.18), (2.19) and (2.20) that are estimated. A full list of the variables used, the way they are defined, and the sources of the information on which they are based, are given in Table 2.

Some of the variables, including the measures of employment, wages, and the state sales tax rate, are straightforward. However several of them are difficult to construct – this is the most challenging and time-consuming part of the modeling exercise – and so a few further comments are warranted on the methods used. Further details are presented in Appendices 1-5.

[5] The log-approximation of ln(1+v) ≈ v for a small value of v is applied, and sim

Table 2
Description of Variables and Their Sources

	Description	Measurement	Source
Lp_i	Employment on payroll by sector	Number of workers; for agriculture, number of jobs.	BLS & BEA
w_i	Annual payroll per employee by sector	Total payroll divided by number of employees.	BLS and BEA
K_i	Capital stock by sector	See appendix 2.	Census Bureau & other sources
q_i	Index of US production in sector i	Index based on US real gross domestic product by sector.	BEA
r_i	Cost of capital	A linear function of d, C and t_{ck}; see appendix 3 for details.	
d_i	Capital replacement rate by sector	Inverse of average age of gross capital stock of reproducible capital.	BEA
C_i	Present value of depreciation allowed for tax return purposes for $1 capital, by sector	See appendix 3.	BEA and other sources
$t_{ck,i}$	Total federal and state tax rate on capital by sector	$t_{fc}+t_{sc}-(t_{fc}\_t_{sc})+t_{fk}+t_{sk}-(t_{fk}\_t_{sk})$	
t_{fc}	Average marginal federal tax rate on corporate income applied to all US firms	See appendix 1.	IRS
t_{sc}	Average marginal state tax rate on corporate income applied to Ohio firms	Statutory marginal tax rate.	State sources
t_{fk}	Average marginal federal tax rate on capital income applied to all US residents	See appendix 1.	IRS
t_{sk}	Average marginal state tax rate on capital income applied to all US residents	See appendix 1.	IRS
G_{tr}	Real government transfer payments per non-working adult aged 16-64	Federal income maintenance transfers and unemployment insurance; see appendix 4.	BEA
t_{fl}	Average marginal federal tax rate on labor income applied to Ohio residents	See appendix 1.	BEA
t_{sl}	Average marginal state plus local tax rate on labor income applied to Ohio residents	See appendix 1.	BEA and state sources
t_{sa}	State plus local sales tax rate		State sources
yun	Unearned income per adult	Federal adjusted gross income less wages and salaries less taxes; see appendix 5.	BEA; SOI
L	Labor endowment	Working age population 16-64.	BLS

Sources
BEA Bureau of Economic Analysis, US Department of Commerce
BLS Bureau of Labor Statistics, US Department of Labor
IRS Internal Revenue Service
SOI Statistics on Income

Average Marginal Tax Rates

The state and federal tax rates on labor (t_{sl} and t_{fl}) and on corporate income (t_{sc} and t_{fc}) are *effective average marginal tax rates*. That is, they aim to measure the average of the marginal tax rates actually facing taxpayers.

For the personal income tax information is available, for a number of income brackets, on the number of taxpayers, their adjusted gross incomes, and their actual tax liabilities. From this information it is possible to infer the extra tax liability which would be incurred as a taxpayer moves from one income class to the next - i.e. the marginal tax rate. The average marginal tax rate is then calculated as a weighted average of these marginal rates:

- for the average marginal tax rate on *labor* income, the weights are the proportion of wages and salaries falling within each income class; and
- for the average marginal tax rate on *capital* income, the weights are the proportion of dividend and capital-gains income falling within each income class.

A similar procedure is followed for the corporation income tax. This is possible because for each of the seven main sectors of the economy – agriculture, construction, FIRE (finance, insurance and real estate), manufacturing, services, trade, and TPU (transport and public utilities) – information on the number of returns, net income, taxable income, and tax liability is available for each of several size classes of business receipts. From this it is possible to infer the marginal tax rates faced by corporations as they expand their net income.

The full details of these procedures are set out in Appendix 1.

The Ohio Capital Stock

It was necessary to construct a measure of the net stock of fixed non-residential private capital, by industry, for Ohio for each year from 1970 through 1995. The Bureau of Economic Analysis publishes national, but not state-level, estimates of private capital, broken down into a number of categories such as depreciable assets for construction, for manufacturing, trucks, gas pipelines, and so on.

In order to estimate Ohio's share of national capital, in each category, we applied a series of proxies. For instance the state's share of capital in the communications sector was taken to be proportional to the state's share of miles of wire in cable. Or again, for capital used in the retail and wholesale trades, we took Ohio's share to be in proportion to the state's share of sales in these categories. The complete details are given in Appendix 2.

The Cost of Capital

Businesses make decisions about investment based, in part at least, on the rental cost of capital (r), which is the total rental charge for capital (including tax costs and a provision for depreciation) divided by the value of capital. It can be shown (Appendix 3, equation (A3.20)) that

$$r = \frac{(\rho + d)(1 - t_{ck} \sum_{t=1}^{DL} \frac{\alpha_t}{(1 + \rho + d)^t})}{(1 - t_{ck})}.$$

This equation show that the rental cost of capital depends on the discount rate (ρ), the capital consumption rate (d), the average marginal tax rate on capital (t_{ck}), the recovery allowance percentage which is allowed under the tax laws (α_t) and the depreciable life of the asset (DL). The systems of depreciation permitted for tax purposes have changed over time, with the sum of the year's digits system in place from 1954 through 1980, an accelerated cost recovery system from 1981 through 1985, and a modified accelerated cost recovery system since then. The average marginal tax on capital is derived from the state and federal taxes on corporate income and on dividends and capital gains. A detailed description of how r was constructed is given in Appendix 3.

Government Transfer Payments

This measure (G_{tr}) is constructed as the total amount of transfer payments – income maintenance and unemployment insurance benefits – per non-working adult. This variable is a proxy for the unearned income of poorer residents, and is likely to affect their choice as to whether to work or not. The procedures followed in constructing G_{tr} are set out in more detail in Appendix 4.

Unearned Income

The amount of unearned income (Y_{un}) that an individual receives affects his or her decision to work, as the discussion in section 2A shows. To calculate after-tax unearned income we used the individual income and tax data reported in the *Statistics of Income Bulletin* published by the Internal Revenue Service. Gross unearned income is measured as adjusted gross income less salaries and wages, with an adjustment (for returns prior to 1987) to add back part of long-term capital gains which was otherwise excluded. By subtracting federal and state income tax on gross unearned income one arrives at the required measure of after-tax unearned income. Appendix 5 gives the full details of the computations involved.

3. RESULTS OF ESTIMATING THE *STAMP* MODEL FOR OHIO

The challenge is to estimate the coefficients of the three reduced-form equations, (2.18), (2.19) and (2.20). These express employment, the wage rate, and the capital stock respectively as functions of a common set of variables, most of them amenable to policy.

The independent variables are listed in Table 2, along with the sources of information used to create them. A value for each variable was constructed for each year from 1970 through 1995 for each of seven sectors of the economy. This gives a total of 182 observations.

The equations were estimated using a two-step generalized least squares procedure. This allowed one to correct for autocorrelation, which arises because the values of variables in one year tended to persist into the next year; in effect this reduces the number of observations to 175. It also permits a correction for groupwise heteroscedasticity, where the errors in the equation differed systematically across the seven sectors. The third adjustment corrected for the fact that shocks which affected one sector tended to affect the other sectors at the same time, causing the errors in the equation to be correlated across groups. Details of the underlying theory are given in Greene,[6] and of the practical estimation in Greene.[7]

The estimation results are set out in Table 3, where it is found that most of the variables have the signs predicted by the theory outlined in section 2 above.

Table 3
Results of estimating the STAMP reduced-form equations for Ohio

	Employment equation		Wage equation		Capital equation	
	Coeff-icient	p-value	Coeff-icient	p-value	Coeff-icient	p-value
Dependent variable:	ln(employment)		ln(wage)		ln(capital stock)	
Independent variables:						
State average marginal tax rate on labor	-.0141	.000	.0118	.006	.00324	.555
Federal average marginal tax rate on labor	.00067	.767	.00267	.265	.00515	.089
Govt transfer payments per non-working adult	-.0723	.000	-.0275	.057	-.0400	.029
State sales tax rate	**-.0375**	**.002**	**-.00046**	**.969**	**-.0493**	**.001**
Cost of capital	.00090	.200	-.00110	.051	.00006	.937
Labor endowment	.304	.092	.247	.224	.534	.043
Unearned income	.0440	.094	.00280	.919	-.0353	.314
Index of real sectoral output	.00235	.000	.00029	.272	.00051	.179
Time trend	.0181	.000	-.00655	.004	.0221	.000
Constant and sectoral dummy variables	…	…	…	…	…	…

Notes: Sample size = 175. P-value < 0.1 denotes coefficient is statistically significant at 10% level or better.

[6] William H. Greene. 1993. Econometric Analysis, Second Edition. Macmillan, N
[7] William H. Greene. 1995. LIMDEP Version 7.0 User's Manual, Econometric Softwa

4. SIMULATING THE EFFECT OF A CHANGE IN THE SALES TAX

Two steps are needed in order to measure the effect of the tax increase on the variables of interest – these variables being the number of jobs (L), the wage rate (w), the capital stock (K) and state tax revenue (TR). First we must establish baseline values for the variables, projecting them out through the end of 1998. Then we use the STAMP results from the previous section to estimate and project employment, wages and the capital stock in the presence of a tax increase.

A. Baseline Projections of Wages, Jobs and Capital

The baseline projections are shown in the table below and were constructed as follows. Information on the *number of jobs* is available through 1996 and information on the *number of workers* is available through August 1997. We suppose that the number of jobs in 1997 grows at the same rate as the number of workers did for the first eight months of 1997 relative to the first eight months of 1996 (1.13%), and assume that the number of jobs in 1998 grows at the same speed as it did from 1995-1997 (1.74%).

The value of the *total payroll* is known through 1996, and we assume that it will continue to grow (in nominal dollars) for the rest of 1997 at the same speed as it did between the first half of 1996 and the first half of 1997, which is by 5.70% per year. We assume that it grows at the same speed in 1998 that it did from 1995-1997 (5.27%). We also assume that the *capital stock* grows at the same speed as the total payroll, so that the capital to labor ratio does not change. Since information on the capital stock in Ohio is available for 1995, we use the historical growth rates of payroll to generate the capital stock value for 1996, and the projected growth of payroll to arrive at the capital stock for 1997 and 1998. The average wage is simply the total value of payroll divided by the number of jobs.

The state sales tax base for the calendar year 1994 ($92,076 million) was estimated by taking an average of sales tax collections for fiscal year 1994 and fiscal year 1995 and dividing them by the sales tax rate of 5%. The 1996 sales tax base ($97,181 million) was derived in a similar manner. For 1996 ($102,569 million), 1997 ($108,256 million) and 1998 ($114,258 million), we assume that the sales tax base grows by the 1995 growth rate (5.54%).

B. *Applying the State Tax Analysis Model*

As discussed in above, the model begins with a series of structural equations that aim to capture the behavior of firms and households, and then rearranges these equations to arrive at a set of reduced form equations which are both theoretically consistent and may be estimated econometrically. The equations are estimated using data from 1970-1994. In simplified form, the two that are relevant here are the labor equation (2.19) and the capital equation (2.20).

The *labor equation* shows how changes in state sales tax rates (and other variables) affect the number of jobs in Ohio. From the full results shown in Table 3 it is clear that the estimated equation is of the form

$$\text{(4.1)} \qquad \ln(L) = \underset{\text{SE}=0.01215}{-0.0375t} + \text{other terms}$$

where ln(L) is the natural log of the number of jobs, and t is the state sales tax rate. The coefficient –0.0375 is statistically significant, and measures the effect of a change in the tax rate (Δt) on ln(L); in other words $\Delta \ln(L)/\Delta t = -0.0375$. With 90% certainty, the coefficient is equal to $-0.0375 \pm 1.645 \times 0.01215$, or lies somewhere in the interval between -0.0575 and -0.0175. Since our concern is with the minimum reasonable effects of the tax change on labor demand, it is the latter number (i.e. -0.0175) that we need to use.

The *capital equation* is similar, except that the dependent variable is capital rather than labor. Specifically the estimated equation is of the form

$$\text{(4.2)} \qquad \ln(K) = \underset{\text{SE}=0.01472}{-0.0493t} + \text{other terms}$$

where ln(K) is the change in the natural log of the value of the capital stock from one year to the next; again the full set of coefficients is set out in Table 3. The coefficient -0.0493 is statistically significant, and with 90% probability lies between -0.0735 and -0.0251.

C1. *Projecting the Effects of the Tax Increase: Employment*

We project the minimum number of jobs that will be destroyed as a result of the tax hike. Since t increases from 5% to 5.5%, we have $\Delta t = 0.5$. Thus

(4.3) $$\Delta \ln(L) = (-0.0175)\Delta t = (-0.0175)(0.5) = -0.0088.$$

The baseline value of ln(L) [=15.5543 = ln(5,690,274)] now falls by 0.0088 to 15.5455; taking the antilog gives the number of jobs with the tax hike, which (when done precisely) is 5,640,790, or a decrease of 49,484 below the baseline case.

C2. Projecting the Effects of the Tax Increase: Capital

The minimum effects of the tax increase on the stock of capital are estimated in the same manner as for employment. Thus

(4.4) $$\Delta \ln(K) = (-0.0251)\Delta t = (-0.0251)(0.5) = -0.0126.$$

The baseline value of ln(K) [=12.7751 = ln($353,297 million)] now falls by 0.0126 to 12.7625; taking the antilog gives a new capital stock, after the tax increase, of $348,886 million, or a decrease of $4,411 million over the baseline case.

C3. Projecting the Effects of the Tax Increase: Wages

The estimated reduced form equations of the tax analysis model show that the state sales tax rate does not have a statistically significant effect on the wage rate in Ohio – see Table 3 for details. Wages are thus assumed to follow the baseline projections both with, and without, the tax increase. The total value of the payroll, in the presence of the tax hike, is calculated by multiplying these average wage rates by the number of people employed.

C4. Projecting the Effects of the Tax Increase: Tax Revenue

What effect would a hike in the tax rate have on state tax revenue? First there is a “static” revenue gain, which is measured as the increase in the sales tax rate times the sales tax base.

The static revenue gain would be $571 million (=0.5%*$114,258 million). But this overstates the true revenue gain, because there is also a “dynamic” revenue effect: The tax increase leads to an decrease in the number of jobs and hence the total payroll, and therefore to some offsetting decrease in revenue. Since the number of jobs falls by (at least) 0.87%, the dynamic revenue loss is 0.87% $\times$ 5.5% $\times$ 114,258 = $55 million. These effects are summarized in Table 4.

Table 4
Minimum Effect of Sales Tax Increase from 5% to 5.5% on Employment, Capital Stock and Tax Revenue in Ohio

		Amount	Growth Rate
	Baselines		
A	Employment	5,690,274	
B	Payroll ($ mill)	168,475	
C	Average wage ($ p.a.) (=B/A)	29,608	
D	Capital Stock ($ mill)	353,297	
E	State Sales Tax Base ($ mill)	114,258	
F	Old Sales Tax Rate	5.0%	
	Minimum Effects with Tax Increase		
G	New Sales Tax Rate	5.5%	
H	Employment in presence of tax increase	5,640,790	-0.87%
I	Job decline with tax increase (=A-H)	49,484	
J	Capital stock in presence of a tax increase ($ mill)	348,886	-1.25%
K	Decrease in capital due to tax increase ($ mill) (=D-J)	4,411	
L	Payroll in presence of tax increase ($ mill)	167,010	-0.87%
M	Decrease in payroll due to tax increase ($ mill) (=B-L)	1,465	
N	"Static" tax revenue effect: ($ mill) (=E_F)	571	
O	"Dynamic" tax revenue effect: ($ mill) (= G_E_((H/A)-1))	-55	
P	Net tax revenue effect: ($ mill) (=N+O)	517	

Note: Figures are rounded.
*There is a 90% probability that the effect of the tax increase will be larger than the amounts shown in the table.

It is also possible to use the regression estimates to calculate a range of possible outcomes, rather than just the minimum likely effect of the tax increase. This is done in Table 5, where we have rounded the net numbers to avoid the appearance of spurious accuracy. The results show that a one percentage point increase in the state sales tax would:

- reduce employment by at least 49,000 with 90% probability, but there is a 10% probability that the loss could be as high as 161,000;
- reduce the capital stock by at least 1.25% with 90% probability, but the numbers indicate that there is a 10% chance that the reduction could be as large as 3.61%; and
- increase state revenue by as much as $517 million, although there is a 10% probability that revenue would rise by $393 million or less.

Table 5
Range of Effects of a Percentage Point Increase in the State Sales Tax

	Low estimate *(90% probability of these effects or more)*	Middle estimate *(based on point estimate from regression results)*	High estimate *(10% probability of these effects or more)*
Employment			
Without tax increase	5,690,274	5,690,274	5,690,274
With tax increase	5,640,790	5,584,709	5,529,186
Estimated job loss	49,484	105,565	161,088
Capital Stock ($m)			
Without tax increase	353,297	353,297	353,297
With tax increase	348,886	344,687	340,539
Estimated reduction in capital	4,411	8,610	12,758
State Tax Receipts ($m)			
"Static" revenue gain	571	571	571
"Dynamic" revenue loss	55	117	178
Net gain	517	455	393

Source: Based on coefficients in Table 3, and using simulation approach set out in section 4.

APPENDIX 1

CALCULATION OF AVERAGE MARGINAL TAX RATES

One of the strengths of the STAMP model is that it uses *average marginal tax rates*. These are calculated, in general, as the average of the marginal tax rates facing individuals (or businesses). A recognized weakness in other state-level tax models is that they typically use measures of average tax rates, with the drawback that these do not summarize the tax rates which face an individual who is trying, at the margin, to decide whether to work more, or a firm wondering whether it should invest more.[8]

The calculation of average marginal tax rates is somewhat complicated, so the procedures followed are set out in this appendix. We use a method similar to the one suggested by John Seater.[9] Since the average marginal tax rate is the weighted average of the marginal tax rates for each income group, weighted by the total income for each group, the marginal tax rates for each group are first calculated. The marginal tax rates are defined differently depending on the availability of data.

A. *Average Marginal State Tax Rate on Labor Income*

The data used to calculate the marginal state tax rate are from the Ohio Department of Treasury, which reports, for each AGI group, the number of returns, adjusted gross income, and tax liability. We define the marginal state tax rate on personal income for AGI group i, $t_{spy,i}$, as the change in tax liability per change in gross income. Let the first (lowest) income class be equal to zero (i=0).[10] Then, $t_{spy,i}$ is written as:

$$t_{spy,i} = \frac{T_{s,i} - T_{s,i-1}}{Y_i - Y_{i-1}}$$

where $T_{s,i}$ = average state tax liability for AGI group i, calculated by dividing the total tax liability by the number of returns of AGI group i; and

Y_i = average gross income for AGI group i,[11] calculated by dividing the total gross income by the number of returns for AGI group i.

[8] Timothy Bartik. 1991. Who Benefits from State and Local Economic Development Upjohn Institute for Employment Research, Kalamazoo, MI. This report surveys the
[9] John Seater, "Marginal Federal Personal and Corporate Income Tax Rates in the U Journal of Monetary Economics (1982).
[10] The marginal tax rate for the first income class is the same as the average ta
[11] Seater used the midpoint of an income class for Y_i, instead of average income.

Since data on *labor* income by income group are not available from OH/DOT, we use data on wages and salaries for each income class, obtained from federal income tax returns for Ohio residents, as published in *Statistics of Income Bulletin (SOI)*, a publication of the Statistics of Income Division of the IRS. To estimate labor income for each group, we calculate the proportion of wages and salaries in AGI reported in the *SOI*, and multiply the proportion by the AGI reported in the OH/DOT source.

Then, the average marginal state tax rate on labor income (t_{sl}) is calculated by multiplying the estimated wages and salaries in each AGI class by the marginal tax rate for that class, then dividing by the total estimated state wages and salaries,

$$t_{sl} = \frac{\sum_i (t_{spy,i}) * (w\&s_i)}{\sum_i (w\&s_i)}$$

where $w\&s_i$ = labor income for income group i. The equation above shows that t_{sl} is the weighted average of the individual AGI class marginal state tax rates, weight being the fraction of total salaries and wages that falls within each income class.

B. *Average Marginal Federal Tax Rate on Labor Income for Ohio Residents*

We use data obtained from the *Statistics of Income Bulletin*. This publication reports, for each AGI group, the number of returns, total AGI, total wages and salaries, and total tax liability. Given these data, we compute the marginal federal tax rate for AGI group i, $t_{fpy,i}$, as the change in tax liability per change in gross income. The marginal federal tax rate for income group i is then written as:

$$t_{fpy,i} = \frac{T_{fpy,i} - T_{fpy,i-1}}{Y_{fy,i} - Y_{fy,i-1}}$$

where $T_{fpy,i}$ = average federal tax liability for AGI group i, calculated by dividing the total tax liability by the number of returns for AGI group i, and

$Y_{fy,i}$ = average gross income for AGI group i, calculated by dividing the total gross income by the number of returns for AGI group i.

Then, the average marginal federal tax rate on labor income for Ohio, t_{fl}, is calculated by multiplying wages and salaries in each AGI class by the marginal tax rate for that class, then dividing by the total wages and salaries,

$$t_{fl} = \frac{\sum_i (Y_{fl,i}) * (t_{fpy,i})}{\sum_i (Y_{fl,i})}$$

where $Y_{fl,i}$ = total wages and salaries for income group i.

C. *Average Marginal Federal Tax Rate on Corporate Income*

For this we used data for firms of all states, as published by the IRS in *Corporation Returns*. This publication reports, for each of the eight sectors of the economy (agriculture, construction, FIRE, manufacturing, mining, service, TPU, and trade) and for each of several size classes of business receipts, the number of returns, net income, income subject to tax, and income tax. Given these data, we calculate the marginal federal tax rate for business receipts group *i*, $t_{fc,i}$, as the change in corporate tax liability per change in corporate taxable income. Hence, $t_{fc,i}$ is written as:

$$t_{fc,i} = \frac{T_{fci} - T_{fc,i-1}}{TY_{fc,i} - TY_{fc,i-1}}$$

where $T_{fc,i}$ = average corporate tax liability for group i, calculated by dividing the total corporate tax liability by the number of returns for business receipts group i, and

$TY_{fc,i}$ = average taxable corporate income for business receipts group i, calculated by dividing the total corporate taxable income by the number of returns for business receipts group i.

Then, the average marginal tax rate on corporate income, t_{fc}, is calculated by multiplying corporate net income in each business receipt by the marginal tax rate for that class, then dividing by the total corporate net income,

$$t_{fc} = \frac{\sum_i (TY_{fc},) * (t_{fc,i})}{\sum_i TY_{fc,i}}.$$

D. *Average Marginal State Tax Rate on Capital Income Applied to all US Residents*

The data used to calculate the marginal state tax rate are from the IRS's *Individual Income Tax Returns*, which reports, for each AGI group, the number of returns, adjusted gross income, and deductions for state and local income taxes paid, which is equivalent to state and local tax liability applied to all states.[12]

[12] See the Table of Returns with Itemized Deductions: Source of Income, Adjustm Deductions by Type, Exemptions, and Tax Items, by Size of Adjusted Gross Income.

The marginal state tax rate is defined as the change in tax liability per change in gross income. Since data on state and local income taxes are not decomposed into different types of income (e.g., wages and salaries, dividends and capital gains), we assume that the marginal state tax rate on individual income is the same as the marginal state tax rate on capital income. Then, the marginal state tax rate for income group i, $t_{sy,i}$, is written as:

$$t_{sy,i} = \frac{T_{sy,i} - T_{sy,i-1}}{Y_i - Y_{i-1}}$$

where $T_{sy,i}$ = average state tax liability for AGI group i, calculated by dividing the total tax liability by the number of returns for AGI group i, and

Y_i = average gross income for AGI group i, calculated by dividing the total adjusted gross income by the number of returns for AGI group i.

Then, we can calculate the average marginal state tax rate on individual capital income applied to all US residents as:[13]

$$t_{sy,k} = \frac{\sum_i t_{sy,i} * Y_i}{\sum_i Y_i}$$

where Y_i = average gross income for AGI group i.

E. *Average Marginal Federal Tax Rate on Capital Income Applied to all US Residents*

We use data from federal tax returns for all US residents published in *Statistics of Income Bulletin* by the IRS.[14] This publication reports, for each AGI class, the number of returns, total AGI less deficit, tax liability, taxable income, dividends, and net capital gains. First, we define the marginal federal tax rate for AGI group i, $t_{fy,i}$, as the change in tax liability per change in taxable income. Then $t_{fy,i}$ is written as:

$$t_{fy,i} = \frac{T_{fy,i} - T_{fy-1}}{TY_i - TY_{i-1}}$$

where $T_{fy,i}$ = average federal tax liability for AGI group i, calculated by dividing the total tax liability by the number of returns for AGI group i, and

TY_i = average taxable income for AGI group i, calculated by dividing the taxable income by the number of returns for AGI group i.

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[13] Since we assume that the marginal state tax rate on individual income is the income, $t_{sy,k}$ is also the same as the average marginal state tax rate on total ir

[14] See section of Selected Historical and Other Data, Individual Income and Tax of Adjusted Gross Income for the US

(1) Average Marginal Federal Tax Rate on Dividend Income

The average marginal tax rate on dividend income for all states (t^d_{fk}) is then calculated by multiplying dividend income in each AGI class, D_i, by the marginal tax rate for that class, and dividing by total dividend income.

$$t^d_{fk} = \frac{\sum_i (t_{fy,i}) * (D_i)}{\sum_i D_i}$$

where D_i = the total dividend income for income group i. As shown, t^d_{fk} is the weighted average of the individual AGI group marginal federal tax rates, the weight being the fraction of total dividends that fall within each income class.

(2) Average Marginal Federal Tax Rate on Capital Gains

The average marginal tax rate on capital gains income for all states (t^g_{fk}) is calculated by multiplying realized capital gains income in each AGI class, G_i, by the marginal tax rate for that class, then dividing by total capital gains income. The *SOI* reports only those capital gains included in the AGI, G^A_i. Since some of the capital gains were excluded at the federal level until the year 1986, realized capital gains are greater than the reported capital gains for that period. We calculate G_i by multiplying G^A_i by the ratio of the total realized capital gains to the total reported capital gains for each year. This ratio is reported by the Office of Tax Analysis of the Internal Revenue Service. Then, t^g_{fk} is calculated as:

$$t^g_{fk} = \frac{\sum_i (t_{fy,i}) * (G_i)}{\sum_i G_i}.$$

Here again, t^g_{fk} is the weighted average of the individual AGI group marginal federal tax rates, with the weight being the fraction of total capital gains that fall within each income class.

APPENDIX 2

ESTIMATION OF THE OHIO CAPITAL STOCK

Since no state-by-state data are available on the stock of private capital, it was necessary to develop a method for allocating capital stock between states from the national totals published by the Bureau of Economic Analysis (BEA). The capital stock series selected were the current-cost net stock of fixed private capital, nonresidential, by industry, for the years 1970-1995. Net stock is calculated as the cumulative value of past gross investment less the cumulative value of past depreciation.[15] The approach taken was to apportion for each year, from 1970 to 1995, the BEA national total for private capital on the basis of various measures of Ohio's economic activity in the following sectors: agriculture, forestry, and fishing (AFF); construction; manufacturing; transportation and public utilities (TPU); wholesale and retail trade (trade); finance, insurance, and real estate (FIRE); and services. Adopting a procedure similar to the one outlined by Munnell,[16] we apportioned BEA national stock estimates of these sectors by using various proxies. The calculation of these proxies is described below.

We obtained much of the data used as proxies from the economic censuses, which take place every fifth year. We apportioned several sectors using data from sources other than the economic censuses. The state's share of the proxy in the census year and other years for which the state’s share of the proxy was available was used to distribute the BEA national capital stock for that year. (Henceforth, the census year or the year for which the proxy was available is called the *base year*.) Thus, the state capital stock for a base year, for each sector, K_τ, is:

$$K_\tau = \rho_\tau \times K_{US,\tau}$$

where ρ_τ = apportionment rate for base year τ, and

$K_{US,\tau}$ = US capital stock for base year τ.

[15] In 1997 BEA revised the US capital stock data based on a new methodology for ca
charges. For a given year, the depreciation charges are obtained by multiplying t
one minus the annual depreciation rate. Net stocks are estimated by subtracting c
from cumulative gross investment.

[16] Alicia M. Munnell, with Leah Cook. "How Does Public Infrastructure Affect Reg
Performance?" New England Economic Review, Sept./Oct. 1990, pp. 11-32.

Then, we estimated the Ohio capital stock for non-base years using the base year apportionment ratios and the annual growth rates of the US capital stock.[17] Using the state capital stock for two base years as reference points, the estimate for the years between the two base years is generated in accordance with the growth rate of the national capital stock as follows.

$$K_t = K_{t-1} \times \exp[(ln K_b - ln K_a) \times \left(g_t / \sum_{t=a+1}^{b} g_t \right)], \quad a<t \le b$$

where K_t = state capital stock for year t,

K_a = state capital stock for the preceding base year,

K_b = state capital stock for the following base year, and

g_t = growth rate of US capital stock for year t.

A. Methodology for Nonresidential Assets

We distributed the BEA estimate of assets in agriculture according to the state's share of the value of farm land, buildings and equipment taken from the *Census of Agriculture* 1969, 1974, 1978, 1982, 1987, and 1992.[18] We estimated assets for 1970 by applying the 1969 ratio; assets for 1971-1973 with data from the 1969 and 1974 *Censuses*; assets for 1975-1977 with data from the 1974 and 1978 *Censuses*; assets for 1979-1981 with data from the 1978 and 1982 *Censuses*; assets for 1983-1986 with data from 1982 and 1987 *Censuses*; and assets for 1988-1991 with data from 1987 and 1992 *Censuses*. Assets for 1993-1995 were obtained by applying the 1992 ratio.

Ohio's Share of US Value of Farm Land, Buildings and Equipment[19]

Year	1969	1974	1978	1982	1987	1992
%	3.25	3.31	3.79	3.07	3.07	3.09

We apportioned the BEA estimate of assets in construction according to the state's share of the gross book value of depreciable assets taken from the *Census of Construction* for 1972, 1977, 1982 , 1987 and 1992. We estimated assets for 1970 and 1971 by applying the 1972 ratio; assets for

[17] Munnell (1990) used the base year apportionment ratios to distribute the BEA na
preceding years and following years. Thus, she used data from the 1972 Census to
stock apportionment ratios for each state for 1969 to 1974; data from 1977 to est
1982 Census data to estimate shares for the 1980 to 1984 stock estimates; and dat
estimate shares for 1985 to 1989. The resulting series, however, sometimes show
annual growth rates from the growth rates of the US capital stock. To avoid this
smoothing method described below.

[18] The ratio obtained from the 1969 Census was applied to 1970, which is the firs

1973-1976 with data from the 1972 and 1977 *Censuses*; assets for 1978-1981 with data from the 1977 and 1982 *Censuses*; assets for 1983-1986 with data from the 1982 and 1987 *Censuses*; assets for 1988-1991 with data from 1987 and 1992 *Censuses*. And assets for 1993-1995 were obtained by applying the 1992 ratio.

Ohio's Share of US Gross Book Value of Depreciable Assets for Construction[20]

Year	1972	1977	1982	1987	1992
%	4.33	4.12	3.42	3.44	3.95

We apportioned the BEA estimate of assets in manufacturing according to the state's share of the gross book value of depreciable assets taken from the 1970 and 1971 *Annual Survey of Manufactures* and from *Census of Manufactures* for 1977, 1982, 1987, and 1992. The data from 1971 *Annual Survey* and the 1977 *Census* were used to estimated assets for 1972-1976.

Ohio's Share of US Gross Book Value of Depreciable Assets for Manufacturing[21]

Year	1970	1971	1977	1982	1987	1992
%	8.56	8.30	7.12	6.34	6.06	5.69

We used several procedures to distribute assets in the transportation and public utilities sector. This sector was divided into three subsectors: transportation; communications; and electric, gas, and sanitary services. We began with the transportation sector for which three sub-sectors were considered; railroad, trucking and warehousing, and air transportation. We distributed the BEA estimate for railroad transportation according to the state's share of road mileage in 1980, 1982, 1984, 1985, 1987, 1990, 1992, 1993 and 1994. We obtained these data from *Railroad Facts*. We estimated assets from 1970 to 1979 by applying the 1980 ratio;[22] assets for 1983 with data from the 1982 and 1984; assets for 1986 with data from the 1985 and 1987; and so on.

Ohio's Share of US Railroad Mileage[23]

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[19] US Bureau of the Census. Census of Agriculture, 1969, 1974, 1978, 1982, 1987,
[20] US Bureau of the Census, Census of Construction, 1972, 1977, 1982, 1987 and
[21] US Bureau of the Census. Annual Survey of Manufactures, 1971 and Census of Ma
1982, 1987, and 1992.
[22] We were unable to find the state's share of US road mileage for early years, sc
apportionment ratio remain constant before 1980 at that year ratio. This assumpti
the ratio after 1980 did not change significantly.
[23] Association of American Railroads. Railroad Facts. Washington, 1983, 1985, 198
DC: Association of American Railroads.

Year	1980	1982	1984	1987	1992	1994
%	3.95	4.09	3.96	3.93	3.65	3.57

We estimated the state's assets in trucking and warehousing according to the state's share of trucks. We collected these data for 1971, 1972, 1977, 1981, 1982, 1987 and 1992 from the *Census of Transportation*.

Ohio's Share of US Trucks[24]

Year	1972	1977	1982	1987	1992
%	3.38	3.34	3.79	3.90	3.70

We apportioned the state's assets in air transportation by estimating the state's share of registered aircraft. We obtained these data from the *Census of US Civil Aircraft*, a publication of the Federal Aviation Administration.

Ohio's Share of US Aircraft[25]

Year	1972	1977	1982	1987	1992	1993
%	4.31	4.00	3.43	3.37	3.26	3.24

We were unable to obtain sufficient proxies for other subsectors of transportation so we apportioned the weighted average of the shares of railroad, trucking and warehousing, and air transportation to total transportation. These three sectors accounted for 79% of 1995 total transportation of US capital stock.

The next subsector is the communication sector. We apportioned the national estimate of this subsector according to the state's share of miles of wire in cable. We collected this set of data from the *Statistics of Communications Common Carriers*, a publication of the Federal Communications Commission, for 1972, 1977, 1980, 1986, and 1987. We estimated the 1993 ratio according to the state’s share of total presubscribed lines since miles of wire and cable is not published anymore.

Ohio's Share of US Miles of Wire in Cable[26]

Year	1972	1977	1980	1986	1987	1993

[24] US Bureau of the Census. Census of Transportation, 1972, 1977, 1982, 1987, 1
[25] US Federal Aviation Administration. 1972, 1977, 1982, 1987, 1992 and 1993. C
Aircraft. Washington, D. C.: Government Printing Office.
[26] US Federal Communications Commission. Statistics of Communications
Common Carriers., 1972, 1977, 1980, 1986, 1987, 1993. Washington, DC: Governm
Office.

%	4.66	4.47	3.90	3.61	3.61	3.97

The final subsector is electric, gas, and sanitary services. We distributed assets in the electric service sector based on the state's share of installed capacity of electric energy (for 1970 to 1989) and net summer capability (for 1990 to 1994).[27] These data were obtained from the *Statistical Abstract of the United States*, 1975, 1985, 1990, 1993 and 1995. We estimated assets for 1971 to 1973 with data from the years 1970 and 1974; assets for 1977 to 1979 with data from the years 1976 and 1980, assets for 1987 with data from the years 1985 and 1988, and so on.

Ohio's Share of US Installed Capacity of Electric Energy[28]

Year	1975	1980	1985	1988	1991	1993	1994
%	4.87	4.47	3.91	3.81	3.97	3.89	3.87

We estimated assets in the gas service sector based on Ohio’s share of miles of pipeline and gas main. We collected these data from *Gas Facts*, a publication of the American Gas Association, for 1970, 1975, 1980, 1985, 1990, 1992, 1993, and 1994. We estimated assets for 1971 to 1974 with data from the years 1970 and 1975, assets for 1976 and 1977 with data from the years 1975 and 1978, assets for 1981 to 1984 with data from the years 1980 and 1985, and so on. Once again we could not find a good proxy for the sanitary service sector.[29] So we apportioned the weighted average of the shares of electric and gas to the total of electric, gas , and sanitary services.

Ohio's Share of US Miles of Pipeline and Gas Mains[30]

Year	1975	1980	1985	1990	1992	1993	1994
%	5.26	5.01	4.84	4.45	4.64	4.72	4.80

We distributed assets in finance, insurance, and real estate according to the state's share of gross production in the US for each year.[31] We obtained the annual data on gross product for each subsector, for US and for Ohio, from the Bureau of Economic Analysis (BEA).

We apportioned BEA estimates of retail and wholesale trade and service sector according to the state's share of sales in each category. We obtained sales data from the *Census*

[27] Data for installed capacity is not available after 1989. It is replaced with ne
[28] US Bureau of the Census. Statistical Abstract of the United States, 1975, 19
1996. Washington, DC: Government Printing Office.
[29] The sanitary service sector is small, e.g. , its share in the total 1993 US ca
and sanitary services was 8.9%.
[30] American Gas Association, Gas Facts, 1975,1980, 1985, 1980, 1992, 1993, and 19
[31] In the Munnell’s study (1990), the state's share of commercial bank deposits
However, the fraction of banks' capital stock in FIRE is relatively small (e.g.,
thus the deposit share may not be a good measure for the whole FIRE sector. For
state share of gross production for which data is available for each year.

of Retail Trade, 1972, 1977, 1982, 1987 and 1992; the *Census of Wholesale Trade*, 1972, 1977, 1982, 1987, and 1992; and the *Census of Service Industries*, 1972, 1977, 1982, 1987, and 1992. The share of Ohio's sales in the retail industry for the years 1986, 1990, 1991, 1993 and 1994 were obtained from the *Statistical Abstract of the United States*, 1993 and 1996.

Ohio's Share of US Sales in Retail Trade, Wholesale Trade, and Service Industries[32]

Year	1972	1977	1982	1987	1990	1991	1992	1994
				(percentages)				
Retail	4.99	4.92	4.35	4.20	4.05	4.19	4.13	4.39
Wholesale	4.84	4.90	3.99	4.12	na	na	3.93	na
Service	4.09	3.93	3.63	3.43	na	na	3.40	na

[32] US Bureau of the Census. Census of Wholesale Trade, 1972, 1977, 1982, 1987, Retail Trade, 1972, 1977, 1982, 1987, 1992 and 1994. Statistical Abstract of the Census of Service industries, 1972, 1977, 1982, 1987 and 1992.

APPENDIX 3

DERIVATION OF COST OF CAPITAL

The gross-of-factor cost of capital that producers are required to pay, *r*, is determined by the equilibrium condition where the present value of the future income stream to the owner of capital (i.e., household, HH) is equal to the price of capital. In other words, HH investors would be willing to give up one dollar of current consumption in order to hold one dollar of capital only if the present value of the income stream (i.e., net of taxes and net of depreciation return of capital) is at least one dollar. Let:

K = price of capital (e.g., cost of new machine or equipment);

R = rental charge for capital including tax costs, i.e., rental cost to firms; and

R_n = net of tax rental income to capital owner.

Then, in equilibrium, the following must hold:

(A3.1) $$K = \int_0^{SL} R_n e^{-(\rho+d)t} dt$$

where

SL = service life of capital asset

ρ = discount rate

d = capital consumption rate or replacement rate.

Investors who own corporate shares deduct corporation income tax liability from their portion of the corporation’s net income before taxes; the investors then pay personal income tax on capital gains and on any dividends paid out to them by the corporation. Then, R_n is obtained as:

(A3.2) $$R_n = R-(T_c+T_k)$$

where $T_c = T_{fc}+T_{sc}$, the sum of federal and state corporate income tax

$T_k = T_{fk}+T_{sk}$, the sum of federal and state personal income tax on capital income.

Also, T_{fc} and T_{sc} are calculated as:

(A3.3) $$T_{sc} = t_{sc}(R-D)$$

(A3.4) $$T_{fc} = t_{fc}(R-D-T_{sc})$$

where t_{sc} = state tax rate on corporate income;

t_{fc} = federal tax rate on corporate income; and

D = depreciation allowed for tax purposes.[33]

Then, T_c is obtained from (A3.3) and (A3.4) as:

(A3.5) $T_c = (t_{fc}+t_{sc})(R\text{-}D)\text{-}t_{fc}*t_{sc}(R\text{-}D) \quad = t_c(R\text{-}D)$

where:

(A3.6) $\tau_c = t_{fc}+t_{sc}\text{-}t_{fc}*t_{sc}.$

After-tax corporate profits are distributed to the investors who own corporate shares in the form of dividend income and / or capital gains. They then pay personal income tax on dividends and capital gains. Now, T_k is calculated as follows.

(A3.7) $T_k = T_{sk} + T_{fk}.$

and, T_{sk} and T_{fk} are:

(A3.8) $T_{sk} = t_{sk}(R\text{-}D\text{-}T_c)$

(A3.9) $T_{fk} = t_{fk}(R\text{-}D\text{-}T_c\text{-}T_{sk}) \quad = (t_{fk}\text{-}t_{fk}*t_{sk})(R\text{-}D\text{-}T_c)$

where t_{fk} = federal tax rate on individual capital income[34] and

t_{sk} = state tax rate on individual capital income.

Substitute (A3.8) and (A3.9) into (A3.7) to get:

(A3.10) $T_k = \tau_k(R\text{-}D\text{-}T_c)$

where:

(A3.11) $\tau_k = t_{fk}+t_{sk}\text{-} t_{fk}*t_{sk}.$

[33] We assume that the depreciation allowed for federal tax purposes is the same fo

[34] Since we assume that the supply of capital is perfectly elastic due to perfect
t_{fk} and t_{sk} are the tax rates on capital income applied to all US residents.

Assuming that individual capital income takes the form of dividends and capital gains, t_{fk} and t_{sk} are calculated as:

(A3.12) $$t_{fk} = t^{d}_{fk}\ p + t^{g}_{fk}\ (1-p)$$

where t^{d}_{fk} = federal tax rate on dividend income;

t^{g}_{fk} = federal tax rates on capital gains;

p = the ratio of dividend income to the total of dividend income and capital gains; and

(A3.13) $$t_{sk} = t^{d}_{sk}p + t^{g}_{sk}(1-p)$$

where t^{d}_{sk} = state tax rate on dividend income; and

t^{g}_{sk} = state tax rate on capital gains.

Now substitute (A3.5) and (A3.10) into (A3.2) to rewrite R_n as:

(A3.14)
$$\begin{aligned} R_n &= R-(T_c+T_y) \\ &= R-[(R-D)\tau_k - T_c\tau_k + T_c] \\ &= R-[\tau_y(R-D)+(1-\tau_y)\tau_c(R-D)] \\ &= R-(R-D)(\tau_c+\tau_k-\tau_k\tau_c) \\ &= (1-t_{ck})R + t_{ck}D \end{aligned}$$

where :

(A3.15) $$t_{ck} = \tau_c+\tau_k-\tau_k*\tau_c.$$

Now substitute (A3.14) into (A3.1) to get:

(A3.16) $$K = \int_0^{SL} [R(1-t_{ck})]\, e^{-(\rho+d)t}dt + \int_0^{DL} t_{ck}D_t e^{-(\rho+d)t}dt$$

$$= \frac{-R(1-\tau_{ck})(e^{-(\rho+d)SL}-1)}{(\rho+d)} + t_{ck}\int_0^{DL}(D_t e^{-(\rho+d)t})dt$$

$$= \frac{R(1-t_{ck})}{(\rho+d)} + t_{ck}\int_0^{DL}(D_t e^{-(\rho+d)t})dt\ ,$$

for $e^{-(\rho+d)SL}\approx 0$ assuming a large SL.

The implicit rental *rate* of capital (or the cost of capital to producers), r, is then defined as the ratio of R to K,

(A3.17) $$r \equiv R/K.$$

As shown in (A3.16) and (A3.17), r is affected by the structure of federal and state taxes and the depreciation method. To get the closed form solution for r, the depreciation which is a function of K and t needs to be specified.

Federal tax law stipulates the depreciable life for various types of capital and the recovery allowance percentages for each recovery year. Assuming that the depreciable basis is equal to the value of capital, the depreciation allowed for year t, D_t, is:

(A3.18) $$D_t = \alpha_t K \quad \text{for } 1 \le t \le DL \text{ ; otherwise, } 0$$

where α_t is the recovery allowance percentage for recovery year t. Since the depreciation for tax purpose is annual, the second term of the right hand side of (A3.16) is a discrete case instead of a continuous one. Hence, we substitute (A3.18) into (A3.16) and (A3.16) is modified as follows.

(A3.19) $$K = \frac{R(1-t_{ck})}{(\rho+d)} + t_{ck} \sum_{t=1}^{DL} \frac{\alpha_t K}{(1+\rho+d)^t}.$$

Now solve (A3.19) for r (=R/K) to get:

(A3.20) $$r = \frac{R}{K} = \frac{(\rho+d)(1-t_{ck}C)}{(1-t_{ck})}$$

where $C = \sum_{t=1}^{DL} \frac{\alpha_t}{(1+\rho+d)^t}$ and C<1. As indicated in (A3.20), r is affected by the structure of the various federal and state taxes and the depreciation method. Using linear log-approximation,[35] the cost of capital, r, is expressed as a linear function of d, t_{ck} and C in our regression equation.[36]

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[35] A detailed description of the linearization appears in Appendix 5.b.

Numerical Example of Calculation of C

The depreciation for federal tax purposes is currently based on Modified Accelerated Cost Recovery System (MACRS). Under MACRS, the depreciable life is 7 years for most industrial equipment, office furniture and fixtures, and the recovery allowance percentages, α, are as follows:

Table 1 - Recovery Allowance Percentages under MACRS

Recovery Year	1	2	3	4	5	6	7	8
Recovery allowance percentages, α, in %	14	25	17	13	9	9	9	4

Suppose that the discount rate, ρ, is .10, the capital consumption rate, *d*, is .12, and the depreciation method is based on MACRS with a depreciable life of seven years. Then, we get:

$$C = \sum_{t=1}^{DL} \frac{\alpha_t}{(1+\rho+d)^t}$$

$$= \frac{.14}{(1+.1+.12)} + \frac{.25}{(1+.1+.12)^2} + \frac{.17}{(1+.1+.12)^3} + \frac{.13}{(1+.1+.12)^4} + ... + \frac{.04}{(1+.1+.12)^8}$$

$$= 0.526.$$

Data on α

The recovery allowance percentages, α, vary depending on depreciation method specified in the tax laws as follows.

Depreciation Method for Federal Tax Purposes

years	method
1985-present	Modified Accelerated Cost Recovery System (MACRS)
1981-1985	Accelerated Cost Recovery System (ACRS)
1954-1980	Accelerated method (sum-of-years'-digits, SYD).

A. ***MACRS***

Under MACRS, a sample of the depreciation life allowed for tax purposes is:

DL=3 years for certain special manufacturing tools,

[36] We assume a constant discount rate, ρ, of 10%.

DL=5 years for automobiles, computers, certain manufacturing equipment,

DL=7 years for most industrial equipment, office furniture and fixtures,

DL=10 years for certain longer-lived types of equipment.

The Recovery Allowance Percentages are:

	Class of Investment		
Recovery Year	3-yr	5-yr	7-yr
1	33%	20%	14%
2	45	32	25
3	15	19	17
4	7	12	13
5		11	9
6		6	9
7			9
8			4

B. ACRS

Under ACRS, a sample of the depreciation life allowed for tax purposes is:

DL=3 years for autos, research and experimental equipment and certain special tools,

DL=5 years for all other machinery and equipment,

DL=10 years for certain public utility property, residential manufactured homes.

The Recovery Allowance Percentages are:

	Class of Investment		
Recovery Year	3-yr	5-yr	10-yr
1	25%	15%	8%
2	38	22	14
3	37	21	12
4		21	10
5		21	10
6			10
7-10			9

C. SYD Method

The Internal Revenue Code of 1954, which authorized taxpayers to use the SYD method, does not specify the depreciation life allowed for tax purposes for different property classes; the SYD method does not provide any guidelines regarding different recovery periods. The depreciation percentages by ownership year under SYD are:

Ownership Year	**3-yr**	**5-yr**	**7-yr**	**10-yr**
1	50.00%	33.33%	25.00%	18.18%
2	33.33	26.67	21.43	16.36
3	16.67	20.00	17.86	14.55
4		13.33	14.29	12.73
5		6.67	10.71	10.91
6			7.14	9.09

7	3.57	7.27
8		5.45
9		3.64
10		1.82

APPENDIX 4

ESTIMATION OF GOVERNMENT TRANSFER PAYMENTS

In STAMP we are using the variable G_{tr}, government transfer payments per person in working age who is not employed. It is calculated as

$$G_{tr} = \frac{GTR}{wap - L}$$

where *GTR* is measured by the sum of the income maintenance and unemployment insurance benefits,[37] *wap* is the total population aged 16-64, and *L* is the number of employed. To estimate G_{tr} for 1998 we first projected *GTR*, *wap* and *L* for 1998 as follows:

1. The estimate of *wap* for 1998 is based on the BEA projection that the Ohio population aged 18-64 will grow by a total of 2.45% between 1993 and 1998. Actual values of *wap* are now available through 1996 from Bureau of Census statistical releases. We found the growth rate to be 1.36% for 1993-1996, which gives a growth rate for 1996-1998 of 1.09% (= 2.45%-1.36%); we applied this growth rate to the actual value of *wap* for 1996 to get a projected value in 1998.
2. Estimation of *L* for 1998 is based on the annual growth rates of employment reported by the BLS for 1994, 1995 and 1996, which are 2.03%, 1.57% and 0.90%, respectively, giving an average growth rate of 1.50%. This average growth rate is then applied to calculate the 1997 employment level to which the same growth rate is applied to compute the 1998 estimate of the number of employed.
3. The latest data on *GTR* available was for 1995. To estimate the 1998 value of *GTR* we used the average annual growth rate of *GTR* for 1993, 1994 and 1995, which was 5.10%. This growth rate was applied, compounded, to the 1995 *GTR* to get the 1998 estimate.
4. The 1998 G_{tr} was projected as $G_{tr,98} = GTR_{98} / (wap_{98} - L_{98}) = \$2{,}345$

APPENDIX 5

ESTIMATION OF AFTER-TAX UNEARNED INCOME OF OHIO RESIDENTS

The after-tax unearned income for Ohio was calculated by using the individual income and tax data reported in *Statistics of Income Bulletin,* published by the Internal Revenue Service.[38] For the base amount of gross unearned income, we used adjusted gross income (AGI) less salaries and wages with the adjustments of long-term capital-gains income.

Until 1978, 50% of net capital gains, defined as long-term gains less short-term losses, was excluded from income for federal tax purposes; after 1978, 60% of net capital gains was excluded from income. The 60% federal capital-gains exclusion was eliminated from 1987 onward. Since the amount of capital-gains exclusion is not included in the AGI reported in *SOI*, we first obtained the amount of the exclusion in order to obtain the gross unearned income that is actually realized. The amount of capital gains excluded in SOI for Ohio residents, CG_x, is calculated as:

$$CG_x = \left(1 - \left(\frac{G^A}{G}\right)\right) * G$$

where G is the capital gains actually realized and G^A is the capital gains reported in SOI. The ratio of G to G^A was obtained from the Office of Tax Analysis, US Department of the Treasury. Then, gross unearned income (GY_u) is:

$$Gy_u = AGI - s\&w + CG_x$$

where AGI is the AGI reported in *SOI*, and s&w is the salaries and wages reported in SOI, and CG_x is the amount of capital gains excluded in SOI.

After-tax unearned income was then calculated by subtracting the total of federal and state taxes on unearned income from the gross unearned income. The *federal* tax on unearned income (T_f) is computed as:

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37 Source: BEA State Personal Income CD-ROM.

$$T_f = \frac{\text{AGI} - \text{s \& w}}{\text{AGI}} * \text{T}$$

where T is the total federal tax on individual income. For *state* tax on unearned income (T_s) we subtracted the amount of state income withheld from state collections of individual income taxes. Both data were obtained from the Ohio Department of Taxation. Then, the after-tax unearned income, Y_u, is gross unearned income less taxes, i.e., $Y_u = GY_u - T_f - T_s$.

[38] See the section, "Selected Historical and Other Data, Individual Income and Ta of Adjusted Gross Income for Ohio."

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