Measuring the Effects of Tax Changes in Minnesota: The Minnesota State Tax Analysis Modeling Program

Prepared by the Beacon Hill Institute
at Suffolk University

David G. Tuerck, Ph.D., Project Director
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A Project of

Center of the American Experiment

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Center of the American Experiment is a nonpartisan, tax-exempt, public policy and educational institution that brings conservative and alternative ideas to bear on the most difficult issues facing Minnesota and the nation.

The Beacon Hill Institute at Suffolk University in Boston, Massachusetts focuses on federal, state and local economic policies as they affect citizens and businesses. The Institute conducts research and educational programs to provide timely, concise and readable analyses that help voters, policymakers and opinion leaders understand today's leading public policy issues.

Foreword

The main conclusion of this highly technical econometric study can be stated simply: Minnesota income taxes can be cut significantly, productively, safely, and permanently.

How significantly? According to Drs. David G. Tuerck and Jonathan Haughton of Boston's Beacon Hill Institute, it's entirely possible to reduce rates in each of Minnesota's three income-tax brackets by a full percentage point.

How productively? Jobs in the state would increase by about 22,000. Payroll payments would grow by more than $800 million annually.

How safe would such a tax cut be? Even if a recession were to occur in 2002, the authors write, the state's budget would remain roughly in balance. (Needless to say, if a recession were to hit, one might expect a governor and legislators to smooth out rough edges by cutting spending a few bucks.)

And as for the permanence of such a reduction, the authors are too savvy to suggest that any tax cut is ever written into stone. But they do make this fundamentally important point about the value of ongoing cuts versus one-time rebates: Cuts in tax *rates* constructively influence the behavior of employees, employers, and consumers. Rebates, on the other hand, are unpredictable and weakly linked to decisions about how much to earn and whether to spend. As such, they have "very little bite at the margin."

Center of the American Experiment commissioned this research — "Measuring the Effects of Tax Changes in Minnesota: The Minnesota State Tax Analysis Program" — for several reasons, none of which should be surprising given our faith in free markets.

They include confidence that tax cuts (the study looks at various options) are synonymous with entrepreneurial and fruitful news. A broader reason is the conviction that low taxes are not just attractive and pleasant as public policies go. They're required by freedom itself.

Minnesota, actually, is the tenth state that the Beacon Hill Institute (which is a part of Suffolk University) has subjected to its rigorous, dynamic model. Others have included California, Massachusetts, Texas, and Virginia. At the core of STAMP — the "State Tax Analysis Modeling Program" — are two straightforward premises.

First, that households seek to maximize their utility by considering their after-tax earnings when deciding how much time to work and how much time to spend at leisure. And second, that firms similarly seek to maximize their profits, with state taxes once again influencing how they go about hiring, employing capital, etc.

I am grateful to project director David Tuerck and project manager Jonathan Haughton for this first-rate investigation. Professor Tuerck also is chairman of the economics department at Suffolk University, where Dr. Haughton is an assistant professor. My thanks as well to Corina Murg, who served as research assistant.

A final point. I would urge readers not to be intimidated by the very advanced statistics on which this study is based. Or, at least, not to be intimidated too badly, as the presentation that follows is readily understandable by prosaic folks (myself, for example) who prefer words to heavy-duty mathematics.

Additional copies of this report are $5 for Center members and $7.50 for nonmembers. Bulk rates are available for schools, civic groups and other organizations. The full text also can be found on our Web site at www.amexp.org[.]

Thank you, and as always, I welcome your comments.

Mitchell B. Pearlstein, Ph.D.
President
April 2001

Acknowledgements

This study by the Beacon Hill Institute at Suffolk University was undertaken at the initiative of Dr. Mitchell B. Pearlstein, President of Center of the American Experiment. We would like to thank him, his colleague Annette T. Meeks and others associated with the Center for their invaluable comments given in response to our presentation of the work in Minneapolis in early December 2000.

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1. Introduction and Summary

With the 2000-01 biennium ending on June 30, 2001, discussion is under way concerning the appropriate forms and levels of taxation and spending for the 2002-03 biennium. Based in large measure on the *November Forecast*,[1] Governor Ventura formulated a set of budget recommendations in January 2001, and these are being debated by the legislature.

In this report we analyze the economic effects of a number of possible changes to the structure and level of taxation. More specifically, we ask what would happen to the number of jobs, the wage rate, the capital stock, payroll and tax revenues, as a result of any of the following:

a. The statutory state income tax rates were reduced in small increments totaling half a percentage point by 2004.
b. The state income tax rates were reduced by 0.5 percentage points in 2001, and a further quarter percentage point in each of 2003 and 2004.
c. The state sales tax were reduced by a percentage point.

These are illustrative and relevant examples. Computations for other tax changes or combinations of changes follow the same methodology, and are straightforward to perform with the help of the accompanying spreadsheet program.

Because of budget surpluses, the state provided tax rebates of $1,300 million in FY1999 and a further $640 million in FY2000, and will return an estimated $856 million in the current fiscal year. An alternative to rebates is to cut the tax rates. In this report we discuss the economic effects of tax rebates versus reductions in tax rates.

It is often argued that tax cuts are imprudent because they may leave the state with insufficient revenue in the event of a recession. To address this issue, we simulate the effects of a tax cut that occurs at the same time as a recession, and analyze whether the state could successfully weather the recession in this case.

[1] Published by the Minnesota Department of Finance, St. Paul, November 2000.

Our analysis leads to the following principal findings:

- A cut in the state income tax of a half percentage point, followed within two years by an additional cut of half a percentage point (cumulating to a total cut of one percentage point) would lead to the creation of over 10,000 more jobs in the short term and 22,000 more jobs by 2004. It would push up payroll payments by almost $400 million in each of the first two years, and over $800 million annually eventually. State tax revenue would fall by $410 million in 2001, and $980 million in 2004. Further details are shown in Table 1. These results add further to the weight of evidence that shows that state-level tax cuts have significant positive effects on state economic activity.[2] Even with these tax cuts, the state would continue to have budget surpluses every year, as Table 2a shows.
- The additional jobs and payroll would not occur if the revenue were rebated to taxpayers rather than built into a lower tax rate, because rebates are too loosely tied to tax contributions to influence economic behavior significantly.
- A reduction in the effective sales tax rate from the current 7.8% (including excises along with the motor vehicle and general sales taxes) to 6.8% would lead to 19,000 more jobs, $660 million more in annual payroll, and a reduction in state revenue of about $500 million annually.
- In round numbers, the state has a current funds balance of about $2 billion. The Commissioner of Finance is required to make a recommendation to the legislature to rebate any accumulated surplus above the allowed "rainy day fund" balance of about $1 billion. Thus there will be a potential rebate of almost $1 billion this year, and although the legislature is not mandated to return this money to taxpayers, we have assumed that most of it will in fact be rebated.

Meanwhile we expect a budget surplus of about $400 million in calendar year 2001, rising to almost $800 million in 2002. Given current tax rates, the accumulated $1 billion rainy day fund provides an ample cushion against recession which, if it were to hit in 2002, would almost halve (but not eliminate) the budget surplus. If the personal income tax were cut by a moderate amount – half a percentage point now, a further half

[2] Timothy J. Bartik, *Who Benefits from State and Local Economic Development Policies?* (Kalamazoo, Michigan: W.E. Upjohn Institute for Employment Research, 1991).

percentage point within a couple of years – the state budget would be roughly in balance (see Table 14) even if there were a recession, which means that such a tax cut would not expose the state to the risk of a fiscal crisis in the event of a recession.

This study does not address two important remaining issues – the equity effects of tax changes, and the appropriate level of spending by the state.

Our conclusions are based on the estimation and use of a rigorous tax model for Minnesota. Nothing less is adequate for this task. The underlying theory is described in chapter 2, which derives the "reduced form" equations that must be estimated. The sources of data and methods used to construct the variables – a time-consuming and intricate process – are set out in Chapter 3, along with the estimates of the reduced-form equations. Readers more interested in the practical results can turn directly to Chapter 4, where the applications of the model to tax changes are set out in more detail. The affordability of the tax cut, particularly if the state enters a recession, is addressed in Chapter 5.

Table 1.
Summary of Economic Effects of Tax Cuts

	Tax rates		Change in Number of Jobs Relative to Baseline	Change in Payroll ($ million)	Change in Net Tax Revenue ($ million)
	Assuming no change in current rates	With new tax rates			
*Lower personal income taxes by 0.2 % points in 2002, a further 0.2 % points in 2003 and another 0.1% point in 2004**					
2001	**7.85/7.05/5.35**	7.85/7.05/5.35	0	0	0
2002	7.85/7.05/5.35	7.65/6.85/5.15	4,277	153	-173
2003	7.85/7.05/5.35	7.45/6.65/4.95	8,759	323	-369
2004	7.85/7.05/5.35	**7.35/6.55/4.85**	11,168	424	-488
*Lower personal income taxes by half a % point in 2001, and a further quarter point in each of 2003 and 2004**					
2001	**7.85/7.05/5.35**	7.35/6.55/4.85	10,597	369	-410
2002	7.85/7.05/5.35	7.35/6.55/4.85	10,778	387	-433
2003	7.85/7.05/5.35	7.10/6.30/4.60	16,564	611	-693
2004	7.85/7.05/5.35	**6.85/6.05/4.35**	22,455	853	-980

Source: From simulations based on Minnesota STAMP 2001.
* Income tax rate is graduated, from 5.35% for taxable income below $25,880 per year (for married filing jointly), rising to 7.05% and then to 7.85% for taxable income above $102,030.

Table 2a.
State Revenue, Spending and Surpluses, for Status Quo and Income Tax Cut Scenarios

	2000	2001	2002	2003	2004
Forecast, based on status quo					
General fund revenue, $m	12,306	13,210	13,808	14,499	15,277
Expenditure, $m	12,299	12,800	13,028	13,463	13,974
Budget surplus, $m	7	410	780	1,036	1,303
Balance in funds, $m, end of year	2,012	1,566	2,346	3,382	4,685
Forecast, lower personal income tax *(down half a % point in 2001,3/4 % point in 2003, full % point in 2004)*					
Tax revenue, $m	12,306	12,800	13,375	13,806	14,296
Expenditure, $m	12,299	12,800	13,028	13,463	13,974
Budget surplus, $m	7	0	346	343	323
Balance in funds, $m, end of year	2,012	1,156	1,502	1,846	2,169

Source: From simulations based on Minnesota STAMP 2001. Data refer to calendar years. Projections of revenue and expenditure in base case are based on Minnesota Department of Revenue, *November Forecast*, November 2000.
Note: The revenue, expenditure and surplus figures represent annual flows of funds; the "balance in funds" measures the outstanding balance that remains at the end of the year, and gives the stock of accumulated funds.

Table 2b.
State Revenue, Spending and Surpluses, Income Tax Cut Coupled with Recession in 2002

	2000	2001	2002	2003	2004
Forecast, lower personal income tax *(down half a % point in 2001,3/4 % point in 2003, full % point in 2004)* **with recession**					
Tax revenue, $m	12,306	12,800	12,897	13,076	13,529
Expenditure, $m	12,299	12,800	12,898	13,061	13,557
Budget surplus, $m	7	0	-1	14	-28
Balance in funds, $m, eoy	2,012	1,156	1,155	1,169	1,141

Source: From simulations based on Minnesota STAMP 2001. Data refer to calendar years. Projections of revenue and expenditure in base case are based on Minnesota Department of Revenue, *November Forecast*, November 2000.
Note: The revenue, expenditure and surplus figures represent annual flows of funds; the "balance in funds" measures the outstanding balance that remains at the end of the year, and gives the stock of accumulated funds.

The Minnesota State Tax Analysis Modeling Program (Minnesota STAMP): Some Background

The results of this study are based on the specification and estimation of a formal model of the economy of Minnesota, designed specifically to address the question of how tax changes affect economic activity. The State Tax Analysis Modeling Program (STAMP) was first developed for Massachusetts in 1994, and has since been refined and re-estimated almost annually. Since then we have built STAMP models for ten other states; all are based on the same theoretical foundations, although they differ slightly in the details.

At the core of the STAMP models are two simple premises. First, households maximize their utility, so that they look at their after-tax earnings when deciding how much time to spend working, and how much at leisure. Second, firms maximize their profits. To achieve this they compare their need to hire labor and employ capital, but these decisions too are influenced by the taxes that are in place in the state. From these first principles we develop a structural model, which we then transform into a set of "reduced form" equations that may be estimated using annual data stretching back to 1974. The results of these estimates are used to simulate the effects of proposed tax changes. The methodology is set out in more detail in Chapter 2.

BHI first developed and applied STAMP in 1994 during a campaign to institute a graduated income tax structure in Massachusetts. The proposal was subsequently turned down by the voters. Since then, BHI has applied Massachusetts STAMP to numerous other proposed tax-law change in the state.

Most recently, Massachusetts STAMP was applied to a November 2000 ballot initiative to lower the state income tax rate from 5.85% to 5%. Massachusetts STAMP showed that lowering the income tax rate to 5% would put 93,000 workers into Massachusetts jobs by 2003, when fully implemented. The proposal was approved by voters.

In 1996, BHI developed an Oklahoma STAMP at the request of the Oklahoma Department of State Finance. In 1997, BHI built STAMPs for New Jersey and Ohio. BHI has built STAMPs for three State Policy Network sister organizations: Texas STAMP, for the Texas Public Policy Foundation in 1999 Virginia STAMP, completed in 2000 for the Thomas Jefferson Institute for Public Policy; and California STAMP, completed in 2000 for the Pacific Research Institute.

In 1999, BHI and the Heritage Foundation's Center for Data Analysis formed a strategic partnership to combine STAMP with the Heritage Foundation's federal and state tax analysis capabilities. As part of that project, in 2000, BHI applied STAMP to four more states: Arizona, Michigan, New York and Pennsylvania.

2. How Minnesota STAMP Works

The Essentials of the Model

Many attempts to model state tax-law changes proceed directly from "reduced-form" estimates that leave unanswered the question of the theoretical underpinnings on what those estimates are based.[3]

The Minnesota State Tax Analysis Modeling Program, "Minnesota STAMP" for short, is a structural model, in that it is rooted in the optimizing behavior of households and firms. The well-being of households comes from the goods and services they consume, as well as the leisure time they enjoy. There is a tradeoff between the two, because by working more, the household earns the wherewithal to buy more goods and services, but now has less leisure time. The structure of taxes affects this tradeoff; thus, for instance, a higher tax on labor income will discourage some households from working.

The goods and services that households buy come from businesses. These firms need inputs of capital and labor, which they employ in such a way as to maximize their profits. The precise amount of capital and labor hired will depend, to some degree, on the level and structure of taxes faced by firms and their owners. A high tax on commercial and industrial property, for instance, would discourage investment, and lead to less employment and lower wages.

A strength of the STAMP tax models is that they measure tax rates in a theoretically appropriate way. We may think of households and firms as making decisions at the margin: Should I work an extra hour? Should I hire the services of an extra machine? Thus it is necessary to measure the weight of taxes at the margin, too. The calculation of marginal tax rates is difficult and time-consuming, which is why it is rarely done.

[3] See, for example, Bartik. An interesting recent example of a study that is rooted in theory, but derives parameters from econometric estimation is Andrew Haughwout, Robert Inman, Steven Craig and Thomas Luce, "Local Revenue Hills: A General Equilibrium Specification with Evidence from Four U.S. Cities," NBER Working Paper 7603, March 2000.

The two sectors – households/consumers and firms/producers – interact to determine equilibrium employment, wage rates and the stock of capital in the economy. Consider again the example of a higher state tax on labor income. As some households work less, employers will now face a lower supply of labor, and so the (pre-tax) wage rate will rise somewhat. This will result in a decrease in the amount of labor employed, in equilibrium, in the market.

The structural model cannot be estimated directly. Instead it is rearranged as a set of reduced form equations, where the variables of interest to us (employment, the stock of capital, and the wage rate) are expressed as a function of the relevant policy variables, including tax rates. These are then estimated, using data for the period 1974-1997.

This section summarizes the components of the model and explains how the reduced form equations are derived. Further details are provided in Appendix 1. Readers more interested in other aspects of the model may turn directly to the discussion of the data that is given in Chapter 3, to the estimation results in Chapter 4, or to the applications in Chapters 5-7

We start with a typical adult who has to allocate his time ($\bar{L}$) between work (L) and leisure ($\bar{L}$ -L). If he works more, then he will be able to earn more and buy more goods to consume (C), but on the other hand this will leave him with less leisure. This tradeoff is captured in the form of a utility function, which the individual maximizes, subject to his budget constraint. The budget constraint shows that consumption must be paid for out of after-tax earnings, transfer payments received from the government, and income from capital that the household owns. This maximization problem may be solved to generate the supply of labor of a typical individual. This needs to be multiplied by the working-age population (PW) in order to get the total labor supply in the state.

However the working-age population itself is determined in part by economic forces. For instance, a state with lower taxes may attract more people to move into the state. We assume that PW is driven by demographic factors (measured by a "time" variable), and the tax rates on residential property, sales, and personal income.

After some manipulation we may derive the labor supply function, given by

$$\ln L^s = c_0 + c_1 \ln G_{tr} + c_2 \ln w + c_3 t_{sl} + c_4 t_{f\ln} + c_5 t_s + c_6 r + c_7 \ln K + c_8 year + c_9 \ln t_{proptr},$$

where c_0 is a constant and all the other coefficients are negative, except for c_2, and the sign of c_8 is indeterminate. The variables here are:

G_{tr}	Government transfer payments (defined as federal transfers to Minnesota for income maintenance, and federal unemployment insurance payments, per nonworking adult in the state)
w	The wage rate
t_{sl}	The state average marginal tax rate on labor income
t_{fln}	The federal average marginal tax rate on labor income
t_s	State sales tax
r	Rental cost of capital
K	Stock of nonresidential private capital
Year	Time trend
t_{proptr}	Tax rate on residential property

Meanwhile producers are striving to maximize their profits by demanding labor (L) and capital (K) in order to produce output (Q). Their profits will be affected by the additional mandatory expenses they incur when hiring labor (such as unemployment insurance payments and workers compensation insurance). We may think of firms as renting the capital they use; the rental rate (r) is affected by the taxes that are borne by capital, including corporation income taxes, taxes on dividends and capital gains, and taxes on commercial and industrial property. By solving the producers' maximization problem it is possible to derive demand curves for labor and for capital, which may be written as:

$$\ln L^d = \lambda_0 + \lambda_1 \ln q + \lambda_2 \ln r + \lambda_3 \ln w^* + \lambda_4 \ln F$$

and

$$\ln K^d = \kappa_0 + \kappa_1 \ln q + \kappa_2 \ln r + \kappa_3 \ln w^* + \kappa_4 \ln F$$

where

q	An index of economic activity in the United States (real GDP)
r	Rental rate of capital
w^*	Wage rate, including cost of hiring labor (workers' compensation and unemployment insurance taxes)
F	Stock of public infrastructure capital.

Our interest is not in these equations per se, but in what happens to wages (w^*), the quantity of employment (L) and the capital stock (K) when there are changes in taxes. It is thus more useful to solve the structural equations simultaneously to arrive at a set of *reduced form equations*, which may then be estimated econometrically. These give:

The wage equation:

$$(1) \qquad \ln w^* = \omega_0 + \omega_1 \ln q + \omega_2 \ln r + \omega_3 v + \omega_4 \ln G_{tr} + \omega_5 t_{sl} + \omega_6 t_{fln} + \omega_7 t_s + \omega_8 \ln F + \omega_9 t_{proptr},$$

where $\omega_8 < 0$, ω_2 has an ambiguous sign, and all the other coefficients are positive.

The labor equation:

$$(2) \qquad \ln L = b_0 + b_1 \ln q + b_2 \ln r + b_3 v + b_4 \ln G_{tr} + b_5 t_{sl} + b_6 t_{fln} + b_7 t_s + b_8 \ln F + b_9 t_{proptr,}$$

where most of the coefficients are negative, although b_1 has an ambiguous sign but is probably positive, and the signs of b_2 and b_9 cannot be predicted theoretically.

The capital equation:

$$(3) \qquad \ln K = d_0 + d_1 \ln q + d_2 \ln r + d_3 v + d_4 \ln G_{tr} + d_5 t_{sl} + d_6 t_{fln} + d_7 t_s + d_8 \ln F + d_9 t_{proptr,}$$

where again most of the coefficients are expected to be positive, with the exceptions of d_2 (ambiguous) and d_8 and d_9 (negative).

To understand the intuition behind these equations, consider an increase in the state tax on labor income. This should lower the amount of employment in the state (although possibly not by much – this is ultimately an empirical issue). The higher tax discourages individuals from working, but with a smaller supply of labor, wages will rise, which in turn will ensure that employers only wish to hire this smaller amount of labor. Despite the rise in pre-tax wages, workers will not be better off, because they will face an even bigger increase in tax payments. Theoretically the capital stock could rise, if employers substitute enough capital for the increasingly-expensive labor; however, this effect could easily be swamped if capital and labor are complements, in which case the expensive labor leads to less employment and less capital, as firms stay away from Minnesota.

The next step is to estimate equations (1) to (3). But before doing this, a few words are in order about other regional models, and then some attention is required to the sources of data used in the estimation, and the construction of the relevant variables.

The focus in the STAMP model is on the supply-side effects of policy. In this respect it differs sharply from the Keynesian approach taken by the widely used REMI (Regional Economic Modeling, Incorporated) model. The REMI and STAMP models are designed with different questions in mind. Where STAMP models focus on tax issues, the REMI model is widely used to measure the local and regional impact, through spending multipliers and input-output effects, of projects such as a new convention center or road. The REMI model links its local and regional forecasts to national forecasts.[4] However, it does have a serious flaw: It does not allow a role for the cost of capital to influence investment,[5] and the absence of an opportunity cost for public funds guarantees that public spending will be found to have positive economic effects.[6] REMI models migration explicitly, as a function of relative wages and relative "employment opportunities" across regions.[7] Although the Texas STAMP model included a migration equation, this was rolled into the reduced form equations in the Minnesota version; migration remains in the model implicitly, and is driven in part by changes in tax rates. Large-scale economy-wide macroeconomic models, such as the WEFA (formerly Wharton Econometric Forecasting Associates) model, typically have regional components, but they are usually linked to the national model in the same fashion as the REMI model.

The analysis of state-level tax issues is often done without the use of formal models. A good recent example is George Zodrow's *State Sales and Income Taxes*.[8] Although the book does a good job of marshalling the available evidence, the lack of a model means that it cannot reach a clear conclusion about the most suitable tax structure for a given state.

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[4] Gang Shao and George Treyz. 1993. "Building U.S. National and Regional Forecasting and Simulation Models," *Economic Systems Research*, 5(1). George Treyz. 1993. *Regional Economic Modeling: A Systematic Approach to Economic Forecasting and Policy Analysis*, Kluwer, Boston/Dordrecht/London. For a recent synopsis see memo from Lisa Petraglia to Michael LaFaive, December 18, 1998.

[5] Dan Rickman, Gang Shao and George Treyz. 1993. "Multiregional Stock Adjustment Equations of Residential and Nonresidential Investment in Structures," *Journal of Regional Science*, 33(2), 207-219.

[6] Edwin Mills. 1993. "The Misuse of Regional Economic Models," *Cato Journal*, 13(1), 29-39.

[7] George Treyz, Dan Rickman, Gary Hunt and Michael Greenwood. 1993. "The Dynamics of U.S. Internal Migration," *Review of Economics and Statistics*, 209-214.

[8] Published by Texas A&M University Press, 1999.

3. Notes on the Data Used to Estimate Minnesota STAMP

A full list of the variables used in the estimation, the way they are defined, and the sources of the information on which they are based, is given in Table 3.

A value for each variable was constructed for each year from 1974 through 1997. All of the dependent variables (labor, capital, wages) as well as some of the independent variables (cost of capital, economic activity elsewhere in the U.S.) are constructed for each of the seven major sectors of the economy, namely:

- Agriculture, forestry and fisheries
- Construction
- Finance, insurance and real estate
- Manufacturing
- Services
- Transport and public utilities
- Wholesale and retail trade.

In principle this disaggregation provides greater variation in the data; the equations were estimated using the pooled cross-section time-series data, allowing for cross-sectional correlation. In practice the estimates of the tax-related parameters based on aggregate data were close to those using sectoral data.

Some of the variables, including the measures of employment, wages, and property tax rates, are relatively straightforward. However several of them are difficult to construct. Here we provide a succinct discussion of the data transformations that were needed, relegating the full details to Appendix 2.

a. Average marginal tax rates

The federal tax rates on labor, and the tax rates that are included in the cost of capital – the federal taxes on capital income (dividends, capital gains) and the federal and state taxes on corporate income – are *effective average marginal tax rates*. That is, they aim to measure the average of the marginal tax rates actually facing taxpayers. Although it has long been recognized that this is the correct measure to use when assessing the incentive effects of most tax changes, it is only over the past decade or so that such measures have been calculated and put to use.[9]

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 that 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, where the weights are the proportions of adjusted gross income falling within each income class.

A similar procedure is followed for the federal corporation income tax. This is possible because for each of the seven main sectors of the economy, 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. Full details of these procedures are described in Appendix 2.

[9] An early example is Leslie Papke (1990), "Taxes and Other Determinants of Gross State Product in Manufacturing: A First Look," in Frederick Stocker (ed.), *Proceedings of the Eighty-Second Annual Conference 1989*, National Tax Association – Tax Institute of America, Columbus Ohio.

Table 3
Description of Variables and Their Sources

	Description	Measurement	Source
L	Labor by sector	Number of people employed, in thousands.	BLS
w	Wage rate by sector	Total payroll divided by number of jobs.	BEA
K	Capital stock by sector	See Appendix 3.	Census & other sources
PW	Working-age population	Population of age 16-64.	Census
q	Index of U.S. economic activity.	Measures used include: U.S. unemployment rate (in %); index of real sectoral output; U.S. real wage rates by sector.	Economic Report of the-President; BEA
G_{tr}	Real government transfer payments per nonworking adult aged 16-64	Federal income maintenance transfers and unemployment insurance.	BEA, BLS and Census
v	State tax rate on use of labor services	Unemployment insurance tax rate.	BLS
r	Cost of capital by sector	See Appendix 4. Also, see Appendix 2 for measurement of the components of r.	BEA, IRS and other sources
t_{sl}	Average marginal state tax rate on income applied to Minnesota residents		
t_{sa}	Sales tax rate	Revenue from general and motor vehicle sales tax, plus revenue from alcohol, tobacco and motor fuel excises, divided by sales of these goods.	State tax dept., BEA, and U.S. Dept. of Energy
t_{fl}	Average marginal federal tax rate on income applied to Minnesota residents	See Appendix 2. Does not include SSI payments.	SOI
t_{pc}	Local tax rate on commercial and industrial property	Average tax rate. See Appendix 2.	Minnesota
t_{pr}	Local tax rate on residential property	Average tax rate. See Appendix 2.	Minnesota

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

b. The stock of private capital in Minnesota

It was necessary to construct a measure of the net stock of fixed nonresidential private capital, by industry, for Minnesota for each year from 1974 through 1997. 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 Minnesota's share of national capital, in each category, we applied a series of proxies. For instance we took the state's share of capital in the communications sector 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 the Minnesota share to be in proportion to the state's share of sales in these categories. The complete details are given in Appendix 3.

c. The cost of capital

Businesses make decisions about investment based, in large 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 4) that

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

This equation shows 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 that is allowed under the tax laws (α_t), the depreciable life of the asset (DL), and the tax rate on corporate property (β). 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 4.

Estimating the Model

To estimate the reduced-form equations we applied a pooled time-series cross-section data estimation method, for the time period of 1974-1998. The estimation method corrects for

common econometric problems arising from pooled data including autocorrelation and groupwise heteroscedasticity. The results of estimating the employment, wage rate and capital stock equations are set out in Table 4. The coefficients shown here are the ones used to develop the simulations that are set out in the subsequent sectors of this report.

Table 4
Results of Estimating the Employment, Wage Rate and Capital Stock Equations

	***Employment Equation*^{L}**		***Wage Equation*^{L}**		***Capital Equation*^{L}**	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Dependent variable:	ln(employment)		ln(wage)		ln(capital stock)	
Independent variables:						
Welfare payment per nonworking adult^{L}	-0.019	-1.487	0.011	0.012	-0.040*	-3.099
State tax rate on use of labor (UE insurance tax)	-0.667	-0.772	-0.451	-0.504	-2.109*	-1.912
Cost of capital^{L}	-0.035*	-4.892	0.017*	2.828	-0.020*	-2.621
State tax rate on labor income	-0.895*	-2.543	-0.354	-1.141	0.016	0.153
Federal tax rate on labor income	0.017	0.116	0.232*	1.668	-0.055	-0.409
State sales tax	-0.635*	-1.481	0.525	1.305	-0.916*	-2.252
Constant	15.153*	8.344	1.869*	3.680	0.040*	3.863
AR(1)	0.999*	514.99	0.816*	21.763	0.875*	18.025
Other variables	Index of US output, by sector		US real wage rate, by sector		Index of US output, by sector	
Adjusted R^2	0.999		0.74		0.68	

Notes: Coefficients significant at 15% level or better are marked with *.
The estimated sector-specific intercept terms are not reported in this table. Variables marked with an ^{L} are in logs.

4. Simulating the Effect of Changes in Taxes

In this chapter we trace the effects of tax changes on economic activity in Minnesota, and more specifically on the number of workers *L*, the wage rate *w*, and the capital stock *K*. The next chapter focuses on the affordability of the proposed tax cuts, and asks whether the cuts are fiscally prudent.

Two steps are needed in order to simulate the effect of tax changes on the variables of interest. First we must establish baseline values for the variables, projecting them out through 2004. Then we have to use our estimated reduced form equations to determine how tax changes affect the variables of interest in each year. By comparing the projections with and without the tax cuts, we are able to identify the net effect of the tax reductions themselves.

Constructing the Baselines

The baseline projections are summarized in Table 5. They show employment, nominal wages, capital stock, and tax revenue for 2000 through 2004, on a calendar year basis. With the exception of the capital stock (which we assume will grow at a real rate of 2% per year, in line with recent historical experience), the projections are derived from the forecasts reported by the Minnesota Department of Finance in its *February Forecast*, which was published in March 2001. All forecasts are subject to regular revision, because it is not easy to predict the future. Fortunately our simulation results are not particularly sensitive to the baseline projections.

Table 5
Baseline Projections for 2000-2004 (in prices of 2000)

	Number of jobs	Wage rate, $ per annum	Capital stock, $m	General fund revenues, $m
2000	2,947,868	45,016	159,543	12,306
2001	2,968,503	45,985	162,734	13,210
2002	2,995,220	47,386	165,989	13,808
2003	3,043,143	48,782	169,309	14,499
2004	3,079,661	50,219	172,695	15,277

Source: Derived from Minnesota Department of Finance, *February Forecast*, March 2001.

Simulation 1: Cutting the State Personal Income Tax in Three Steps

What would happen if the state personal income tax rate were changed – for instance if it were reduced by half a percentage point now, by a further quarter percentage point in 2003, and yet another quarter percentage point in 2004?

We first estimate the effect of the change in the statutory rate on the average marginal tax rate, by asking how much tax would be paid by individuals in each income bracket before and after the tax cut. The new average marginal tax rate can then be computed, and in this case it falls by 0.40 percentage points (relative to current levels) in 2001 and 2002, by 0.60 points in 2003, and by 0.80 percentage points thereafter.

These are the numbers required to work out the economic effects of the tax change, using the reduced form equations. For instance, from the estimation results in Table 4 we note that when the tax on labor income, t_{sl}, falls by one percentage point, the number of jobs rises by 0.895%. Thus

$$\Delta L_{2001} = L_{\text{baseline}} * (-0.895)*(\Delta t_{sl}) = 2.969\text{m} \times (-0.895)*(-0.004) = 10{,}597,$$

which means that the tax reduction will boost employment by 10,597. Employment growth now continues as before, but from a larger base. The effect of tax changes in subsequent years is computed in similar fashion. According to our estimations, the state income tax does not affect the wage rate or the capital stock. However the larger employment means that payroll payments will be higher than they otherwise would have been.

The economic effects of cutting the proposed tax cuts are summarized in Table 6. The most noteworthy points are:

- The tax cut would raise the number of jobs in the state by over 10,000 initially, and by about 22,000 by 2004. This would be a permanent increase.
- The tax cut would boost payroll payments by almost $400 million annually, eventually doubling to over $800 million, or about $250 per working-age adult per year.

Table 6
Economic Effects of Cutting Personal Income Tax
(by half a percentage point in 2001 and a further half percentage point in 2003)

	Employment ('000)			*Payroll ($m)*			*Tax revenue ($m)*		
	Baseline	Tax cut	Change	Baseline	Tax cut	Change	Baseline	Tax cut	Change
2000	2,948	2,948	0	100,409	100,049	0	12,306	12,306	0
2001	2,969	2,979	11	103,288	103,657	369	13,210	12,800	-410
2002	2,995	3,006	11	107,395	107,781	387	13,808	13,375	-433
2003	3,043	3,060	17	112,325	112,927	61	14,499	13,806	-693
2004	3,080	3,102	22	117,023	117,876	853	15,277	14,296	-980

Source: Based on Minnesota-STAMP model. See text for explanation of computations.

Tracing the effects of tax cuts on tax revenue

How will the proposed cuts in the income tax rate affect state tax revenue? In answering this question it is helpful to distinguish between static and dynamic revenue effects.

The static revenue effect measures the change in tax revenue that results directly from the change in the tax rate, assuming that firms and households do not react to the tax change by altering their behavior. Thus the static revenue effect is measured by the change in the tax rate times the tax base. Most analyses of tax changes only compute the static revenue effects.

Of course tax changes do affect behavior, as we have demonstrated clearly above. For example, our regression results show that a cut in the tax rate on labor income leads to an increase in the number of workers and the total payroll. This in turn expands the tax base, leading to more tax revenue (the "dynamic" revenue effect), offsetting in part the static revenue effects. In what follows we report the net tax effects, while also presenting information on both the static and dynamic components.

Static Tax Revenue Effect: Labor Income. The static revenue loss from the tax cut is computed as the change in the average tax rate times the old tax base. The income tax base is not known directly, but we took payroll payments as a convenient and plausible proxy. So, for instance, the static revenue effect of lowering the statutory income tax rate by a half percentage point would

be to reduce the *average* tax rate (as defined here) from 5.82% to 5.39%, or by 0.43% points. Thus

$$\Delta TR_L^S = \$103.3 \text{ billion} \times \Delta t_{sl} = \$103.3 \text{ billion} \times (-0.43\%) = -\$444 \text{ million}.$$

Similar computations are needed for each year.

Dynamic Revenue Effects. The dynamic revenue gain arises because the tax cuts themselves lead to more economic activity, and hence an increase in the tax base for labor income, capital income, sales, and property values. Let us consider each of these in turn.

- The income tax base is assumed to rise in line with payroll payments. When the tax cuts lead to more employment and a higher payroll, the income tax base will expand too.
- A proxy for the base of the sales tax ("taxable sales") is estimated total sales, and this was used to get the average sales tax rate. The level of taxable sales is closely related to payroll payments, and we assume that the two move together (although not on a one-to-one basis; a regression shows sales = constant + 0.49 × payroll).
- The base of the corporate income tax is assumed to change in proportion to the total stock of capital.

The net effects of these changes are summarized in Table 7.

Table 7
Static and Dynamic Revenue Effects of a Cut in the State Personal Income Tax
(by half a percentage point in 2001 and a further half percentage point in 2003)

	Static Effects ($m)	Dynamic Effects ($m)				Net
	Income Tax	Labor Income Tax	Sales Tax	Capital Income Tax	Total Dynamic	$m
2000	0	0	0	0	0	0
2001	-444	20	13	0	33	-410
2002	-469	22	14	0	36	-433
2003	-750	34	23	0	57	-693
2004	-1,061	48	33	0	80	-980

Source: Derived from simulations based on Minnesota STAMP model.

Given that it entails a significant loss of revenue, is an income tax cut of this magnitude affordable? The simplest way to measure the affordability of tax cuts is to project revenues and expenditures into the future with, and without, the tax cut. It is then straightforward to trace the effects on the budget deficit, and the accumulated fiscal surplus (the "funds balance"), and to

look at the effect on the budget deficit. This is done in Table 8 for a phased reduction of the state income tax – down by half a percentage point in 2001, a further quarter percentage point in 2003 and another quarter percentage point in 2004.

Table 8.
State Revenue, Spending and Surpluses, for Status Quo and Income Tax Cut
(by half a percentage point in 2001 and further quarter percentage points in 2003 and 2004)

	2000	2001	2002	2003	2004
Forecast, based on status quo					
General fund revenue, $m	12,306	13,210	13,808	14,499	15,277
Expenditure, $m	12,299	12,800	13,028	13,463	13,974
Budget surplus, $m	7	410	780	1,036	1,303
Balance in funds, $m, end of year	2,012	1,566	2,346	3,382	4,685
Forecast, lower personal income tax *(down half a % point in 2001,3/4 % point in 2003, full % point in 2004)*					
Tax revenue, $m	12,306	12,800	13,375	13,806	14,296
Expenditure, $m	12,299	12,800	13,028	13,463	13,974
Budget surplus, $m	7	0	346	343	323
Balance in funds, $m, end of year	2,012	1,156	1,502	1,846	2,169

Source: From simulations based on Minnesota STAMP 2001. Data refer to calendar years. Projections of revenue and expenditure in base case are based on Minnesota Department of Revenue, *February Forecast*, March 2001..

It is clear from the numbers in Table 8 that a one percentage point decrease in the state personal income tax is affordable under normal conditions – i.e. if there is no recession. We show below (Table 13) that this tax cut would also be manageable even if there were a recession.

A note on capital gains

Minnesota is somewhat unusual in that the state taxes capital gains at the same rate as other forms of income. Massachusetts, for instance, taxes short-term capital gains at a similar rate to other income, but taxes long-term capital gains at much lower rates.[10] The case for a lower rate on long-term capital gains is to avoid taxing capital gains that are, in effect, due largely to inflation.

[10] Massachusetts levies the following tax rates on capital gains:

Assets held 1-2 years	5%
Assets held 2-3 years	4%
Assets held 3-4 years	3%
Assets held 4-5 years	2%
Assets held 5-6 years	1%
Assets held >6 years	0%.

To illustrate, consider the case of an investor who buys a piece of land for $100,000. Five years later he sells the land for $130,000, for a nominal capital gain of $30,000, which will now be taxed. However, suppose that over this same period prices in general rose by 20%. Then $20,000 of this capital gain was not a true capital gain, but just an adjustment for inflation. If capital gains tax were properly indexed, the tax would apply to the net capital gain of $10,000. In practice, capital gains are rarely indexed; instead, the tax rate on capital gains tends to be set at a lower rate – a crude and imperfect solution to the indexing problem. The longer the holding period, the bigger the problem, which is why Massachusetts has successively lower tax rates on longer-term capital gains.

The Minnesota STAMP model could be used to measure the economic effects of a lower state capital gains tax. A lower capital gains tax would reduce the average marginal tax rate on income, and this would boost employment and payroll.

Simulation 2: Lowering the Sales Tax

Very similar reasoning applies to the analysis of a change in the sales tax, so we report the numbers without much discussion. The thought experiment here asks what would be the effects of reducing the sales tax rate by one percentage point. The economic effects are shown in Table 9 and the revenue effects in Table 10. The figures are easy to compute, using the simulation spreadsheet that accompanies this report. Of note are the following:

- The cut in the sales tax would raise the number of jobs by about 19,000 annually.
- The capital stock would rise by over $1 billion in the first year. By 2004 it would have accumulated to the point of being $6 billion larger than without the tax cut.
- State revenue would be about $500 million lower annually, but payroll in the state would be at least $600 million higher.

Source: *2000 Massachusetts Resident Income Tax Form 1: All Schedules and Instructions*, Boston.

Table 9
Economic Effects of Cutting Sales Tax by One Percentage Point

	Employment ('000)			*Payroll ($m)*			*Tax revenue ($m)*		
	Baseline	Tax cut	Change	Baseline	Tax cut	Change	Baseline	Tax cut	Change
2000	2,948	2,948	0	100,409	100,049	0	12,306	12,306	0
2001	2,969	2,987	19	103,288	103,945	656	13,210	12,701	-509
2002	2,995	3,014	19	107,395	108,083	689	13,808	13,292	-516
2003	3,043	3,063	20	112,325	113,057	731	14,499	13,963	-536
2004	3,080	3,100	20	117,023	117,794	771	15,277	14,715	-562

Source: Based on Minnesota STAMP model. See text for explanation of computations.

Table 10
Static and Dynamic Revenue Effects of Cutting Sales Tax by One Percentage Point

	Static Effects ($m)	Dynamic Effects ($m)				Net
	Sales Tax	Labor Income Tax	Sales Tax	Capital Income Tax	Total Dynamic	$m
2000	0	0	0	0	0	0
2001	-575	39	21	7	67	-509
2002	-595	42	22	16	79	-516
2003	-631	46	24	26	96	-536
2004	-675	50	26	37	113	-562

Source: Derived from simulations based on Minnesota STAMP model.

Simulation 3: Smaller reductions in the personal income tax

In our third experiment, we ask what the effects would be if the personal income tax were reduced by 0.2% points in 2002, a further 0.2% in 2003 and an additional 0.1% in 2004. This scenario is of interest because it reflects Governor Jesse Ventura's current proposal. The key results are summarized in Table 11.

Table 11
Economic Effects of Introducing an Revenue-Neutral Flat Income Tax

	Employment ('000)			*Payroll ($m)*			*Tax revenue ($m)*		
	Baseline	Tax cut	Change	Baseline	Tax cut	Change	Baseline	Tax cut	Change
2000	2,948	2,948	0	100,409	100,049	0	12,306	12,306	0
2001	2,969	2,969	0	103,288	103,288	0	13,210	13,210	0
2002	2,995	2,999	4	107,395	107,548	153	13,808	13,635	-173
2003	3,043	3,052	9	112,325	112,649	323	14,499	14,130	-369
2004	3,080	3,091	11	117,023	117,447	424	15,277	14,788	-488

Source: Based on Minnesota STAMP model. See text for explanation of computations.

Cutting the Tax Rate versus Tax Rebates

There is an important implication of these findings, which is that changes in the tax rate matter. This means that a cut in the tax rate, which affects behavior, will have more marked effects than a tax rebate. The reason is that tax rebates, because they are so unpredictable, and because they are so weakly linked to actual decisions (about how much to earn, or whether to spend), have very little bite at the margin. Although the recent rebates have been billed as "sales tax" rebates, in practice they have been more closely related to household income, and even then only loosely. Earlier rebates were linked to the property tax (see Table 12).

This logic is probably behind an important shift in Minnesota tax policy, which is moving away from large rebates and toward rate reductions. The trend is captured in Table 12, which shows the size of rebates and tax cuts in the recent past and for the foreseeable future.

Table 12
Value of tax rebates and cuts, $million

	Rebates:		Tax reductions	
	Property tax	Sales tax	Income tax	Motor Vehicle Tab
FY 1997	500			
FY 1998	470			
FY 1999		1,300		
FY 2000		650	788	
FY 2001		856 (est.)	787	147
FY 2002			745	157
FY 2003			777	171

Sources: Minnesota Department of Finance, *Economic Update*, July 2000; and *February Forecast*, March 2001.

5. Weathering a Recession

An important concern voiced by opponents of tax cuts is that they are not affordable. There are actually two arguments here. First, would the tax cuts lead to budget deficits. Second, even if the tax cuts are affordable under normal conditions, they might be imprudent in that they would endanger the state's ability to weather a recession without a fiscal crisis.

In the previous section we simulated the effects of three tax proposals. We also showed that in each case the proposed tax reductions are affordable, in the sense that under normal economic conditions they would not push the state budget into deficit.

Weathering a recession: economic effects

Would it be fiscally imprudent to cut the income tax by one percentage point? One way to address this question is to ask whether such a tax cut would undermine the ability of Minnesota state government to weather a recession. We proceed by supposing that the United States slips into recession in 2002,[11] and then trace the effects of the recession on the fiscal health of Minnesota, assuming that a tax cut has been implemented.

The reduced form equations for the number of jobs, and for the capital stock, in the Minnesota STAMP model include, as exogenous variables, an index of output in the rest of the United States, for each sector. On average, in the last six recessions, U.S. GDP has fallen by 2%. Let us assume that this will occur in the next recession, which we further suppose will begin in 2002. Putting this reduction into the model allows us to predict that the recession will

- reduce the number of jobs by 0.7%,[12] and
- reduce the capital stock by 0.1%.

We also suppose that employment growth (but not total employment) returns to normal by 2003.

[11] As of this writing – April 2001 – the U.S. economy is not slipping into recession, although it is certainly growing rather slowly. For a well-respected analysis, see www.wefa.com.

Our interest here is in the effects of the combination of a tax cut and recession on the fiscal health of Minnesota. The procedures used to estimate the revenue effects of the tax cut were discussed in detail above. The effects of recession have to be superimposed on these results: the lower level of employment leads to less revenue from the taxes on labor income and on sales, and the reduced capital stock causes the revenue from the commercial and industrial property tax to shrink. We also assume that the onset of recession would reduce the growth of state spending modestly (by 1% in the first year, and 2% in the subsequent year). Restraint in hiring and in wages paid by the state, greater discipline in capital spending, and lower debt servicing costs would outweigh the additional costs of health care and welfare payments.[13]

Consider the case of a cut in the state income tax of half a percentage point from 2001, and further quarter percentage point reductions in each of 2003 and 2004, combined with a recession in 2002. The result would be that instead of running a surplus, the state budget would be essentially in balance - with a tiny surplus in 2003 and a small deficit in 2004. The details are set out in Table 13. Although our simulation thus shows that this tax cut is manageable *even in the event of a recession*, one could also hedge against the risks of premature tax cuts by making successive rounds of cuts contingent on there being a sufficiently large balance carried over in the rainy day fund.

Table 13
State Revenue, Spending and Surpluses, Income Tax Cut Coupled with Recession in 2002

	2000	2001	2002	2003	2004
Forecast, lower personal income tax, recession scenario					
(Tax cut: half a % point in 2001,a further 1/4 % point in 2003 and a further 1/4 % point in 2004)					
Tax revenue, $m	12,306	12,800	12,897	13,076	13,529
Expenditure, $m	12,299	12,800	12,898	13,061	13,557
Budget surplus, $m	7	0	-1	14	-28
Balance in funds, $m, eoy	2,012	1,156	1,155	1,169	1,141

Source: From simulations based on Minnesota STAMP 2001. Data refer to calendar years. Projections of revenue and expenditure in base case are based on Minnesota Department of Revenue, *February Forecast*, March 2001.

[12] This may seem like a small reduction. However if the labor force is growing at the same time (e.g. by 1.3% p.a.), then the effect on the unemployment rate could be large (in this case pushing it up by 2 percentage points in a year).
[13] Health care costs are largely driven by demographics, and so (surprisingly) are not very sensitive to recession; see the Minnesota Department of Revenue, *February Forecast* (March 2001), p.48, for a discussion. A significant amount of spending for needy families comes from the TANF (Temporary Assistance to Needy Families) fund, largely financed by block grants from the Federal government, and which is separate from the general fund.

6. Detailed Simulation Results

Minnesota STAMP comes with a spreadsheet that is straightforward to use, and allows one quickly to estimate the effects of different tax changes. The spreadsheet has a worksheet labelled "Summary Table" that provides a wealth of detail for each simulation. In this section we reproduce the summary table results the three simulations discussed above, along with very brief commentaries.

1. *Cut personal income tax by half a percentage point in 2001 and a further quarter percentage point in each of 2003 and 2004 (Table 14).*

This simulation has already been presented in some detail above. For the first two years, the number of jobs would rise by over 10,000, and when the full tax reduction is in effect the number of jobs would increase by 22,000. Tax revenue would fall by about $1 billion annually from 2003 onwards; in normal times, this is eminently affordable. If a recession were to hit Minnesota in 2002, then the tax cut would still be affordable because the budget would still be in balance.

2. *Lower the sales tax by one percentage point (Table 15).*

This too is a simulation that was discussed above. The employment effects are moderately large – about 20,000 more jobs would be added in Minnesota – and the revenue cost would be just slightly more than $500 million annually, which is definitely affordable, even in a recession.

3. *Cut the personal income tax by 0.2% points in 2002, as much again in 2003, and by a further 0.1% points in 2004 (Table 16).*

In effect this phases in a half percentage point cut over three years. In a recession, there would still be significant surpluses (at least $250 million per year) even with this tax cut, so it is easily affordable.

Table 14

Results of simulations, compared to baseline values (in 2000 dollars)

	1997	1998	1999	2000	2001	2002	2003	2004
Baseline values								
Number employed	2,755,559	2,836,185	2,895,745	2,947,868	2,968,503	2,995,220	3,043,143	3,079,661
Capital Stock, $M	150,341	153,348	156,415	159,543	162,734	165,989	169,309	172,695
Wage rate, $/person/yr	$ 40,895	$ 42,090	$ 43,244	$ 45,016	$ 45,985	$ 47,386	$ 48,782	$ 50,219
Payroll, $M	85,267	90,325	94,751	100,409	103,288	107,395	112,325	117,023
Tax revenue, $M, nom.				12,306	13,210	13,808	14,499	15,277
State expenditure, $M, nom				12,299	12,800	13,028	13,463	13,974
Budget surplus, $m				7	410	780	1,036	1,303
Fund balance, eoy, $m				2,012	1,566	2,346	3,382	4,685
Simulation results								
Number employed				2,947,868	2,979,101	3,006,008	3,059,707	3,102,116
Capital Stock, $M				159,543	162,734	165,989	169,309	172,695
Wage rate, $/person/yr				45,016	45,985	47,386	48,782	50,219
Payroll, $M				100,409	103,657	107,781	112,937	117,876
Tax revenue, $M, nom.				12,306	12,800	13,375	13,806	14,296
Change vis a vis baseline								
Number employed				-	10,597	10,788	16,564	22,455
Capital Stock, $M				-	-	-	-	-
Wage rate, $/person/yr				-	-	-	-	-
Payroll, $M				-	369	387	611	853
Tax revenue, $M, nom.				-	(410)	(433)	(693)	(980)
of which: static					(444)	(469)	(750)	(1,061)
dynamic					33	36	57	80
Tax revenue, $m				12,306	12,800	13,375	13,806	14,296
Expenditure, $m				12,299	12,800	13,028	13,463	13,974
Budget surplus, $m				7	(0)	346	343	323
Fund balance, eoy, $m				2,012	1,156	1,502	1,846	2,169
Values in recession								
Number employed	2,755,559	2,836,185	2,895,745	2,947,868	2,968,503	2,947,980	2,995,148	3,031,090
Capital Stock, $M	150,341	153,348	156,415	159,543	162,734	162,594	163,407	165,041
Wage rate, $/person/yr	$ 40,895	$ 42,090	$ 43,244	$ 45,016	$ 45,985	$ 46,237	$ 46,673	$ 48,049
Payroll, $M	85,267	90,325	94,751	100,409	103,288	103,137	105,776	110,200
Tax revenue, $M, nom.	-	-	-	12,306	13,210	13,314	13,729	14,452
State expenditure, $M, nom				12,299	12,800	12,898	13,061	13,557
Budget surplus, $m				7	410	416	667	895
Fund balance, eoy, $m				2,012	1,566	1,982	2,649	3,544
Change vis a vis baseline								
Number employed	-	-	-	-	-	(47,239)	(47,995)	(48,571)
Capital Stock, $M	-	-	-	-	-	(3,395)	(5,902)	(7,654)
Wage rate, $/person/yr	-	-	-	-	-	(1,150)	(2,108)	(2,170)
Payroll, $M	-	-	-	-	-	(4,258)	(6,549)	(6,823)
Tax revenue, $M, nom.	-	-	-	-	-	(494)	(770)	(824)
State expenditure, $m, non	-	-	-	-	-	(130)	(401)	(416)
Simulation results, recession case								
Number employed				2,947,868	2,979,101	2,958,431	3,011,281	3,053,019
Capital Stock, $M				159,543	162,734	162,594	163,407	165,041
Wage rate, $/person/yr				45,016	45,985	46,237	46,673	48,049
Payroll, $M				100,409	103,657	103,502	106,346	110,997
Tax revenue, $M, nom.				12,306	12,800	12,897	13,076	13,529
Change vis a vis recession baseline								
Number employed				-	10,597	10,451	16,132	21,929
Capital Stock, $M				-	-	-	-	-
Wage rate, $/person/yr				-	-	-	-	-
Payroll, $M				-	369	366	570	797
Tax revenue, $M, nom.				-	(410)	(417)	(653)	(923)
of which: static					(444)	(451)	(706)	(999)
dynamic					33	34	53	75
Tax revenue, $m				12,306	12,800	12,897	13,076	13,529
Expenditure, $m				12,299	12,800	12,898	13,061	13,557
Budget surplus, $m				7	(0)	(1)	14	(28)
Fund balance, eoy, $m				2,012	1,156	1,155	1,169	1,141
Memo:								
PIT				**5.35**	4.85	4.85	4.60	4.35
				7.05	6.55	6.55	6.30	6.05
				7.85	7.35	7.35	7.10	6.85
Sales tax				**7.80**	7.80	7.80	7.80	7.80
Corp Inc Tax				**5.10**	5.10	5.10	5.10	5.10

Table 15

Results of simulations, compared to baseline values (in 2000 dollars)

	1997	1998	1999	2000	2001	2002	2003	2004
Baseline values								
Number employed	2,755,559	2,836,185	2,895,745	2,947,868	2,968,503	2,995,220	3,043,143	3,079,661
Capital Stock, $M	150,341	153,348	156,415	159,543	162,734	165,989	169,309	172,695
Wage rate, $/person/yr	$ 40,895	$ 42,090	$ 43,244	$ 45,016	$ 45,985	$ 47,386	$ 48,782	$ 50,219
Payroll, $M	85,267	90,325	94,751	100,409	103,288	107,395	112,325	117,023
Tax revenue, $M, nom.				12,306	13,210	13,808	14,499	15,277
State expenditure, $M, nom				12,299	12,800	13,028	13,463	13,974
Budget surplus, $m				7	410	780	1,036	1,303
Fund balance, eoy, $m				2,012	1,566	2,346	3,382	4,685
Simulation results								
Number employed				2,947,868	2,987,367	3,014,423	3,062,958	3,099,946
Capital Stock, $M				159,543	164,226	169,031	173,964	179,025
Wage rate, $/person/yr				45,016	45,985	47,386	48,782	50,219
Payroll, $M				100,409	103,945	108,083	113,057	117,794
Tax revenue, $M, nom.				12,306	12,701	13,292	13,963	14,715
Change vis a vis baseline								
Number employed				-	18,863	19,203	19,815	20,285
Capital Stock, $M				-	1,491	3,042	4,655	6,331
Wage rate, $/person/yr				-	-	-	-	-
Payroll, $M				-	656	689	731	771
Tax revenue, $M, nom.				-	(509)	(516)	(536)	(562)
of which: static					(575)	(595)	(631)	(675)
dynamic					67	79	96	113
Tax revenue, $m				12,306	12,701	13,292	13,963	14,715
Expenditure, $m				12,299	12,800	13,028	13,463	13,974
Budget surplus, $m				7	(99)	264	501	741
Fund balance, eoy, $m				2,012	1,057	1,321	1,822	2,563
Values in recession								
Number employed	2,755,559	2,836,185	2,895,745	2,947,868	2,968,503	2,947,980	2,995,148	3,031,090
Capital Stock, $M	150,341	153,348	156,415	159,543	162,734	162,594	163,407	165,041
Wage rate, $/person/yr	$ 40,895	$ 42,090	$ 43,244	$ 45,016	$ 45,985	$ 46,237	$ 46,673	$ 48,049
Payroll, $M	85,267	90,325	94,751	100,409	103,288	103,137	105,776	110,200
Tax revenue, $M, nom.	-	-	-	12,306	13,210	13,314	13,729	14,452
State expenditure, $M, nom				12,299	12,800	12,898	13,061	13,557
Budget surplus, $m				7	410	416	667	895
Fund balance, eoy, $m				2,012	1,566	1,982	2,649	3,544
Change vis a vis baseline								
Number employed	-	-	-	-	-	(47,239)	(47,995)	(48,571)
Capital Stock, $M	-	-	-	-	-	(3,395)	(5,902)	(7,654)
Wage rate, $/person/yr	-	-	-	-	-	(1,150)	(2,108)	(2,170)
Payroll, $M	-	-	-	-	-	(4,258)	(6,549)	(6,823)
Tax revenue, $M, nom.	-	-	-	-	-	(494)	(770)	(824)
State expenditure, $m, non	-	-	-	-	-	(130)	(401)	(416)
Simulation results, recession case								
Number employed				2,947,868	2,987,367	2,966,583	3,014,348	3,050,749
Capital Stock, $M				159,543	164,226	165,574	167,899	171,091
Wage rate, $/person/yr				45,016	45,985	46,237	46,673	48,049
Payroll, $M				100,409	103,945	103,787	106,454	110,915
Tax revenue, $M, nom.				12,306	12,701	12,814	13,218	13,917
Change vis a vis recession baseline								
Number employed				-	18,863	18,603	19,200	19,659
Capital Stock, $M				-	1,491	2,980	4,493	6,050
Wage rate, $/person/yr				-	-	-	-	-
Payroll, $M				-	656	651	678	715
Tax revenue, $M, nom.				-	(509)	(500)	(511)	(535)
of which: static					(575)	(576)	(600)	(641)
dynamic					67	75	90	106
Tax revenue, $m				12,306	12,701	12,814	13,218	13,917
Expenditure, $m				12,299	12,800	12,898	13,061	13,557
Budget surplus, $m				7	(99)	(84)	157	360
Fund balance, eoy, $m				2,012	1,057	973	1,130	1,490
Memo:								
PIT				**5.35**	5.35	5.35	5.35	5.35
				7.05	7.05	7.05	7.05	7.05
				7.85	7.85	7.85	7.85	7.85
Sales tax				**7.80**	6.80	6.80	6.80	6.80
Corp Inc Tax				**5.10**	5.10	5.10	5.10	5.10

Table 16

Results of simulations, compared to baseline values (in 2000 dollars)

	1997	1998	1999	2000	2001	2002	2003	2004
Baseline values								
Number employed	2,755,559	2,836,185	2,895,745	2,947,868	2,968,503	2,995,220	3,043,143	3,079,661
Capital Stock, $M	150,341	153,348	156,415	159,543	162,734	165,989	169,309	172,695
Wage rate, $/person/yr	$ 40,895	$ 42,090	$ 43,244	$ 45,016	$ 45,985	$ 47,386	$ 48,782	$ 50,219
Payroll, $M	85,267	90,325	94,751	100,409	103,288	107,395	112,325	117,023
Tax revenue, $M, nom.				12,306	13,210	13,808	14,499	15,277
State expenditure, $M, nom				12,299	12,800	13,028	13,463	13,974
Budget surplus, $m				7	410	780	1,036	1,303
Fund balance, eoy, $m				2,012	1,566	2,346	3,382	4,685
Simulation results								
Number employed				2,947,868	2,968,503	2,999,497	3,051,903	3,090,829
Capital Stock, $M				159,543	162,734	165,989	169,309	172,695
Wage rate, $/person/yr				45,016	45,985	47,386	48,782	50,219
Payroll, $M				100,409	103,288	107,548	112,649	117,447
Tax revenue, $M, nom.				12,306	13,210	13,635	14,130	14,788
Change vis a vis baseline								
Number employed				-	-	4,277	8,759	11,168
Capital Stock, $M				-	-	-	-	-
Wage rate, $/person/yr				-	-	-	-	-
Payroll, $M				-	-	153	323	424
Tax revenue, $M, nom.				-	-	(173)	(369)	(488)
of which: static					-	(188)	(400)	(530)
dynamic					-	15	31	42
Tax revenue, $m				12,306	13,210	13,635	14,130	14,788
Expenditure, $m				12,299	12,800	13,028	13,463	13,974
Budget surplus, $m				7	410	607	668	815
Fund balance, eoy, $m				2,012	1,566	2,173	2,840	3,655
Values in recession								
Number employed	2,755,559	2,836,185	2,895,745	2,947,868	2,968,503	2,947,980	2,995,148	3,031,090
Capital Stock, $M	150,341	153,348	156,415	159,543	162,734	162,594	163,407	165,041
Wage rate, $/person/yr	$ 40,895	$ 42,090	$ 43,244	$ 45,016	$ 45,985	$ 46,237	$ 46,673	$ 48,049
Payroll, $M	85,267	90,325	94,751	100,409	103,288	103,137	105,776	110,200
Tax revenue, $M, nom.	-	-	-	12,306	13,210	13,314	13,729	14,452
State expenditure, $M, nom				12,299	12,800	12,898	13,061	13,557
Budget surplus, $m				7	410	416	667	895
Fund balance, eoy, $m				2,012	1,566	1,982	2,649	3,544
Change vis a vis baseline								
Number employed	-	-	-	-	-	(47,239)	(47,995)	(48,571)
Capital Stock, $M	-	-	-	-	-	(3,395)	(5,902)	(7,654)
Wage rate, $/person/yr	-	-	-	-	-	(1,150)	(2,108)	(2,170)
Payroll, $M	-	-	-	-	-	(4,258)	(6,549)	(6,823)
Tax revenue, $M, nom.	-	-	-	-	-	(494)	(770)	(824)
State expenditure, $m, non	-	-	-	-	-	(130)	(401)	(416)
Simulation results, recession case								
Number employed				2,947,868	2,968,503	2,952,190	3,003,769	3,042,081
Capital Stock, $M				159,543	162,734	162,594	163,407	165,041
Wage rate, $/person/yr				45,016	45,985	46,237	46,673	48,049
Payroll, $M				100,409	103,288	103,284	106,080	110,599
Tax revenue, $M, nom.				12,306	13,210	13,148	13,381	13,992
Change vis a vis recession baseline								
Number employed				-	-	4,210	8,621	10,991
Capital Stock, $M				-	-	-	-	-
Wage rate, $/person/yr				-	-	-	-	-
Payroll, $M				-	-	147	304	400
Tax revenue, $M, nom.				-	-	(166)	(347)	(460)
of which: static					-	(180)	(377)	(499)
dynamic					-	14	29	39
Tax revenue, $m				12,306	13,210	13,148	13,381	13,992
Expenditure, $m				12,299	12,800	12,898	13,061	13,557
Budget surplus, $m				7	410	250	320	435
Fund balance, eoy, $m				2,012	1,566	1,816	2,136	2,571
Memo:								
PIT				**5.35**	5.35	5.15	4.95	4.85
				7.05	7.05	6.85	6.65	6.55
				7.85	7.85	7.65	7.45	7.35
Sales tax				**7.80**	7.80	7.80	7.80	7.80
Corp Inc Tax				**5.10**	5.10	5.10	5.10	5.10

Appendix 1:
Minnesota-STAMP: Deriving the Reduced-Form Equations

a. Introduction

This note provides a detailed derivation of the reduced form equations that are estimated in *The Minnesota State Tax Analysis Modeling Program (Minnesota-STAMP): Methodology and Applications*.

b. Labor Supply by Households

Households with a fixed labor endowment of $\overline{L}$ choose how to divide $\overline{L}$ between work (*L*) and leisure $\left(1 = \overline{L} - L\right)$ 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:

(A1.1) $\max U = AC^{\theta}1^{1-\theta}$

subject to

(A1.2) $C(1+t_s) + 1w(1-t_{fl})(1-t_{sl}) = w\overline{L}(1-t_{fl})(1-t_{sl}) + G_{tr}$,

where

C = the consumption of goods and services;

t_s = the sales tax rate;

λ = 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; and

G_{tr} = government transfer payments.

The problem in (A1.1) may be rewritten as:

(A1.3) $$\max \Psi = AC^{\theta} l^{(1-\theta)} - \lambda\left[C(1+t_s) + l w(1-t_{fl})(1-t_{sl}) - w\bar{L}(1-t_{fl})(1-t_{sl}) - G_{tr}\right].$$

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

(A1.4) $$\frac{\partial \Psi}{\partial C} = \frac{\theta U}{C} - \lambda(1+t_s) = 0,$$

(A1.5) $$\frac{\partial \Psi}{\partial l} = \frac{(1-\theta)U}{l} - \lambda w(1-t_{fl})(1-t_{sl}) = 0,$$

(A1.6) $$\frac{\partial \Psi}{\partial \lambda} = (1+t_s)C + l w(1-t_{fl})(1-t_{sl}) - w\bar{L}(1-t_{fl})(1-t_{sl}) - G_{tr} = 0.$$

By solving (A1.4) and (A1.5) simultaneously for λ one obtains:

(A1.7) $$l = \frac{(1-\theta)(1+t_s)C}{\theta w(1-t_{fl})(1-t_{sl})}.$$

Substituting (A1.7) into (A1.6) yields:

(A1.8) $$C = \frac{\theta\left[w\bar{L}(1-t_{fl})(1-t_{sl}) + G_{tr}\right]}{(1+t_s)}.$$

Substituting (A1.8) into (A1.7) yields the demand for leisure:

(A1.9) $$l = (1-\theta)\left[\bar{L} + \frac{G_{tr}}{w(1-t_{fl})(1-t_{sl})}\right].$$

Then, an individual's total supply of labor, L, is $\bar{L} - \lambda$ and is written as:

(A1.10) $$L = \theta\bar{L} - \frac{(1-\theta)G_{tr}}{w(1-t_{fl})(1-t_{sl})}.$$

Here L refers to the labor supply of a single individual. Total labor supply, L^s, is found by multiplying by the working-age population (PW), so $L^s = PW * L$, and so $\ln L^s = \ln PW + \ln L$. With appropriate substitution from equation (A1.10) we obtain

(A1.11) $$\ln L^s = q_0 + q_1 \ln G_{tr} + q_2 \ln w + q_3 t_{fl} + q_4 t_{sl} + q_5 \ln PW.$$

We could work with this equation, but there is one difficulty: the working-age population in the state (PW) is not given exogenously. It is determined in part by economic conditions in the state (where in our study the employment level reflects current job market conditions, L^s), the state tax on labor income (t_{sl}), the state sales tax (t_s), and the residential property tax rate (t_{proptr}). This gives:

(A1.12) $$\ln PW = e_0 + e_1 \ln L^s + e_2 t_{sl} + e_3 t_s + e_4 t_{proptr}.$$

Substituting this into the previous equation gives

(A1.13) $$\ln L^s = c_0 + c_1 \ln G_{tr} + c_2 \ln w + c_3 t_{fl} + c_4 t_{sl} + c_5 t_s + c_6 t_{proptr},$$

where

$c_0 = q_0 + q_5 e_0$;

$c_1 < 0$;

$c_2 > 0$;

$c_3 < 0$;

$c_4 = q_4 + q_5 e_2 < 0$;

$c_5 = q_5 e_3 < 0$;

$c_6 = q_5 e_4 < 0$.

c. Labor and Capital 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.[14] As explained below, *r* increases with the total tax rate on capital t_{ck}.

We treat the sales tax rate, t_s, 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. Buchanan and Marilyn R. Flowers have

[14] A detailed derivation of cost of capital appears in Appendix 4.

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."[15] 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."[16]

We assume a generalized Cobb-Douglas production function of the following form:

(A1.14) $Q = HqL^{\alpha}K^{\beta}$.

where $0<\alpha,\beta<1$ and H is a parameter. 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. Concretely, the effect of national economic conditions is usually measured by the U.S. production index, *q*. It may be helpful to think of this as a shift paramater, that measures how far below its production frontier the state economy is actually producing. The profit-maximizing problem of producers may be written as:

(A1.15) $\max \pi = pHq\left(1-t_s\right)L^{\alpha}K^{\beta} - w(1+v)L - rK$,

where p is the price of output, here normalized to 1.

The first-order conditions for a profit maximum are:

(A1.16) $\frac{\partial \Pi}{\partial L} = \alpha Hq(1-t_s)\frac{L^{\alpha}}{L}K^{\beta} - w(1+v) = 0$ and

(A1.17) $\frac{\partial \Pi}{\partial K} = \beta Hq(1-t_s)L^{\alpha}\frac{K^{\beta}}{K} - r = 0$.

Some manipulation gives

[15] James M. Buchanan, *The Public Finances: An Introductory Textbook*, 3d ed., (Homewood, IL: Richard D. Irwin, 1970), p. 382.
[16] Richard E. Wagner, *Public Finance: Revenues and Expenditures in a Democratic Society* (Boston: Little, Brown and Company, 1983), p. 269.

$$\frac{\alpha K}{\beta L} = \frac{w(1+v)}{r} \text{ so } K = \frac{w(1+v)L}{r}\frac{\beta}{\alpha} \text{ and } L = \frac{r}{w(1+v)}\frac{\alpha K}{\beta}.$$

Then

$$\alpha Hq(1-t_s)L^{\alpha-1}\left(\frac{w(1+v)L}{r}\frac{\beta}{\alpha}\right)^{\beta} = w(1+v),$$

so

$$L^{\alpha+\beta-1} = w^{1-\beta}(1+v)^{1-\beta}r^{\beta}(1-t_s)^{-1}\alpha^{\beta-1}\beta^{-\beta}H^{-1}q^{-1}.$$

Assuming $\alpha+\beta<1$ and using the approximation that $\ln(1+x)\approx x$, we get

(A1.18)
$$\ln L = \frac{\beta-1}{1-\alpha-\beta}\ln w + \frac{\beta-1}{1-\alpha-\beta}v - \frac{\beta}{1-\alpha-\beta}\ln r + \frac{1}{1-\alpha-\beta}\ln q - \frac{1}{1-\alpha-\beta}t_s + \frac{1}{1-\alpha-\beta}\ln\left(\alpha^{\beta-1}\beta^{-\beta}H^{-1}\right),$$

which may be simplified to give

(A1.19)
$$\ln L^d = \lambda_0 + \lambda_1\ln q + \lambda_2\ln r + \lambda_3\ln w + \lambda_4 v + \lambda_5 t_s.$$

$$+ \quad - \quad - \quad - \quad -$$

Similarly,

$$\beta Hq(1-t_s)\left(\frac{r\alpha K}{w(1+v)\beta}\right)^{\alpha}K^{\beta-1} = r,$$

and so

$$K^{\alpha+\beta-1} = r^{1-\alpha}w^{\alpha}(1+v)^{\alpha}\beta^{\alpha-1}\alpha^{-\alpha}(1-t_s)^{-1}H^{-1}q^{-1}.$$

This gives

(A1.20)
$$\ln K = \frac{\alpha-1}{1-\alpha-\beta}\ln r - \frac{\alpha}{1-\alpha-\beta}\ln w - \frac{\alpha}{1-\alpha-\beta}v + \frac{1}{1-\alpha-\beta}\ln q - \frac{1}{1-\alpha-\beta}t_s + \frac{1}{1-\alpha-\beta}\ln\left(\alpha^{-\alpha}\beta^{\alpha-1}H^{-1}\right).$$

(A1.21)
$$\ln K = \kappa_0 + \kappa_1\ln r + \kappa_2\ln w + \kappa_3 v + \kappa_4\ln q + \kappa_5 t_s.$$

$$- \quad - \quad - \quad + \quad -$$

d. Deriving the Reduced Form Equations

Setting labor supply (A1.13) equal to labor demand (A1.19) gives

(A1.22) $$c_0 + c_1 \ln G_{tr} + c_2 \ln w + c_3 t_{fl} + c_4 t_{sl} + c_5 t_s + c_6 t_{proptr} = \lambda_0 + \lambda_1 \ln q + \lambda_2 \ln r + \lambda_3 \ln w + \lambda_4 v + \lambda_5 t_s .$$

Collecting terms, yields the following:

(A1.23) $$(c_2 - \lambda_3)\ln w \approx (\lambda_0 - c_0) + \lambda_1 \ln q + \lambda_2 \ln r + \lambda_4 v - c_1 \ln G_{tr} - c_3 t_{fl} - c_4 t_{sl} + (\lambda_5 - c_5) t_s - c_6 t_{proptr} ,$$

or, more simply,

(A1.24) $$\ln w = \pi_0 + \pi_1 \ln q + \pi_2 \ln r + \pi_3 v + \pi_4 G_{tr} + \pi_5 t_{fl} + \pi_6 t_{sl} + \pi_7 t_s + \pi_8 t_{proptr} ,$$

\+ - - + + + ? +

where '?' denotes that the sign of the coefficient is not known a priori.

Substituting this last equation into equation (A1.19) gives

(A1.25) $$\ln L = \lambda_0 + \lambda_1 \ln q + \lambda_2 \ln r + \lambda_3 (\pi_0 + \pi_1 \ln q + \pi_2 \ln r + \pi_3 v + \pi_4 G_{tr} + \pi_5 t_{fl} + \pi_6 t_{sl} + \pi_7 t_s + \pi_8 t_{proptr}) + \lambda_4 v + \lambda_5 t_s ,$$

or, more concisely,

(A1.26) $$\ln L = b_0 + b_1 \ln q + b_2 \ln r + b_3 v + b_4 t_s + b_5 G_{tr} + b_6 t_{fl} + b_7 t_{sl} + b_8 t_{proptr} .$$

? ? ? ? - - - -

Finally, for the capital demand equation we have

(A1.27) $$\ln K = \kappa_0 + \kappa_1 \ln r + \kappa_2 (\pi_0 + \pi_1 \ln q + \pi_2 \ln r + \pi_3 v + \pi_4 G_{tr} + \pi_5 t_{fl} + \pi_6 t_{sl} + \pi_7 t_s + \pi_8 t_{proptr}) + \kappa_3 v + \kappa_4 \ln q + \kappa_5 t_s .$$

Simplification gives

(A1.28) $$\ln K = d_0 + d_1 \ln r + d_2 v + d_3 \ln q + d_4 t_s + d_5 G_{tr} + d_6 t_{fl} + d_7 t_{sl} + d_8 t_{proptr} .$$

? ? ? ? - - - -

Appendix 2: Calculation of Tax Rates

The STAMP model includes various tax rates, as regressors or as components of the cost of capital. The tax rates that are used as regressors are:

(a) the federal tax rate on labor income applied to Minnesota residents;
(b) the state tax rate on personal income;
(c) the state tax rates on the use of labor service – unemployment insurance tax rate and workers compensation tax rate combined; and
(d) the local tax rates on commercial/industrial property and residential property.

The tax rates that we include as the components of the cost of capital are:

(e) the corporate income tax rate for businesses operating in Minnesota;
(f) the federal tax rate on corporate income by sector;
(g) the state tax rate on capital income applied to all U.S. residents; and
(h) the federal tax rate on capital income applied to all U.S. residents.

We used *average marginal tax rates* whenever the data needed to calculate them were available. 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. These measures do not summarize the tax rates that face an individual who is trying, at the margin, to decide whether to work more, or a firm wondering whether it should invest more.[17]

The calculation of average marginal tax rates is somewhat complicated, so the procedures followed are described in this Appendix. We use a method similar to the one suggested by John Seater.[18] 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.

[17] Timothy Bartik. 1991. *Who Benefits from State and Local Economic Development Policies?*, W.E. Upjohn Institute for Employment Research, Kalamazoo, MI. This report surveys the relevant literature.
[18] John Seater, "Marginal Federal Personal and Corporate Income Tax Rates in the US, 1909-1975," *Journal of Monetary Economics* (1982).

Average Marginal Federal Tax Rate on Labor Income for Minnesota Residents

We used data obtained from the *Statistics of Income* publication. 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 Minnesota, 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*.

Average State Property Tax Rate

The data used to calculate the average property tax rate for Minnesota were obtained from two sources: the Minnesota Department of Revenue and the Research Division of the Minnesota House or Representatives. The property tax collections for these years were presented for fiscal years as opposed to calendar years. The fiscal years run from July 1 of one year to June 30 of the following year, so our conversion from fiscal year to calendar year consisted of averaging two fiscal year amounts.[19]

We calculated the average state property tax rate, t_{sp}, for each of the two categories of property: residential and commercial/industrial as:

[19] For instance, calendar year data for 1990 was calculated as an average of FY 90 and FY 91.

$$t_{sp,ij} = \frac{PTC_{ij}}{MV_{ij}};\ j = 1970,...,1998.$$

where $t_{sp,i\,j}$ = average state property tax rate for i^{th} class in year j

i = class (residential or comm/ind)

PTC = property tax collected

MV = market value of taxable property.

Average Income Tax Rate for Minnesota Corporations

The tax rates described below in this and the subsequent three sections are components of the cost of capital.

We generated the average corporate excise tax rate in Minnesota (*tsca*) by applying the following formula:

$$tsca = \frac{\text{corporate \& business excise collections}}{\text{Minnesota taxable base}}.$$

Fiscal year data on the total excise collections were obtained from the Minnesota Department of Revenue. Fiscal year data were converted to calendar year data in order to be consistent with other data used in this calculation.

To estimate the total Minnesota taxable base, we first calculated the taxable base for each of seven primary sectors: agriculture, construction; manufacturing; trade (wholesale and retail); transportation and public utilities (TPU); finance, insurance and real state (FIRE); and services (which includes many high-tech sectors such as software development). We did this by multiplying the U.S. corporate net income for each sector, as reported in the IRS publication, *Corporation Income Tax Returns*, by the MN apportionment ratio as:

$$TB_i = ar_i * Y_i$$

where TB_i, ar_i, and Y_i are taxable base, apportionment ratio and U.S. corporation net income for sector i, respectively. The apportionment ratio was obtained using the following formula:

$$ar_i = \left[0.70 * \left(\frac{MNsales}{USsales} \right)_i + 0.15 * \left(\frac{MNassets}{USassets} \right)_i + 0.15 * \left(\frac{MNpayroll}{USpayroll} \right)_i \right].$$

The payroll ratios were computed using data on payroll for the state and for the United States, which were obtained from the Bureau of Economic Analysis (BEA). We calculated the asset ratios using data on U.S. nonresidential capital stock published by BEA and the state capital stock data estimated by BHI.[20] To estimate the sales ratio for each sector we used the ratio of state GSP to US GDP in each sector.

Once all the ratios (sales, asset and payroll ratios) in the apportionment formula were estimated or calculated, we multiplied the apportionment ratio by the U.S. corporate net income (less deficit) to get the taxable base for each sector. Then the total state taxable base was obtained by adding the taxable base for all sectors: $TB_{state} = \Sigma_i TB_i$. The last step in the calculation of *tsca* was to divide state collection of corporate income taxes by the total state taxable base.

Average Marginal Federal Tax Rate on Corporate Income

In order to calculate the average marginal federal tax rate on corporate income, we used data for firms of all states, as published by the IRS in *Corporation Returns*. This publication reports, for each of the seven sectors of the economy (agriculture, construction, FIRE, manufacturing, service, TPU and trade) and for each different size 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.[21] Hence, $t_{fc,i}$ is written as:

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

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 net income (less deficits) for business receipts group i, calculated by dividing the total corporate taxable income by the number of returns for business receipts group i.

[20] See later in this section for a detailed description of the state capital stock estimation.

[21] The average tax rate on corporate income was used for the first business receipts income group. The marginal tax rate on corporate income was used on the remaining income groups, with the exception of negative or erroneous results, in which case the average tax rate on corporate income was used.

Then, the average marginal tax rate on corporate income, t_{fc} , is calculated by multiplying corporate net income (less deficits) in each business receipt group by the marginal tax rate for that class, and then dividing by the total corporate net income to give

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

Average Marginal State Tax Rate On Capital Income Applied to All U.S. Residents

The data used to calculate the marginal state tax rate come 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).[22]

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 U.S. residents as:[23]

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

[22] See the table of Returns with Itemized Deductions: Source of Income, Adjustments, Itemized Deductions by type, Exemptions, and Tax Items, by Size of Adjusted Gross Income.

Average Marginal Federal Tax Rate On Capital Income Applied to All U.S. Residents

To compute this tax rate, we used data from federal tax returns for all U.S. residents published in *Statistics of Income Bulletin* by the IRS.[24] 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:

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

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*.

Average Marginal Federal Tax Rate on Dividend Income

The average marginal tax rate on dividend income for all states, t^g_{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.

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

where D_i = the total dividend income for income group *i*.

As shown, t^g_{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.

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[23] Since we assumed that the marginal state tax rate on individual income is the same as that on capital income, $t_{sy,k}$ is also the same as the average marginal state tax rate on total individual income.

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 *actually 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_i^A. Since some of the capital gains were tax deductible 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_i^A 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.

[24] See section of Selected Historical and Other Data, Individual Income and Tax Data by State and Size of Adjusted Gross Income for the U.S.

Appendix 3:
Measuring the Stock of Private Nonresidential Capital in Minnesota

a. The basic approach

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 1970-1997. Net stock is calculated as the cumulative value of past gross investment less the cumulative value of past depreciation.[25] The approach taken was to apportion for each year, from 1970 to 1997, the BEA national total for private capital on the basis of various measures of Minnesota'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,[26] 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. The most recent census was carried out in 1997.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:

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

where ρ_τ = apportionment rate for base year τ, and

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

[25] In 1997 BEA revised the U.S. capital stock data based on a new methodology for calculating depreciation charges. For a given year, the depreciation charges are obtained by multiplying the prior year's charge by one minus the annual depreciation rate. Net stocks are estimated by subtracting cumulative depreciation from cumulative gross investment.

[26] Alicia M. Munnell with Leah Cook, "How Does Public Infrastructure Affect Regional Economic Performance?" *New England Economic Review* (Sept./Oct. 1990): 11-32.

Then, we estimated the Minnesota capital stock for nonbase years using the base year apportionment ratios and the annual growth rates of the U.S. capital stock.[27] 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.

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

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.

For the real value of capital stock in FIRE, from 1970-1976, there are no GSP data available. For these years we apportioned U.S. capital stock using the ratio of wages and salary employment in FIRE, of Minnesota to the U.S. In the construction sector, we used the ratio of Minnesota to U.S. real capital stock, as the apportionment ratio to apply to U.S. capital stock.

b. 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, 1992, and 1997.[28] 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 the 1982 and 1987 *Censuses*; and assets for 1988-1991 with data from the 1987 and 1992 *Censuses*. Assets for 1993-1996 were obtained with data from the 1992 and 1997 *Censuses*.

[27] Munnell used the base year apportionment ratios to distribute the BEA national capital stock for preceding years and following years. Thus, she used data from the 1972 *Census* to estimate the capital stock apportionment ratios for each state for 1969 to 1974; data from 1977 to estimates for 1975 to 1979; 1982 *Census* data to estimate shares for the 1980 to 1984 stock estimates; and data from the 1987 *Census* to estimate shares for 1985 to 1989. The resulting series, however, sometimes show significant divergence of annual growth rates from the growth rates of the U.S. capital stock. To avoid this problem we used the smoothing method described below.

[28] The ratio obtained from the 1969 Census was applied to 1970, which is the first year of the series.

Minnesota's Share of U. S. Value of Farm Land, Buildings and Equipment[29]

YEAR	1969	1974	1978	1982	1987	1992	1997
%	2.79	3.75	4.27	4.38	3.39	3.66	3.72.

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, 1992, and 1997. We estimated assets for 1970 and 1971 by applying the 1972 ratio; assets for 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 1993-1996 were obtained by applying the 1992 and 1997 *Censuses.*

Minnesota's Share of U. S. Gross Book Value of Depreciable Assets for Construction[30]

YEAR	1972	1977	1982	1987	1992	1997
%	2.63	2.64	2.58	2.39	2.36	2.68

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, 1992, and 1997. The data from 1971 *Annual Survey* and the 1977 *Census* were used to estimate capital stock for 1972-1976.

Minnesota's Share of U. S. Gross Book Value of Depreciable Assets for Manufacturing[31]

YEAR	1970	1971	1977	1982	1987	1992	1997
%	1.18	1.18	1.22	1.44	1.66	1.80	1.91

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 subsectors 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, and the years 1984 through

[29] U.S. Bureau of the Census, *Census of Agriculture*, 1969, 1974, 1978, 1982, 1987, 1992, and 1997.
[30] U.S. Bureau of the Census, *Census of Construction*, 1972, 1977, 1982, 1987, 1992, and 1997
[31] U.S. Bureau of the Census, *Annual Survey of Manufactures*, 1971, and *Census of Manufactures*, 1977, 1982, 1987, 1992, and 1997.

1997. We obtained these data from *Railroad Facts*. We estimated assets from 1970 to 1979 by applying the 1980 ratio,[32] and assets for 1983 with data from the 1982 and 1984.

Minnesota's Share of U. S. Railroad Mileage[33]

YEAR	1980	1982	1984	1987	1991	1994	1995	1996	1997
%	3.57	3.70	3.66	3.36	3.49	3.67	3.62	3.29	3.18

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, 1992, and 1997 from the *Census of Transportation*.

Minnesota's Share of U. S. Trucks[34]

YEAR	1972	1977	1982	1987	1992	1997
%	2.28	2.38	2.62	1.91	1.95	1.99

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 U.S. Civil Aircraft*, a publication of the Federal Aviation Administration.

Minnesota's Share of U. S. Aircraft[35]

YEAR	1972	1977	1982	1987	1992	1994
%	2.48	2.39.	2.28	2.20	2.34	2.34

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 U.S. 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 Communication Commission, for 1972, 1977, 1980, 1986, and 1987. We estimated the 1991, 1992, 1993, 1994, 1996 and 1997 ratios according

[32] We were unable to find the state's share of U.S. road mileage for early years, so we assume that the apportionment ratio remained constant before 1980 at that year's ratio. This assumption seems reasonable since the ratio after 1980 did not change significantly.
[33] Association of American Railroads, *Railroad Facts*, 1983, 1985, 1988, 1993, 1995, 1996 and 1997.
[34] U.S. Bureau of the Census, *Census of Transportation*, 1972, 1977, 1982, 1987, 1992, and 1997.

to the state's share of total presubscribed lines since miles of wire and cable are no longer published (and are increasingly less relevant anyhow).

Minnesota's Share of U. S. Miles of Wire in Cable[36]

YEAR	1972	1977	1980	1986	1987	1993	1996
%	2.44	1.63	2.64	2.71	2.75	2.46	2.39

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 1997).[37] These data were obtained from the *Statistical Abstract of the United States*, for 1975, 1985, 1990, 1993, 1995 through 1997. We estimated assets for 1971 to 1973 with data from 1970 and 1974; assets for 1977 to 1979 with data from 1976 and 1980, assets for 1987 with data from 1985 and 1988, and so on.

Minnesota's Share of U. S. Installed Capacity of Electric Energy[38]

YEAR	1970	1975	1980	1985	1988	1990	1995	1997
%	1.26	1.38	1.43	1.22	1.30	1.27	1.26	1.29

We estimated assets in the gas service sector based on Minnesota'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, 1994, 1995, 1996, and 1997. We estimated assets for 1971 to 1974 with data for 1970 and 1975, assets for 1976 and 1977 with data for 1975 and 1978, assets for 1981 to 1984 with data for 1980 and 1985, and so on. Once again we could not find a good proxy for the sanitary service sector, so we apportioned the weighted average of the shares of electricity and gas to the total of electric, gas, and sanitary services.[39]

Minnesota's Share of U. S. Miles of Pipeline and Gas Mains[40]

YEAR	1970	1975	1980	1985	1990	1992	1993	1994	1997
%	1.55	1.56	1.59	1.63	1.77	1.83	2.10	2.04	2.07

[35] U.S. Federal Aviation Administration, *Census of U. S. Civil Aircraft*, 1972, 1977, 1982, 1987, 1992 and 1994.
[36] U.S. Federal Communications Commission, *Statistics of Communications Common Carriers*, 1972, 1977, 1980, 1986, 1987, 1993, 1994, 1995, 1996 and 1997.
[37] Data for installed capacity are not available after 1989. They are replaced with net summer capability.
[38] U.S. Bureau of the Census, *Statistical Abstract of the United States*, for 1975, 1985, 1990, 1993, 1995 through 1997.
[39] The sanitary service sector is small, e.g., its share of the total 1993 U.S. capital stock in electric, gas, and sanitary services was 8.9%.
[40] American Gas Association, *Gas Facts*, 1975,1980, 1985, 1980, 1992, 1993, 1994, 1995, 1996 and 1997.

We distributed assets in finance, insurance, and real estate according to the state's share of gross production in the U.S. for each year.[41] We obtained the annual data on gross product for each subsector, for the U.S. and for Minnesota, from the Bureau of Economic Analysis (BEA).

Minnesota's ratio of U.S. GSP in FIRE

YEAR	1977	1980	1981	1985	1990	1991	1992	1997
%	1.78	1.78	1.71	1.66	1.52	1.58	1.63	1.83

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 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 Minnesota's sales in the retail industry for the years 1986, 1990, 1991, 1993, 1994, 1995, and 1996, were obtained from various issues of the *Statistical Abstract of the United States.*

Minnesota's Share of U. S. Sales in Retail Trade, Wholesale Trade, and Service Industries[42]

YEAR	1972	1977	1982	1987	1990	1991	1992	1994	1996	1997
%										
Retail	1.82	1.88	1.84	1.82	1.84	1.93	1.88	1.88	1.84	1.92
Wholesale	2.17	2.31	2.37	2.19	n.a.	n.a.	2.24	n.a.	n.a	2.44
Service	1.53	1.55	1.52	1.50	n.a.	n.a.	1.56	n.a.	n.a.	1.65

[41] In Munnell's study (1990), the state's share of commercial bank deposits in the U.S. was used. However, the fraction of banks' capital stock in FIRE is relatively small (e.g., it was 20% in 1993) and thus the deposit share may not be a good measure for the whole FIRE sector. For this reason, we used the state share of gross production for which data are available for each year.

[42] U.S. Bureau of the Census. *Census of Wholesale Trade*, 1972, 1977, 1982, 1987, 1992, and 1997. *Census of Retail Trade*, 1972, 1977, 1982, 1987, 1992, 1994, and 1997. *Statistical Abstract of the United States*, 1998. *Census of Service Industries*, 1972, 1977, 1982, 1987, 1992, and 1997.

Appendix 4:
Derivation of the 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:[43]

(A2d.1) $K = \int_0^{SL} R_n e^{-(\rho+d)t} dt$,

where
SL = service life of capital asset,
ρ = real discount rate, and
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 taxes on capital gains and on any dividends paid out to them by the corporation. Then, R_n is obtained as:

(A2d.2) $R_n = R-(T_p + T_c + T_k)$,

where T_p is the tax on corporate property,

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

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

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

[43] See Robert E. Hall and Dale W. Jorgensen, "Tax Policy and Investment Behavior," *American Economic Review* 57 (June 1967): 391-414.

(A2d.3) $T_{sc} = t_{sc}(R\text{-}T_p\text{-}D)$,

(A2d.4) $T_{fc} = t_{fc}(R\text{-}T_p\text{-}D\text{-}T_{sc})$,

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

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

D = depreciation allowed for tax purposes.[44]

Then T_c is obtained from (A2d.3) and (A2d.4) as:

(A2d.5) $T_c = (t_{fc}+t_{sc})(R\text{-}T_p\text{-}D)\text{-}t_{fc}*t_{sc}(R\text{-}T_p\text{-}D) = \tau_c(R\text{-}T_p\text{-}D)$,

where:

(A2d.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 taxes on dividends and capital gains. Now T_k is calculated as follows:

(A2d.7) $T_k = T_{fk} + T_{sk} - T_{fk}T_{sk.}$

Here T_{fk} is given by

(A2d.8) $T_{fk} = t_{fk}(R\text{-}T_p\text{-}D\text{-}T_c) = t_{fk}(R\text{-}T_p\text{-}D\text{-}T_c)$,

where t_{fk} = federal tax rate on individual capital income.[45] Hence

(A2d.9) $T_k = t_{fk}(R\text{-}T_p\text{-}D\text{-}T_c)$.

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

(A2d.10) $t_{fk} = t^d_{fk}\ p + t^g_{fk}\ (1\text{-}p)$,

where

t^d_{fk} = federal tax rate on dividend income;

t^g_{fk} = federal tax rates on capital gains; and

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

[44] We assume that the depreciation allowed for federal tax purposes is the same for state tax purposes.

[45] Since we assume that the supply of capital is perfectly elastic due to perfect capital mobility in the U.S., t_{fk} is the tax rate on capital income applied to all U.S. residents.

Now substitute (A2d.5) and (A2d.9) into (A2d.2) to rewrite R_n as:

(A2d.11) $R_n = R - T_p - (T_c + T_k)$

$= R - T_p - [(R - T_p - D)t_{fk} - T_c t_{fk} + T_c]$

$= R - T_p - [t_{fk}(R - T_p - D) + (1 - t_{fk})\tau_c(R - T_p - D)]$

$= R - T_p - (R - T_p - D)(t_{fk} + (1 - t_{fk})\tau_c)$

$= (1 - t_{ck})(R - T_p) + t_{ck}D$,

where :

(A2d.12) $t_{ck} = \tau_c + t_{fk} - t_{fk} * \tau_c$.

Now substitute (A2d.11) into (A2d.1) to get:

(A2d.13) $K = \int_0^{SL} [(R - T_p)(1 - t_{ck})]\, e^{-(\rho+d)t} dt + \int_0^{SL} t_{ck} D e^{-(\rho+d)t} dt$

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

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

for $e^{-(\rho+d)SL} \approx 0$, which will be true for $SL \to \infty$.

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

(A2d.14) $r \equiv R/K$.

As shown in (A2d.13) and (A2d.14), the structure of federal and state taxes and the depreciation method affect *r*. To get the closed form solution for *r*, the depreciation that is a function of *K* and *t* needs to be specified.

The second term on the right hand side of (A2d.13) is the present value of the tax benefits of depreciation allowances (TBD), expressed in continuous time. It may be rewritten as

$$TBD = t_{ck} \int_0^{SL} (De^{-dt}) e^{-\rho t} dt \equiv t_{ck} \int_0^{SL} Ae^{-\rho t},$$

where De^{-dt} measures the depreciation allowed in any given time period and $e^{-\rho t}$ discounts this allowance to the present. In discrete form this gives

$$TBD = t_{ck} \sum_0^{DL} \frac{A_t}{(1 + \rho)^t},$$

where A_t is the depreciation allowed for tax purposes by the federal government for recovery year *t*. Note that the depreciation allowance is summed up over *DL* years, reflecting the tax depreciation life of the asset.

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*, A_t, is:

(A2d.15) $A_t = \alpha_t K$, for $1 \le t \le DL$; otherwise, 0,

where α_t is the recovery allowance percentage for recovery year *t*. With these changes, equation (A2d.13) is modified to give

(A2d.16) $$K = \frac{(R - T_p)(1 - t_{ck})}{(\rho + d)} + t_{ck} \sum_{t=1}^{DL} \frac{\alpha_t K}{(1+\rho)^t}.$$

The tax on business property is given by $T_p = t_{pc} K$. Substituting this into (A2d.16), and solving for *r* (=*R/K*) yields

(A2d.17) $$r = \frac{R}{K} = \frac{(\rho + d)(1 - t_{ck} C)}{(1 - t_{ck})} + t_{pc},$$

where

$C = \sum_{t=1}^{DL} \frac{\alpha_t}{(1+\rho)^t}$ and $C<1$. As indicated in (A2d.17), *r* is affected by the structure of the various federal and state taxes and the depreciation method.

a. Numerical Example of Calculation of C

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

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%, and the depreciation method is based on MACRS with a depreciable life of seven years. Then, we get:

$$\text{(A2d.18)} \quad C = \sum_{t=1}^{DL} \frac{\alpha_t}{(1+\rho)^t} = \frac{.14}{(1+.1)} + \frac{.25}{(1+.1)^2} + \frac{.17}{(1+.1)^3} + \frac{.13}{(1+.1)^4} + ... + \frac{.04}{(1+.1)^8} = 0.722.$$

Data on α

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

Depreciation Methods for Federal Tax Purposes

Years	Method
1986-present	Modified Accelerated Cost Recovery System (MACRS)
1981-1985	Accelerated Cost Recovery System (ACRS)
1954-1980	Accelerated method (sum-of-years'-digits, SYD)

b. MACRS

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

DL=3 years for certain special manufacturing tools,

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-year %	5-year %	7-year %
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

c. 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-year %	5-year %	10-year %
1	25	15	8
2	38	22	14
3	37	21	12
4		21	10
5		21	10
6			10
7-10			9

d. 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 years under SYD are:

	Class of investment			
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

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